POTENTIAL FOR SAVING ELECTRIC ENERGY IN KENYAN UNIVERSITIES USING TECHNOLOGICAL AND BEHAVIOURAL TECHNIQUES

BY

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DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been presented for a degree in any other university. No part of this thesis may be reproduced without prior written permission of the author and/or University of Eldoret.

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DEDICATION

This work is dedicated to my lovely mother Nelly Talam, dear wife Lily Chemutai Mutai and lovely children Eddah Chepngeno Mutai, Susan Chepkemoi Mutai and Mercy Chebet Mutai for their constant encouragement and prayers.

ABSTRACT

The nature of daily activities in Kenyan universities means that electric energy consumption constitutes a big percentage of their budgets. This study sought to determine the potential for saving electric energy in Kenyan universities. Specifically, the study sought to: determine the amount of electric energy that would be saved by applying the available electric energy saving technologies; find out the electric energy wasted through unauthorised electric loads; determine the electric energy that would be saved through the use of alternative electric energy sources; and establish the level of awareness of electric energy saving techniques of end-users in universities in Kenya. The study employed the parallel mixed method research design. Pragmatism philosophy was adopted and a survey research strategy was used. Questionnaires, interview schedules and observation checklist were used in collection of data. Collected data from questionnaires was analysed using descriptive statistics and were done with the help of the statistical package for the social sciences (SPSS) computer program. The data obtained from the observation check-list were analysed using Microsoft Office Excel computer program. The findings revealed that: 82% of electric energy could be saved by replacing all the T8 linear fluorescent lamps with the T8 LED lamps where daylight sensors are also installed in university buildings; 61% of electric energy was being wasted through unauthorized loads; End-users had not been made aware of electric energy saving measures; Policy on energy saving that could guide the users was not clearly spelt out; Universities did not make use of green electric energy sources for heating and lighting; 29% of electric energy could be saved by replacing the existing power equipment with electric energy efficient types. Arising from these findings, the study concluded that there was electric energy saving potential at universities in Kenya that needed to be exploited so as to reduce the budget on electricity bills. The recommendations made were that the universities should: Replace all the linear T8 fluorescent lamps with T8 LED lamps and at the same time install daylight sensors; Replace the inefficient electric power equipment and appliances with energy efficient types; Use green energy sources for cooking; Implement training and education strategy on energy saving techniques for all end-users; and Install solar panels for heating and electricity production.

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LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

AVG: Average

CI1: Commercial industrial one

CO_2 : Carbondioxide

FT: Feet

GHG: Green house gas

GWh: Gigawatt hour

HRS: Hours

IEA: Institute of Economic Affairs

IEC: International Electrotechnical Commission

IPP: Independent Power Producers

KenGen: Kenya Electricity Generating Company Limited

KIPPRA: Kenya Institute for Public Policy Research and Analysis

KNBS: Kenya National Bureau of Statistics

KPLC: Kenya Power and Lighting Company

Ksh: Kenya Shillings

KUCCPS: Kenya Universities and Colleges Central Placement Service.

kWh: Kilowatt hour

LED: Light Emitting Diode

QTY: Quantity

REA: Rural Electrification Authority

TWh: Terrawatt hour

UNESCO-UNEVOC: International Centre for Technical and Vocational Education and Training of the United Nations Educational, Scientific and Cultural Organization

OPERATIONAL DEFINITION OF TERMS

Ballast: An electrical device used in fluorescent lamps to regulate starting and operating characteristics of the lamps.

Daylight Harvesting: The term used in the building controls industry for a control system that reduces electric light in building interiors when daylight is available, in order to reduce energy consumption.

Daylight Sensor: A device that reads available light and sends a signal to the control system. Daylight Sensor = Photo Cell = Photo Sensor

Electric energy: Is the energy created by electrons moving through an electrical conductor. The world is made of matter. All matter contains atoms that contain electrons that are always moving. When electrons are forced down a conductive path, such as a wire, the movement produces electricity, or electric energy. Electricity lights homes, offices and public spaces, underpins information and communication technology, enables financial transactions and powers gadgets and mobile phones.

Electric energy efficiency: Using less energy to provide the same service (Berkeley National Laboratory, 2016). For example, replacing an incandescent lamp with a compact fluorescent lamp (which uses much less energy to produce the same amount of light) is energy efficiency.

Electric energy conservation: Reducing or going without a service to save energy (Berkeley National Laboratory, 2016). For example, turning off a light is energy conservation.

Electric energy saving: Electric energy conservation and the use of electric energy efficient equipment contribute to electric energy saving which in turn saves money on the energy bill, and reduces the amount of greenhouse gases going into the atmosphere.

Exajoule: Is equal to 10^{18} (one quintillion) joules

Lumen: A rating of a lamp that tells how much visible light it generates (how bright it is as a source of light).

Lux: The amount of light (the number of lumens) illuminating a square metre of a surface.

Normal hydrology: Hydrology is the study of water in the environment. It deals with the water cycle from the arrival of water at the land surface as precipitation to its eventual loss from the land either by evaporation or transpiration back to the atmosphere or by surface and subsurface flow to the sea. Normal hydrology is a state when there is enough water in the dams used for generating electricity.

Potential: Having or showing the capacity to develop into something in the future. Generally it refers to a currently unrealized ability.

Renewable green energy sources: Energy supplies that are refilled by natural processes as fast as they are used. These include sunlight, wind, rain, tides, waves and geothermal heat. All renewable energy comes, ultimately, from the sun. We can use the sun directly (as in solar heating systems) or indirectly (as in hydroelectric power, wind power, and power from biomass fuels).

Unauthorised electric loads: A load is any device that converts electric energy to other form of energy for example light, heat or mechanical energy. When installing electric system in a building for instance, the final circuits are designed so as to meet the projected load demand. If a load which was not projected is connected to the circuit it may bring about overload and may cause fire. This is called unauthorised electric load and should be avoided at all cost.

Saving energy: Decreasing the amount of energy used while achieving a similar outcome of end use

Technique: A systematic procedure or routine by which a task is accomplished

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CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Introduction

The chapter contains background to the study, statement of the problem, objectives of the study, research questions, justification for the study, significance of the study, the assumptions of the study, scope of the study, limitations of the study, the theoretical framework, and the conceptual framework.

1.2 Background to the study

Energy is fundamental to the quality of our lives today as we totally dependent on it for living and working and that the only real bottleneck preventing development is its shortage (Qurashi, 2005). It heats and lights our homes, fuels our transport and runs various machines. Currently, most of the energy used comes from fossil fuels such as oil, gas and coal. Unfortunately, the rate at which these resources are being depleted is alarming. Another challenge of fossil fuels is that burning them for energy also produces carbon-dioxide (CO_2), a greenhouse gas, which contributes to climate change. Any means of energy production has an impact on the environment, which encompasses issues such as land use, waste production, and disturbance to flora and fauna. Therefore, it has significance for both the economy and nature conservancy. These effects need to be addressed if we are to attain a sustainable energy sector (UNESCO-UNEVOC, 2017).

Energy is a basic requirement for different functions in industries around the world because industrial operations such as manufacturing, production and processing need huge amounts of energy to be accomplished appropriately. Energy is therefore a crucial factor for economic competitiveness and employment and hence a large amount of it is required in countries with faster economic growth. Varadi (2011) opined that the total primary energy consumption of the world will be 1800 exajoule by 2060, which is 2.6 times of today's consumption. Lifestyles have been changing very quickly and they tend to force consumers to demand more electric energy sources in order to satisfy their needs (Kamaludin, 2013). The need for electricity has been on the increase in the last two decades in developing countries such as Nigeria because of economic and industrial developments (Adekunle, 2008). Availability of energy has been identified as an important component of social, economic and political sustainability of any nation and therefore as the world experiences a higher demand and cost of energy, there is an urgent need to reduce the energy consumption as means to control cost and sustainability.

As global energy demand continues to grow, actions to increase energy efficiency will be essential. While one way of meeting the projected demand is through increased generation, extension of the grid, strengthening the grid to cope with increased generation, another very important way is to apply a parallel strategy of using available technologies and sensitizing end users to benefits of saving energy. Coming up with new power plants not only requires large investments but also involves the securing of land and convincing neighbouring residents, which are challenging and time consuming procedures. On the other hand, electric energy saving measures are much less expensive and can be done within a short period of time.

Maheswaran (2012) alluded to the fact that there were numerous cost-effective opportunities to use electricity more efficiently and to avoid the costs and pollution associated with new plant construction and still have the same energy services. The two energy conservation methods are the technological and the behavioural approaches. The energy efficient technologies widely used world-wide include: occupancy sensors, daylight sensors, energy-efficient motors, soft-starters with energy savers, variable speed drives, energy-efficient lamps, energy lighting efficient controls and photovoltaic systems. Today, a 30% increase in energy efficiency is possible when the currently available technologies are applied (International Electrotechnical Commission, 2013).

Choong (2007) posits that behavioural approach requires changes in human attitudes by using motivation, raising awareness and skill developing. Schooldude (2013) postulates that simple changes in people’s behaviour can quickly lead to significant energy savings, but such changes will only happen if people are aware of the energy consumption they have the power to control. Despite the fact that the technical opportunities are many and energy saving potential is real, most consumers and utilities have so far been slow to invest in the most cost-effective and energy-efficient technologies available (Maheswaran, 2012).

The current National installed electricity capacity in Kenya is 2370 MW (KenGen, 2017). Out of this, 1631 MW, 712 MW and 27 MW are produced by KenGen, IPP and REA respectively. Generation capacities from hydro, geothermal, baggase (co-generation) and wind are 52.1%, 13.2%, 1.8% and 0.4% respectively while fossil based thermal contributes at 32.5%. According to the Institute of Economic Affairs (2015) the peak load is projected to grow to about 15,000 MW by 2030 and to meet this demand, the projected installed capacity should increase gradually to 19,200 MW by 2030.

The cost of electricity in Kenya is four times that of South Africa which is her main competitor in the region, and also more than three times that of China (Kenya Institute for Public Policy Research and Analysis, 2010). The high cost of energy in Kenya is one of the biggest bottlenecks to socio-economic development and the country has continued to lose out on foreign direct investments partly because of this problem. The challenges of the energy sector in Kenya include a weak power transmission and distribution infrastructure due to limited investments in power system upgrading. These power system weaknesses coupled with the high cost of power from Independent Power Producers (IPPs) contribute to high cost of doing business in Kenya (IEA, 2015). The Kenya Institute for Public Policy Research and Analysis (KIPPRA) carried out a comprehensive study and analysis on energy consumption patterns in Kenya in the year 2010 with an aim of gathering data on the energy usage pattern in Kenyan commercial, industrial and institutional sectors. It established that energy as used by households and enterprises may make a large difference if enough measures were directed on efficiency and conservation.

Another study on energy performance of industrial, commercial and institutional energy users in Kenya was carried out by ECOCARE International Limited in the year 2013 and was able to establish that a small number of commercial and institutional energy users were well aware of rising energy costs and the implications of energy efficiency with regard to production costs. It further found out that a small percentage of commercial and institutional energy users had implemented a number of energy efficiency measures and energy efficiency was likely to remain poor with lack of awareness. From these findings, there is therefore an urgent need to take action so as to save electric energy available in the country because the moment electric energy is available in abundance the cost of running businesses reduces drastically.

Higher educational institutions consume a substantial amount of energy because of the nature of their daily activities (Lo, 2013). In the universities, much of the electric energy is consumed by lighting loads, computers in offices, unauthorised loads, laboratory equipment and workshop machinery that are used for practical and demonstrations. Thus, if universities were to achieve the goals of teaching, research and community service, then proper management of electricity supplied to the institutions' power system is required in view of its limited availability (Adekunle, 2008).

The rising energy costs have become a major impediment to the growth of these institutions and this has made the higher educational institutions around the world become engaged in energy conservation (Lo, 2013). With the current situation therefore, universities have to adjust their energy use habits in order to cope with the current situation of rising costs of energy which has made them use a large portion of their budgets on energy bills. Currently, there are ways of saving electrical energy which include the application of modern technologies, use of alternative sources and raising the users' level of awareness on electric energy saving techniques. If electric energy saving techniques were to be applied accordingly in universities, wasted electric energy would reduce significantly.

1.3 Statement of the problem

Higher educational institutions consume a substantial amount of energy because of the nature of their daily activities (Lo, 2013). There are 63 universities in Kenya

(KUCCPS, 2016) with a total population of 446,183 (KNBS, 2015). This large population constitutes high electric energy consumption in hostels, offices, tuition blocks, libraries, laboratories and workshops. This means that universities use a large proportion of their budgets on electricity bills every year. It is therefore worth researching on areas where electric energy is wasted and how to reduce the wastage considering the fact that universities require much more funds to run other essential teaching, learning and research activities. This study sought to determine the potential for saving electric energy in Kenyan universities using technological and behavioural techniques.

1.4 Objectives of the study

(a) Main objective

The main objective for this study was to determine the potential for saving electric energy consumption in Kenyan universities using technological and behavioural techniques.

(b) Specific objectives

The specific objectives of this study were to:

1. Determine the amount of electric energy that would be saved by applying the available electric energy saving technologies in Kenyan universities.
2. Establish the electric energy wasted through unauthorised electric loads in Kenyan universities.
3. Determine the amount of electric energy that would saved in Kenyan universities through the use of alternative green energy sources.

4. Establish the level of awareness of electric energy saving techniques of end-users in Kenyan universities.

1.5 Research questions

1. What percentage of electric energy would be saved by applying the available electric energy saving technologies in Kenyan universities?
2. What percentage of electric energy is wasted through unauthorised electric loads in Kenyan universities?
3. What percentage of electric energy would be saved in Kenyan universities through the use of alternative green energy sources?
4. What is the level of awareness of electric energy saving techniques of end-users in Kenyan universities?

1.6 Justification of the study

Universities historically exist as institutions for the creation and dispersion of knowledge and technology which are the master key to economic development and globalization. To perform these core functions, universities must intensify research activities in all disciplines offered in the institutions. This in turn calls for modern science and technology research facilities which are relatively expensive and has become a major challenge especially in developing economies. According to Lo (2013) universities consume a substantial amount of electric energy because of the nature of their daily activities and this means that large proportions of their budgets are used to pay electricity bills. Bearing this in mind, it is necessary to carry out research that provides information on the energy saving potential in universities through the application of available energy saving measures so that universities could act accordingly to save money and use it for research activities.

1.7 Significance of the Study

This study established the electric energy saving potential in Kenyan universities through the application of electric energy saving measures. The results indicated that substantial amount of electric energy could be saved through the use of technological innovations and raising the level of awareness of the end users. Universities would therefore reduce the proportions of their budgets meant for electricity bills and the amount of money saved could be used to improve infrastructure and other facilities necessary for quality education and training in these institutions. Apart from reducing electricity bills, proper energy management helps protect environment and promotes the greening of institutions. It also elongates the life span of equipment and provides a serene environment for teaching and learning which would in turn improve competitiveness of these institutions within the limited financial resources available to them. The results of this study may become useful to any other institutions of learning such as technical and vocational colleges which may be facing the same challenges.

1.8 Assumptions of the study

The study assumed that the respondents would give truthful responses and that the concerned personnel in the higher educational institutions would not modify anything for the sake of the study. Also, it was assumed that the power supply authority personnel would cooperate and allow access to their power intake points in the various universities that would participate in the study. It was also assumed that universities would readily avail records of their monthly electric energy bills.

1.9 Scope and limitations of the study

1.9.1 Scope

The study was carried out in one private and two public universities in Kenya which were considered to be relatively large and well established. The selected universities also offered engineering courses among other academic programs. To establish the level of awareness of energy saving techniques of the end-users, university students, staff (only those who worked in offices, workshops and laboratories) and administrators were randomly sampled to participate in the study. To determine the potential for saving electric energy, the ratings of lighting loads (in hostels, libraries, administration blocks, lecture halls, kitchens and offices); power equipment (in workshops, laboratories, offices, kitchens and hostels) were recorded and compared to those of the more energy efficient types.

1.9.2 Limitations

Investigating electrical energy consumption in universities involved the use of Kenya Power Company property at the intake points which could only be accessed with the company's permission. Another limitation to the study was the level of vandalism of electrical equipment and systems in the universities. Some of the electrical equipment and machines were so old that identifying their electric ratings became a big challenge. Accessing documents concerning the cost of electrical consumption in universities also posed a challenge because in some cases these documents were confidential. To go over these limitations, the researcher had to ask permission from Kenya power to access the intake points, spent a bit of time to establish the ratings of the old equipment, and also to explain the purpose and importance of the research to the university personnel concerned with the relevant documents.

1.10 Theoretical framework

This research was based on the theory of Diffusion of Innovations, which was pioneered by Rogers (1962) a communication scholar, sociologist, writer, and teacher. Diffusion of Innovations seeks to explain how innovations are taken up in a population. An innovation is an idea, behaviour, or object that is perceived as new by its audience. One reason why there is so much interest in the diffusion of innovations is because getting a new idea adopted, even when it has obvious advantages, is often very difficult. There is a wide gap in many fields, between what is known and what is actually put into use. Many innovations require a lengthy period, often of some years, from the time when they become available to the time when they are widely adopted. A common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation (Rogers, 1962).

According to Robinson (2009), the adoption of an innovation is determined by its perceived relative advantage; compatibility with the values, norms or practices of the potential adopters; experimentation and; ease of seeing results. This study was therefore guided by the theory of diffusion of innovations to explain the fact that currently a 30% increase in energy efficiency is possible with currently available technologies but the adoption and implementation of energy saving solutions have been low despite the promising benefits of these technologies (Anastasi, Corucci & Marcelloni, 2011).

1.11 Conceptual framework

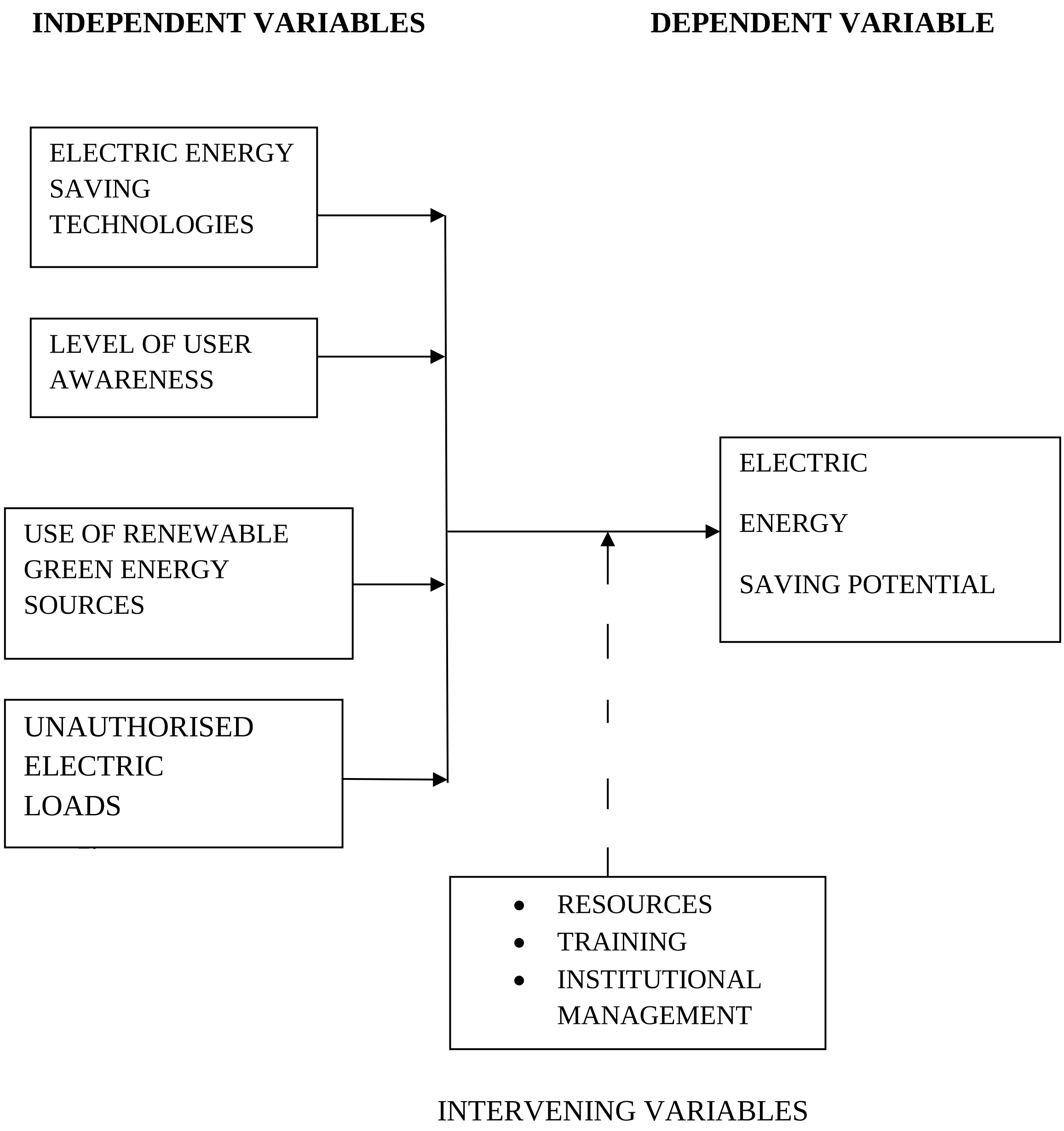

Figure 1 : Conceptual framework (Source: Author, 2018)

The researcher conceptualized in the study that electric energy saving potential in an institution depends on the types of energy saving techniques adopted which include raising the users' level of awareness of electric energy saving techniques; applying available electric energy saving technologies; making use of green energy sources and reducing illegal or unauthorised loads connected to the power supplies. Electric energy saving potential in a given institution also depends on available resources, training of the users and the general institutional management.

Summary of chapter one

Energy is a crucial factor for domestic use, economic competitiveness and employment and hence a large amount of it is required in countries with faster economic growth. As global energy demand continues to grow, actions to save energy are essential and this includes applying a parallel strategy of using available technologies and sensitizing end users to benefits of saving energy. The current installed electricity capacity in Kenya under normal hydrology is 2370 MW (KenGen, 2017) and the cost of electricity in Kenya is four times that of South Africa, the country's main competitor in the region, and more than three times that of China. The rising energy costs have become a major impediment to the growth of higher institutions of learning and this has made them to engage in energy conservation. There are 63 universities in Kenya with a total population of 446,183 students. The large population constitutes high electric energy consumption in hostels, offices, tuition blocks, libraries, laboratories and workshops. The purpose of this study, therefore, was to determine the electric energy saving potential at the universities in Kenya with the view to reducing the budget on electricity bills.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter presents a critical analysis of related literature in the area of electric energy saving. It covers the following: importance of electrical energy, electric energy consumption in higher institutions of learning, electric energy saving measures, and electricity users' levels of awareness of energy saving measures

2.2 Importance of electric energy

Energy is fundamental to the quality of our lives and today we depend on it for living and working (Qurashi, 2005). Energy may be needed as heat, as light or motive power. Electricity is one of the most important discoveries that science has given to mankind. It is one of the greatest technological innovations that has occurred in the world and has now become a part of our daily life and one cannot think of a world without electricity. Electricity is the key component to modern technology and without it most of the things that we use everyday simply could not work. At homes it runs domestic appliances like iron box, electric cookers, refrigerators, electric fan, electric ovens, and lighting loads among others. In factories, large machines such as lathe machines, drilling machines and grinding machines, all work with the help of electricity.

Electricity also provides means of amusement, radio, television and cinema, which are the most popular forms of entertainment are the result of electricity. Modern equipment like computers and robots have been developed because of electricity. The modern means of transportation and communication have been revolutionized by electricity. Today a large number of travelling medium like the electric train, aeroplanes, and electrical cars run on electricity. In medical facilities electricity is used to operate machines like X-rays, electrocardiograph, CT scan, MRI, and other medical machines. It also facilitates the provision of instant results regarding blood tests. It is also important for the purpose and operations of machines such as computers or monitors that display data to enhance medicine. Therefore electricity has made people to live longer and become healthier because without electricity, hospitals would have significantly less medical equipment available to help people with medical problems.

Internet has had a major effect in our lives. It has made people to be more aware of the world they live in and allowed them to learn about our surroundings. It is the gateway for knowledge and has made it possible for the users to find out almost everything within a matter of seconds. In general therefore, Electricity is now an important part of homes & industries because almost whole the devices at homes, businesses and industries are running because of it. It has greatly improved the living standards of human beings all over the world and also it is a major component of technological innovations and inventions taking place globally.

Mehta (2004) alluded to the fact that the advancement in science and technology has made it possible to convert electrical energy into any desired form and this has given electrical energy a place of pride in the modern world. Access to electricity is particularly crucial to human development, as certain basic activities such as: lighting, refrigeration, running household appliances, and operating equipment, cannot easily be carried out using other forms of energy. The present day supply of electricity in many countries, however, is not able to meet the emerging demands and therefore the electricity crisis has become a grave issue that must be addressed at extreme priority (Faraz, 2012).

2.3 Electric energy consumption in higher institutions of learning

The core business of any higher education institution is teaching and learning. It therefore has two main goals: to create and disseminate knowledge. The creation of knowledge is achieved through the research and its dissemination is done through the education. In order to deliver their core teaching and research mission, higher education institutions need to develop and maintain good infrastructures which may include laboratories, workshops, offices, lecture halls, hostels, student centers and libraries.

Generally, higher educational institutions have a large number of buildings which leads to a significant overall energy consumption. Since each kWh of energy delivered causes emission of carbon-diode, it therefore implies that the large amount of energy consumed in the building constitutes a significant carbon-dioxide emissions and hence global warming. Proper energy management practices result into buildings with high energy performance and one of the ways to achieve this is through proper targeting and monitoring of energy consumption (Maimunah, 2010). Reducing energy consumption not only reduces cost, but also helps to minimize the environmental impact of an institution by reducing carbon dioxide emission and other gases associated with global warming. Appropriate energy management also helps in enhancing of institutional greening which eventually improves the image of the institution itself.

The increase in energy demand has raised concerns over adverse impacts on the environment from energy generation. It is important to understand the status of energy consumption for institutions so as to ensure the sustainability of energy usage, and also to reduce its costs. Energy audits are carried out to understand the energy performance of buildings and facilities so that areas with potential for energy savings can be identified. Tang (2012), in his research on the energy consumption study for a Malaysian university, he found out that the number and types of electrical appliances, population and activities in the campus impacted the energy consumption directly and that the occupancy rate of a building has an indistinct direct impact on the total energy consumption. It was therefore safe to relate energy consumption to behaviour of the occupants rather than the number of occupants. Energy wastage due to poor occupants' behaviour increased energy consumption unnecessarily. He also found that the electricity consumption of the university was affected by the population in campus, activities conducted and also the types of electrical appliances used. When higher population was present in the campus, energy consumption tended to be higher. Moreover, buildings of more functionality consumed more electricity as more types of appliances were used for different functions. Buildings with more computers were found to consume more energy because computers required higher power compared with other appliances such as lighting and printers.

Electricity transforms lives by lighting homes, offices and public spaces, underpins information and communication technology, enables financial transactions, powers gadgets and mobile phones (International Electrotechnical Commission, 2013). Cooper, (2014) affirmed that the increasing numbers of digital devices in homes coupled with higher usage levels have resulted in significant growth in energy consumption over the past decade. Energy consumed in a building is determined by both the design and functions of the building as well as the behaviour of occupants (Wong, 2005).

The growth of economy and the need for modern technology such as computers, refrigerators and air conditioning, have led to increased electricity energy demand. Today's typical classroom may have plug-load equipment such as overhead projection systems, camera systems and air conditioning systems. Energy-demanding computer laboratories for instructional use and student use are also commonly found in universities. This typical instructional equipment has increased the demand for energy at the same time that the other costs for running institutions have grown (EPA, 2007).

Research carried out by Adekunle et al in 2008 on the energy consumption and demand in tertiary institutions in Nigeria found out that at the University of Lagos, the use of electric energy fell under the following categories: Space cooling, refrigeration, water heating, cooking, personal computers, office machines, laboratory machines, lighting, electronics and ordinary machines. Reduction of energy consumption in domestic buildings and commercial settings has been a major aim worldwide in view of the limiting of the growing demand for electricity and the efforts to reduce CO_2 emissions. Faraz (2012) alluded to the fact that the growth in electricity consumption was very much related to economic growth, however, its demand was higher than its supply. Institutions of higher learning all over the world were now engaged in energy saving because they were the most affected group whenever there was a shortage of it (Lo, 2013).

2.4 Electric energy saving measures

An energy saving measure is any type of project conducted, or technology implemented to achieve a reduction in the amount of energy used by a particular process, technology or facility. These measures could be technological or behavioural in nature. The technical techniques could include, for example replacing fluorescent lamps with light emitting lamps, using occupancy sensors, daylight sensors, replacing power equipment with more efficient types, among others. Behavioural, measures, on the other hand, involve raising the level of awareness of energy end-users by educating them on the importance of energy saving to individuals, community and organizations. The increasing cost of electrical energy and continuous depletion of energy resources calls for energy saving measures as discussed in the following categories:

2.4.1 Lighting

Meugheuvel (2014) posited that while energy cutback was an important aspect, paying attention to the visual comfort needs of occupant users in terms of illuminance requirements is also important. Having sufficient lighting was important and relevant to every business and it was one of the most energy intensive parts of the business and could be responsible for up to 40% of a building's electricity use (SME, 2015). Lighting system retrofits had high energy savings for both office buildings and stores because artificial lighting was used throughout the year (Peng Xu, 2015). Presently, approximately 33 billion lamps operate worldwide, consuming more than 2650 TWh of energy annually, which was roughly 19% of the global electricity consumption (Maheswaran, 2012). To reduce the electricity consumption due to lighting, the following measures may be taken:

Utilization of natural light, that is, daylighting: This is the practice of placing windows, or other transparent media, and reflective surfaces in buildings so that, during the day, natural light provides effective internal illumination for building users (Deval, 2008). When the natural light from windows and skylights is properly designed and effectively integrated with the electric lighting system, daylighting can offer significant energy savings by offsetting a portion of the electric lighting load. To make use of this natural light in its full potential, any object such as window blinds should be opened or relocated. In areas where both natural and artificial light is used, it is advisable to install daylight sensors so that lamps are turned off automatically whenever there is sufficient daylight in those areas. Skylights are an effective use of natural light and when retrofitting a building, double glazing skylights can be installed to considerably reduce the need for artificial lighting.

In switched daylighting, loads are turned off when the daylight reaches the required level. To reduce the frequent on-off behaviour of the lamps, this type of daylighting uses a delay-to-off and hysteresis technique. Figure 2 shows that as the sun rises, the total light in the space increases. The moment the daylight getting to the space exceeds the minimum required light level, the electric lights will turn off. The electric lamps will stay off until when the natural light is no longer providing the minimum required light level in the space.

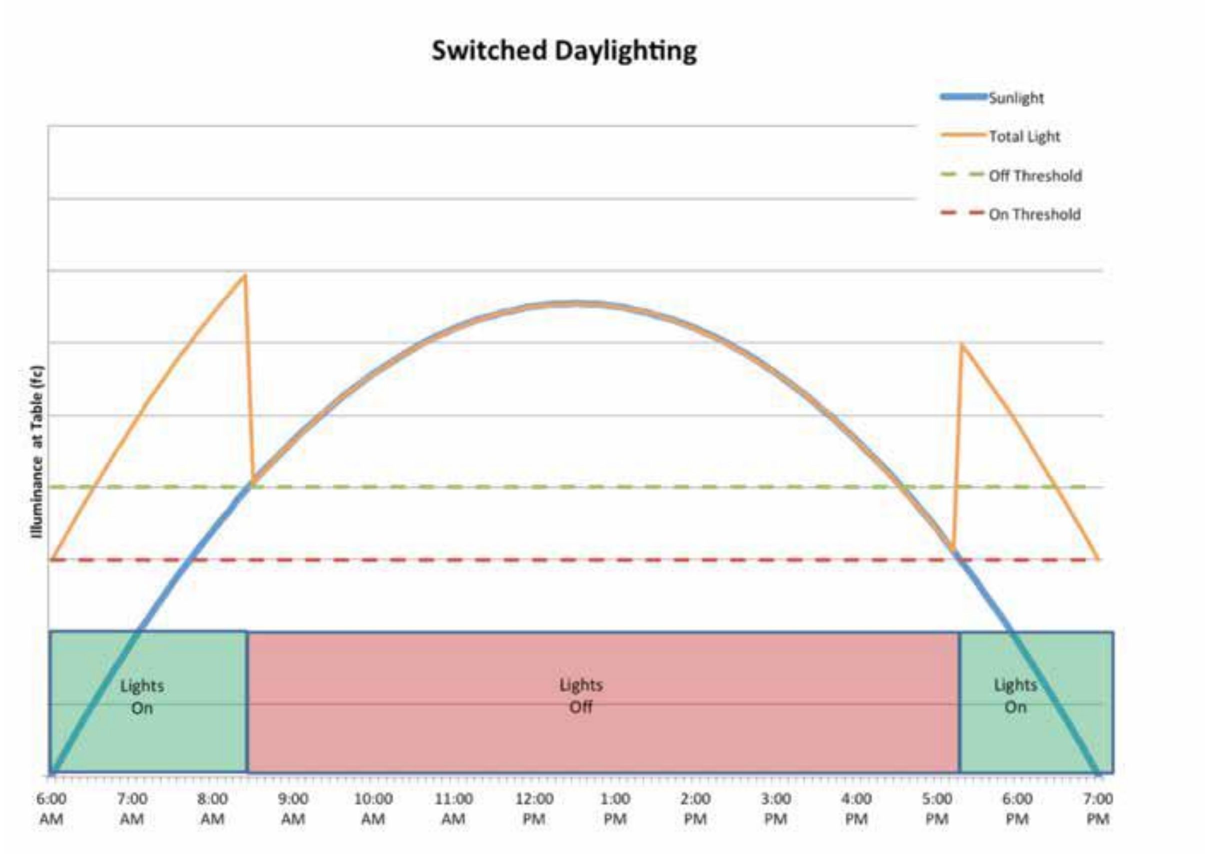

Figure 2: Switched daylighting (source: Lutron Electronics company (2014)

A research on the analysis of energy savings of three daylight control systems carried out by Delvaeye (2016) revealed that between 18% and 46% of electric energy can be saved using daylight control systems. The more efficient lighting and control, including the use of effective daylighting strategies, can save up to 30% on electrical demand (Schneider electric, 2007). The amount of energy saved, however, depends on the position of daylight sensor in the room, climate conditions, interior finish and orientation of rooms. Young (2011) in his research on daylighting effectiveness and energy saving potentials of light pipe systems in buildings asserts that by using a light pipe, a device which allows natural light to enter spaces where windows or skylights are not available, 27% of lighting energy could be saved. According to Krarti (2004), increasing window area leads to greater daylighting benefits and that geographical location has a relatively low impact on daylighting savings potential. Roisin (2007), on the other hand, in his research on the lighting energy savings using different control systems, posits that between 45% and 61% of electrical energy could be saved by using daylight sensors depending on room orientation and location. It is also important to note that poorly maintained fixtures can lead to inefficient lighting and therefore it is important to incorporate lighting maintenance into the overall maintenance procedures.

Energy efficient lamps: The most common linear fluorescent lamps that are widely used in commercial spaces such as offices, schools, hospitals, and stores are nominally four feet in length, with bi-pin sockets and tubular T12 or T8 envelopes. They remain common in existing buildings because of their good quality light output, one of the most efficient light sources available, good life-span and relatively low up-front cost (Premier lighting, 2015). According to Regency lighting (2016), however, the linear fluorescent lamps have some disadvantages that include: Some amount of mercury, a toxic metal which is harmful to environment; It is not as efficient as light emitting diode (LED); Has shorter life span of about 20000 hours compared to 50000 hours for LED and it experiences colour variation and fading such that different light levels will be produced with time and eventually dark corners are seen.

A linear T8 LED lamp is a new player in the lighting arena and has the following advantages over linear T8 fluorescent lamp: Mercury free, dimmable, directional lighting, works well with controls, better efficiency, a good quality light and does not buzz and flicker. At the moment, there is an ever-increasing numbers of LED replacement products available on the market. However, there is no direct comparison between LEDs and fluorescent lamps because LEDs have the advantage of directing light to the surface that requires it. On the other hand, a fluorescent lamp wastes light within the fixture and illuminates unnecessary surfaces. Maxlite (2014) stressed that in this regard, it is important therefore to consider delivered lumens of both the lamp and luminaire together.

To make informed purchasing decisions, lighting users should compare the performance of LED replacements for linear fluorescent lamps on the basis of light output, distribution, colour quality, energy efficiency, and cost-effectiveness (US department of energy, 2011).The lumen rating of a lamp tells how much visible light a lamp generates (how bright it is as a source of light). As light leaves a lamp source, it spreads out and illuminates any surfaces it encounters. Illumination levels on surfaces (measured in lux) are highest near to the lamp but decrease rapidly as the distance from the lamp increases. A lux value is the amount of light (the number of lumens) illuminating a square metre of surface. According to Khan (2010), the operational cost of LED lamp is 1.21 times higher that of fluorescent tubes, however, Aman (2012) found out that the current development shows a tremendous improvement in LED lighting performance and at the same time reduction in their development cost. Hence, it is expected that the major portion of lighting system will be provided by LED lamps in near future. Ryckaert (2012), in his research on the performance of LED linear replacement lamps, opines that by replacing fluorescent tubes with LED tubes, up to 70% of energy could be saved, however, the mean illuminance would reduce significantly.

2.4.2 Energy efficient process and production equipment

Process and production equipment is vital to operations in both industries and institutions. However, older, poorly maintained and inefficient equipment increases energy wastage during process and production. In some developing countries with large industries and outdated electrical equipment, the electricity consumed is higher compared to that of developed economies. Electric power machines are driven by motors and globally, electric motors consume about 9000TWh/year, however, the more advanced models could save about 1000TWh (World energy council, 2013). Waide (2011) propagates that electric motor driven systems is estimated to account for between 43% and 46% of all global electricity consumption and by 2030 it is expected to rise to 13360 TWh per year if no comprehensive and effective energy-efficiency policy measures are taken.

Abdelaziz (2010) postulates that energy saving technologies such as the use of high-efficient motor driven machines and also the application of variable speed drives to match load requirement are cost-effective energy saving measures that would reduce energy consumption of major equipment in industries. According to Perrat (2010), the use of electric machines with motors such as synchronous motors that have high dynamic performance leads to saving up to 20% of electric energy. In his review of electrical motors energy use and energy savings, Saidur (2010) asserts that motors were not being used at full load and in most cases they were oversized that encouraged wastage of energy. About 75% of motors were operated below 60% load yet it has been established that motors are efficient if they are operated above 75% of their load. So, there was therefore a huge potential to save energy by sizing or selecting motors appropriately. To sort out this challenge, variable speed drives could be used so as to match the required loads and hence saving energy.

Office equipment such as computers, printers and kitchen utilities has become common in both learning institutions and business premises in the recent years. They consume a substantial amount of electric energy and have contributed dramatically to the increase in energy consumption and cost per square foot (E-source, 2003). Most of the equipment sold today can be set to go into a low-power sleep mode after a period of inactivity. However, although most computers are currently manufactured and the power management settings are enabled, some end-users may disable them and computers are therefore left in less effective modes. A significant electric energy savings can be gained by ensuring that computer power management settings are enabled so that both computers and monitors are forced to enter sleep mode after a specified period of inactivity.

SMART power strips with built-in occupancy sensors are also available to shut off plugged-in devices like printers, computers and monitors when no users are present. Many electrical devices continue using power even when they are turned off. Those glowing stand-by lights run on electricity. What smart power strips do is completely cut off the power to these devices when it's sensed that they are not in use. This can save between 5% -10% of the total energy bill (Nightingale, 2016). When equipment needs to be replaced, the energy efficiency type should be purchased. The more energy efficient products, however, are likely to cost more but this will be outweighed by the savings made in lifetime running costs. A policy should be in place which commits one to look at both the initial purchase and lifetime running costs of any new equipment purchased. If possible, laptops should be used instead of desktop personal computers as they use much less energy. They are also much quieter and emit less heat. Replace any cathode ray tube (CRT) monitor with modern flat screen technology which reduces monitor running costs by at least 50% and are less damaging to the eyes (SME, 2015). If there are several individual printers, replace them with one large communal printer to increase efficiency and reduce idle energy costs.

Storage water heaters, instant water heaters, electric cooktop, microwave oven, pressing iron and arc welding machine are electric loads that convert electric energy to heat energy. To save electric energy consumed due to heating, induction cooktop is recommended for cooking where electrical energy is transferred directly to ferrous-metal cookware through magnetic induction. This type of cooktop has an efficiency of about 84% and it is also a safer way of cooking because the cooking surface does not heat up (Wilson, 2007). Microwave oven, on the other hand, is also effective because the microwaves penetrate the food heating it more rapidly and hence using less energy than a conventional oven. They are about five times as energy efficient as standard electric ovens and more than 10 times as energy efficient as gas ovens (Wilson, 2007). Timers and thermostats of electric cookers should be set correctly to avoid wastage of energy. This could be done even better by using computer controlled heating system whereby a system is programmed to switch off the heaters after a predetermined time.

2.4.3 Alternative Green Energy Sources

The use of fossil fuels by industries has been blamed for global warming that has been witnessed in the world today. Burning of coal, gas and oil releases harmful gases that trap heat in the atmosphere and causes global warming (Omer, 2017). Industrialized countries have the highest emission levels and they therefore bear the greatest responsibility for global warming. However, action must also be taken by developing countries to avoid future increases in emission levels as their economies develop and population grows. Any means of energy production has an impact on the environment, which comprises of issues such as land use, waste production, and disturbance to flora and fauna (UNESCO-UNEVOC, 2017). These effects need to be addressed if sustainable energy sector is to be attained. Since fossil fuels are a finite resource and their use has contributed greatly to climate change, renewable energy sources are regarded as a generally preferable alternative.

Devabhaktuni (2012) argued that to meet future energy demands efficiently, energy security and reliability must be improved and alternative energy sources must be investigated aggressively. Of the many available renewable sources of energy, solar energy is clearly a promising option as it is extensively available particularly in tropical regions. The various forms of solar energy such as solar heat, solar photovoltaic, solar thermal electricity, and solar fuels offer a clean, climate-friendly, very abundant and in-exhaustive energy resource to mankind. Energy generation from photovoltaic technology is simple, reliable, available everywhere, in-exhaustive, almost maintenance free, clean and suitable for off-grid applications (Singh, 2013).

According to Mekhilef (2010), solar energy systems could be considered either as the power supply or applied directly to a process. Large scale solar thermal systems with large collector fields are economically viable due to the usage of stationary collectors. Solar Photovoltaic systems on the other hand are reliable substitutes to be considered as an innovative power source in building and processes industries. Photovoltaic energy power systems take place as the most dominant source among renewable energy technologies. The most important reason is that it is unlimited and clean energy of the solar power systems. Many studies show that photovoltaic power systems will have an important share in the electricity of the future (Dincer, 2010).

Wind power, on the other hand, has been used increasingly to generate electricity since the early 1990s in Europe, the United States and elsewhere, and the global installed wind power capacity has been doubling every three to four years. It is now making the transition from being a minor contributor to becoming an important source of electricity (Musgrove, 2010). The size of the turbine and the speed of the wind determine how much electricity it will make. According to Kaldellis (2011), the dynamics of wind power at the global energy scene during the last thirty years indicates that the set target of 1 TW of wind power installation by the year 2030 is achievable especially considering the challenges introduced by the need of each country to safeguard security of supply and promote clean power technologies.

The efficient integration of wind generators into electrical interconnected power system is very necessary in order to enjoy green electricity production (Agbetuyi, 2012). Clean electricity generation from wind energy will not only put more electricity to the national grid, but also ensure improved access and reduction in cost of power as well as protect the environment from carbon dioxide emissions (KIPPRA, 2010)

Biogas is produced when bacteria decompose organic material such as garbage and sewage, especially in the absence of oxygen. Biogas is a mixture of about 60% methane and 40% Carbon dioxide. Methane is the main component of natural gas. It is relatively clean burning, colourless, and odourless and can be captured and burned for cooking and heating. Biogas can be used as fuel for domestic stoves, boilers, internal engines, gas turbines, vehicles and fuel cells, or injected into natural gas grids to replace gaseous fuel (Sun, Li, Yan, Liu and Yu, 2015). It can also be used for heating purpose and the scheme is best suitable for hostels and residences (Faraz, 2012). Amjid (2011) alludes that biogas energy generation systems are cheaper and can be run with very low operating cost. In his research on biogas energy, Walekhwa (2009) affirms that the adoption of biogas technology increases with the number of available cattle.

Human activities, as well as occupations in the workplace, need to be carried out in a way that is sustainable and environmentally friendly. There is a need to develop and adapt new ways of carrying out these activities so as to replace environmentally unfriendly alternatives and thereby creating a more sustainable society. This may include developing skills and promoting the study of technologies that lead to avoiding the use of irreplaceable raw materials, recycling waste, minimizing energy use, and avoiding pollution of the environment (UNESCO-UNEVOC, 2017). There is a need for launching of public awareness campaigns among local investors particularly small-scale entrepreneurs and end users of renewable energy technologies to highlight the importance and benefits of renewable sources of energy, particularly solar, wind, and biomass energies (Omer, 2017).

2.4.4 Raising end-users' level of awareness of electric energy saving measures

While one way of meeting the projected demand is through increased generation, extension of the grid, strengthening the grid to cope with increased generation, another very important way is to apply a parallel strategy of sensitizing end users to benefits of saving energy. According to Vikhorev (2012), the existing solutions for measurement, analysis and control of energy do not address all the requirements of energy management at the organization, factory or process level because they do not adequately address in a focused manner the workforce level of awareness of the energy used in their business. Electrical energy is wasted each day due to lack of awareness among societies and in fact, energy awareness is the first step to achieve energy sustainability. Without energy awareness, efforts to promote energy conservation can be difficult and lead to energy wastage. Public and private universities in Malaysia are confronting with issues of energy wastage due to the lack of awareness among the students and no specific model is available to guide facilities and energy managers to improve the situation (Choong, 2010). Meeting rooms, storage areas and corridors in particular are often lit unnecessarily, as there is often no one person responsible for them.

A significant part of electric energy consumption is due to an improper use of appliances and devices such as leaving them in a standby mode for many hours. To improve energy awareness level, there is a need to make public aware of information such as the monthly energy consumption and a bench marking measure for example kWh/m^2. Other good awareness measures include placing stickers on light switches to remind people to turn off lights when leaving an area and mounting posters that instruct computer users to implement power-saving features for monitors. The consumption of electricity in residential buildings is highly dependent on the behaviour of the residents. Whittle, (2013) propagates that the reason for high energy consumption in the university of Sheffield buildings was that the occupants cited a lack of awareness about the energy consumption of the building and a lack of personal control over and responsibility for energy conservation. In the past, education has played a role in bringing awareness regarding energy conservation and environmental issues, but has not necessarily resulted in sustained behavioural changes, for example, among students across university campuses (Emeakaroha, 2012)**.**

According to Khan *et al* (2015), energy saving or energy conservation through the change of human behaviour only, without any capital cost can be a great option to meet demand instead of increasing generation. However, because of unpredictable nature of human behaviour change long term individuals and organizational involvement is essential for energy efficiency achievement. Some people may claim to favour energy efficiency, but do not follow through when it comes to changing their own behaviours (U.S department of energy, 2007). Choong, (2007) asserts that although raising awareness is significant, most facility managers and operators still do not pay much attention to the benefits of raising energy awareness because they tend to be sceptical of behavioural approach and have little understanding of them and their potential. Energy management best practices are proven, non-technical techniques or methodologies revolving around behavioural change amongst staff arising from increased awareness, training, accountability and information systems. It is a fact that empowering the knowledge of staff contributes to sustainable energy savings (ESKOM, 2015)

Without energy awareness, effort to promote energy conservation can be difficult and lead to energy wastage (Choong, 2007). 46% of electricity in businesses is used outside the standard operating hours which could include leaving computer monitors on or vending machines keeping things unnecessarily at night (SME, 2015). If a piece of office equipment is not being used, there is no need to leave it on otherwise one would be paying for energy which is not being utilised.

2.4.5 A Framework for an Energy Efficiency Awareness Plan

The success of an energy efficiency initiative depends on people as much as or even more than technology. To maximize the energy savings potential in any premise an effort to raise the awareness of everyone involved should be made through an Energy Efficiency Awareness Program (energy innovators initiative, 2010). Fig 3 provides a comprehensive framework for implementing an awareness program. One can choose to follow the framework step-by-step or implement one on a smaller scale.

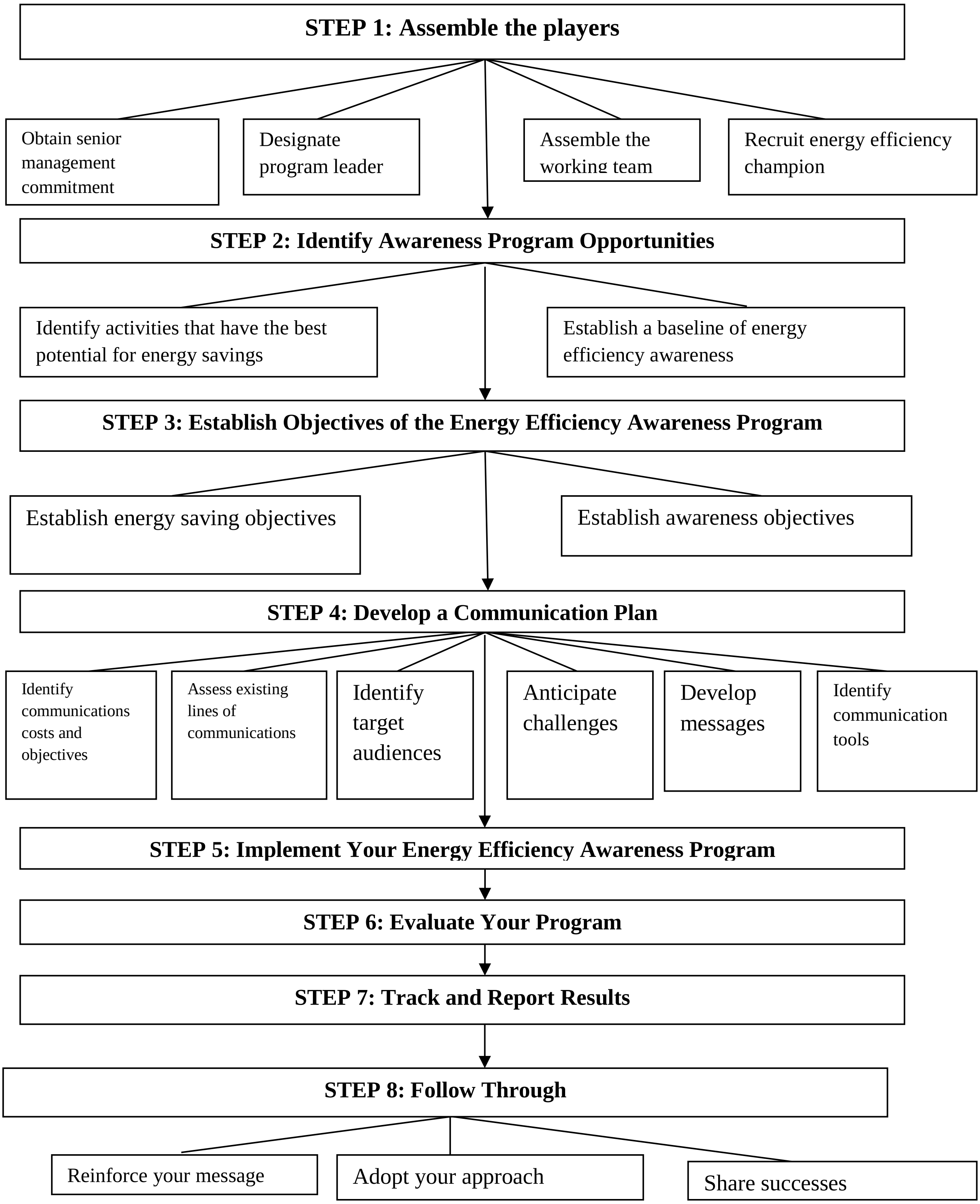

Figure 3: A framework for an energy efficiency awareness plan
(Source: Energy Innovators Initiative, 2010)

Step 1: Assemble the players

The overall success of the initiative depends on the cooperation, acceptance and involvement of everyone who uses the facilities. More importantly is to obtain commitment from senior management of the organization. A team composed of the key players is then organized and the team members are then assigned responsibilities for implementing the program. Recruiting a “champion” to represent the program is crucial to achieving the objectives. The champion should be someone who is enthusiastic and committed to ensuring that energy efficiency is a high-profile activity. The champion should be prepared to become the spokesperson for the program, someone who is recognized and publicly associated with energy initiatives in the organization and the community.

Step2: Identify awareness program opportunities

Knowing how and where energy is used and by whom makes it easier to focus on the activities that will generate the best results. Information about how the organization consumes energy establishes an energy consumption baseline for setting objectives for the program. It also helps establish some of the indicators against which the program can be evaluated. The success of the program is measured by how it facilitates energy reduction initiatives and by the increased level of energy efficiency awareness in the workplace. To evaluate the success at a later stage, one must determine a baseline of energy efficiency awareness before the program begins. To develop this baseline, distribute a brief questionnaire to determine the general level of knowledge of energy issues and efficiency measures within the organization.

Step 3: Establish objectives of the energy efficient awareness program

It is important that the program supports the energy savings objectives in the energy management plan. Specific objectives will vary depending on the size, type and location of the organization and a range of other variables. The Green Team, in conjunction with senior management, determines what constitutes realistic and obtainable goals. Establishing objectives that are too high can have a demoralizing effect if one cannot reach the targets. It is also important that the objectives are measurable. Setting a time frame for energy savings can make the objectives easier to evaluate.

Step 4: Develop a communication plan

A team comprising of employees who are experienced in communications should be formed to help in developing the plan. Buy-in should be encouraged by assigning specific tasks to team members and by ensuring that roles and responsibilities are understood and accepted by all.

Step 5: Implement your energy efficiency awareness program

After finalizing the communications plan, the next step is to get the message out. Implementing the program takes commitment, energy, time, enthusiasm and imagination. The program launch should be promoted at least two to four weeks in advance by using posters, newsletters and other communications tools. After determining the key messages, delivery tools, activities and events, detailed schedule for the timing and delivery must be developed. Interest should be built by organizing numerous activities over the course of a year. It is important to book a date for the program launch and to schedule reminders ahead of time.

Step 6: Evaluate your program

Evaluating the program against its original objectives will help determine if it is effective, identify what works and what does not work and find out which tools and activities best encourage changes in behaviour. Frequent evaluations throughout the roll-out of the program will provide the information needed to adapt the program and plan future activities to achieve the desired results.

Step 7: Track and report results

The evaluation of the program will provide data on the energy use patterns of the organization over time. It is important to illustrate the progress with easy-to-read bar graphs and pie charts and provide concrete examples. Reporting publicly on the progress of the program enhances its effectiveness. This makes the participants to know that their efforts really matter. It is worth determining whether additional employees want to become involved in the Green Team initiatives, and what suggestions and comments they may have on the program.

Step 8: Follow through

Building awareness is an ongoing work. To maintain interest in the program, there is need to reinforce the Green Team's messaging by providing regular updates to the staff and other users through newsletter articles, displays and management meetings. These updates will sustain the momentum of the program, reinforce new behaviours and lead to the continuous improvement of the overall program. Throughout the implementation, the team will adapt elements of the program to respond to the organization's changing needs. As the awareness level changes, so should the messaging. One should learn from experience and adapt the program as he or she goes. Information from the evaluations and observations should be used to redirect the program.

Internal and external audiences should be provided with an update of the success of the program and celebrate the team's achievements and recognize the important role that the employees and other users have played in reducing energy use.

Energy is wasted each day due to lack of awareness among societies and behavioural approach requires changes in human attitudes by using motivation, raising awareness and skill developing (Choong, 2007). Many organizations hire energy consultants or other professionals to help them reduce energy consumption and costs. Energy consultants can provide a full range of services, including help in implementing an awareness campaign. One should familiarize himself with the various steps identified in the framework of figure 3 and create a schedule to map out the awareness program. The time required for each step will vary according to: the size of the organization; the number of employees and/or building users; building use and hours of operation; and the scale and complexity of the program. The schedule should be flexible to accommodate changing circumstances.

As from the above discussion, raising awareness of end-users is so significant in reducing energy consumption. However, most managers still do not pay much attention to the benefits of raising energy awareness. This is because facility managers and plant operators tend to be sceptical of behavioural approach and have little understanding of them and their potential (Choong, 2007). It is easier to change a participant's knowledge about energy and conservation than it is to change their attitudes. For instance, although many smokers are aware that smoking is harmful to their health, they still continue to smoke. In the similar circumstance, those who aware the importance of energy conservation and understand the energy conservation technique may not practice them.

2.4.6 Summary of chapter two

Electric energy frees large amounts of time and labour and promotes better health and education, however, the present day supply of electricity is not able to meet the emerging demands. Institutions of higher learning all over the world are now engaged in energy saving because they are the most affected group whenever there is shortage of it. Between 45% and 61% of electrical energy could be saved by using daylight sensors depending on room orientation and location.By replacing fluorescent tubes with LED tubes, up to 70% of electric energy could be saved and the current development shows a tremendous improvement in LED lighting performance and at the same time reduction in their development cost. When electric power equipment needs to be replaced, the energy efficiency type should be purchased. The more energy efficient products, however, are likely to cost more but this will be outweighed by the savings made in lifetime running costs. To meet future energy demands efficiently, energy security and reliability must be improved and alternative energy sources (solar, wind and biogas) need to be made use of. Electrical energy is wasted each day due to lack of awareness among societies and efforts to promote energy conservation can be difficult if the level of awareness is not raised.

The literature reviewed in this study showed that higher institutions of learning consumed a large amount of energy due the nature of their daily activities and that they were the most affected consumers whenever there was a shortage of it. The literature also revealed that a substantial amount of electric energy could be saved through the use of technologies and change in behaviour of the end-users. Through an extensive literature reading, it became clear that the studies that had been done in the area of energy saving did not address in a focussed manner the amount of energy that could be saved in higher institutions of learning through the use of the available energy- efficient methods.. This study therefore sought to address this gap by determining the potential for saving electric energy in Kenyan universities using technological and behavioural techniques.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter details the research methods and procedures that were used in this study. It covers research approach, research philosophy, research design, study area, population and sample, sampling procedures, research instruments, validity and reliability of research instruments, data collection procedures, data analysis techniques and ethical considerations.

3.1 Research approach

This study employed the convergent parallel mixed method research approach which makes use of the qualitative and quantitative approaches at the same time while valuing both equally so that the topic can be illuminated from both sides (DePoy, 1993). In a convergent parallel mixed method the researcher merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem. In this design, the investigator typically collects both forms of data at roughly the same time and then integrates the information in the interpretation of the overall results (Creswell, 2014).

Qualitative research explores attitudes, behaviour and experiences through such methods as interviews or focus groups. It attempts to get an in-depth opinion from participants. As it is attitudes, behaviour and experiences which are important, fewer people take part in the research, but the contact with these people tends to last a lot longer (Dawson, 2002). It is a research that involves the study of things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them (Denzin, 1994). Qualitative research investigates questions without statistical tools, relying instead on the ability of the researcher to observe patterns (Kalof et al., 2008).

Quantitative research, on the other hand, is a means for testing objective theories by examining the relationship among variables. These variables in turn can be measured on instruments so that numbered data can be analysed using statistical procedures (Creswell, 2009). It is a research which is concerned with quantities and measurements (Biggam, 2008). It generates statistics through the use of large-scale survey research, using methods such as questionnaires or structured interviews (Dawson, 2002). Quantitative research uses statistical tools to aid in the interpretation of data (Kalof, 2008).

Sometimes researchers employ two methodologies which have their roots in distinctively different views of the world so as to gain a variety of information, illuminate a particular problem from different angles, or look at different aspects of a phenomenon (Denzin, 1994). This study therefore used the convergent parallel mixed method research approach because the data obtained from the closed-ended responses found in questionnaires and observation schedule were quantitative in nature and were analysed using statistical procedures. The data obtained from interviews and those from the open-ended responses in questionnaires were qualitative in nature and were analysed thematically. Both these data were being collected concurrently.

3.2 Research philosophy

A research design involves the intersection of philosophy, strategies of inquiry, and specific methods (Creswell, 2009). The research philosophy adopted contains important assumptions about the way in which one views the world. These assumptions will underpin the research strategy and the methods chosen as part of that strategy (Sanders, 2009). This study adopted pragmatism research philosophy which is a world view that arises out of actions, situations and consequences (Creswell, 2009). Pragmatism is not committed to any one system of philosophy and reality and in fact Pragmatists do not see the world as an absolute unity and they agree that research always occurs in social, historical, political, and other contexts. This gives researchers freedom to choose the methods, techniques, and procedures of research that best meet their needs and purposes. For pragmatism, both specific beliefs and general methods of inquiry should be judged by their consequences and by their usefulness in achieving human goals (Geofrey-Smith, 2015). Pragmatists stress the role of knowledge in guiding action and solving practical problems. A pragmatist stance requires us to reflect on our own aspirations as researchers and the various objectives or interests that knowledge may bring about, and not accept the primacy of one of them. At the core of pragmatist thought is the view that our theories must be linked to experience or practice (Rylander, 2012).

Whereas a positivist holds that reality is objective and independent of the observer and so can be measured and predicted and that it is not influenced by the unpredictable behaviour of human beings (Biggam, 2008) on one hand, and that constructivist (or interpretivist) on the other hand, believes that there are many, equally valid interpretations of reality and that these interpretations are dependent on when they are made and the context in which they are made, a pragmatist argues that the most important determinant of the epistemology and ontology adopted is the research question. A pragmatist's view works with variations in the epistemology, ontology and axiology if a research question does not suggest clearly whether a positivist or constructivist philosophy is adopted (Saunders, 2009).

According to Creswell (2014) pragmatism applies well to mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions when they engage in their research. Mixed methods researchers look to many approaches for collecting and analyzing data rather than subscribing to only one way such as quantitative or qualitative approaches. Thus, for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis. Pragmatic world view was chosen because of the mixed method approach which was adopted in this study.

3.3 Research design

The survey research design was used in this study. A research design is the plan and procedures for research that span the decisions from assumptions to detailed methods of data collection and analysis (Creswell, 2009). A survey is a method of obtaining large amounts of data, usually in a statistical form, from a large number of people in a relatively short time. It usually takes the form of a self-completion questionnaire or interview schedule. It is regarded as highly reliable because it can be easily replicated and the quantifiable data can be verified by others. It is a representative selection from the population of a particular type (Biggam, 2008). It aims to be explanatory or descriptive or both (Mcneill et al., 2005).

Generally, a survey is a means for measuring demographic characteristics and aggregate attitudes and opinions in many societies and sub-societies around the world. It does this in a systematic way: sampling a population and then using a standardized measurement in order to estimate various characteristics of it (Drew, 2006). A survey research provides a quantitative description of trends, attitudes, or opinions of population by studying a sample of that population. It includes cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection, with the intent of generalising from a sample to a population (Babbie, 1990 as quoted in Creswell, 2009).

A survey research gives a numeric description of attitudes, trends and opinions of a population by studying a sample of that population. Surveys are popular as they allow the collection of a large amount of data from a sizeable population in a highly economical way. Often obtained by using a questionnaire administered to a sample, these data are standardised, allowing easy comparison (Saunders, 2009). This study therefore adopted a survey research design because data was obtained from an observation schedule and a sample of university students, staff and administrators through questionnaires and face-to-face interviews. Findings that were a representative of the whole university population were generated.

3.4 The study area

This study was carried out in public and private universities in Nairobi, Uasin Gishu and Nandi counties of Kenya. Purposive sampling technique was used to select one private and two public universities to participate in the study. The selection was based on the years of existence, the population, types of programmes offered and the set up of the university. The study was concerned with university electric loads that consumed a larger percentage of energy which included lighting, office equipment and production and process equipment. It was therefore necessary to purposively select universities offering academic programmes that include engineering courses so as to determine the potential for saving electric energy of the power equipment in the workshops and laboratories. The selected university in Nairobi County represented public universities offering engineering courses and are in urban setting, while that in Uasin Gishu County represented public universities offering engineering courses and were in rural setting. The selected university in Nandi County represented private universities offering engineering courses. It was therefore hoped that the selected universities were representative enough for the findings to be generalised to the entire Kenyan universities.

3.5 The study population

The target population was all the public and private universities in Kenya. There are 63 universities in Kenya, 33 of which are public and 30 private (KUCCPS, 2016) with a total population of 446,183 students, 400,218 of which are in public and 45,965 in private universities (KNBS, 2015). Out of these 63 universities, one private and two public universities were purposively sampled to participate in this study. The sample population was therefore drawn from the three universities.

3.6 Sampling procedures and sample size

Purposive sampling procedure was used to select one private university (Z) and two public universities (X and Y) out of 63 universities in Kenya to take part in the study. The selection was guided by the objectives of the study, accessibility, diversity of programmes offered and the set up of the institution. All the selected universities offered engineering and technology courses and hence had the production and process equipment which was a major component of this research. Krejcie and Morgan table (1970) was used to determine the sample size for students and staff from the three selected universities who participated in the research. Students from different departments and staff working in different sections in the universities participated in this study. Some university administrators, who were in charge of the relevant sections, were interviewed concerning energy saving measures in the universities. Simple random sampling technique was used in the selection of students and staff who took part in the research.

3.7 Research instruments

Two types of questionnaires were used, one for the university staff and another for the university students. Each of them aimed at collecting data concerning the electricity user behaviour of both university students and staff. The questionnaires were a combination of both closed-ended and open-ended types. Closed-ended questionnaires are generally used to generate statistics in quantitative research while open-ended questionnaires are for qualitative research, although some researchers will quantify the answers during the analysis stage (Dawson, 2002). The fundamental rule is that every respondent needs to understand what is required in the precise sense that the researcher meant it. Normally a pilot run is used to show or confirm this fact (Swetnam, 2007).

Structured interviews schedule were conducted among selected students, staff and administrators of each university. These interviews focussed on the level of awareness of electrical energy saving measures in the universities. Interviewing is a method of collecting data that can stand on its own or be a follow-up process to another method.

Interviews should never be random as they demand a heavy investment of time (Swetnam, 2007). In these interviews, the researcher attempted to achieve a holistic understanding of the interviewees' point of view or situation as suggested by Dawson (2002).

Observation check- list was used to collect data on the types and ratings of electric loads in universities which included: Lamps, office equipment, laboratory and workshop equipment, kitchen equipment and unauthorised loads. The same instrument was also used to establish the types of alternative (green) energy sources as well as the electricity user behaviour in the universities.

3.8 Validity and Reliability of research instruments

3.8.1 Reliability of the research instruments

Reliability is the extent to which measurements are repeatable when different persons perform the measurements, on different occasions, under different conditions, with supposedly alternative instruments which measure the same thing (Drost, 2008). It refers to the extent to which data collection techniques or analysis procedures will yield consistent findings (Saunders, 2009). The questionnaires used in this study were tested for reliability. This was done by carrying out a pilot study on respondents who would not participate in the final study but had the same characteristics as the real research respondents. In the pilot study, a test-retest technique was used to establish the reliability of the questionnaires. Test-retest reliability involves calculating a reliability estimate by administering a test on two occasions and calculating the correlation between the two sets of scores (Brown 2002).

Questionnaires were presented to a group of respondents in one university and were allowed to respond and afterwards the completed questionnaires were collected and analysed. After two weeks, the same questionnaires were presented the second time to same group of respondents. The results were again analysed and was then compared to first results. A coefficient of correlation was calculated at the level of 0.5 using the statistical package for the social sciences (SPSS, version 21) computer program. The reliability coefficient was found to be 0.72 which indicated that the research instruments were reliable enough to be used for data collection.

3.8.2 Validity of research instruments

Validity is often as the extent to which an instrument measures what it purports to measure (Kerlinger, 1973). Validity requires that an instrument is reliable, but an instrument can be reliable without being valid (Kimberlin, 2008). Construct validity is judgment based on the accumulation of evidence from numerous studies using a specific measuring instrument. Content validity is a type of validity that addresses how well the items developed to operationalize a construct provide an adequate and representative sample of all the items that might measure the construct of interest. Criterion-related validity is a type of which provides evidence about how well scores on the new measure correlate with other measures of the same construct or very similar underlying constructs that theoretically should be related. It is crucial that these criterion measures are valid themselves.

Validity is the degree to which results obtained from the analysis of the data actually represent the phenomenon and the variables of the study. This therefore means that the items in the instruments should arise from the objectives of the study. According to Kimberlin (2008) there is no statistical test to determine whether a measure adequately covers a content area or adequately represents a construct and therefore content validity of research instruments usually depends on the judgment of experts in the field. In this study therefore, supervisors and other professionals who have a sound knowledge of the subject matter looked at the questionnaires, interview schedule and observation check-list before administering them to the respondents.

3.9 Data collection procedures

The researcher obtained a letter of introduction from the department of Technology education, University of Eldoret and used it to seek a research permit from the National Council of Science, Technology and Innovation (NACOSTI) before proceeding to collect data. A letter of authorization to carry out research in each of the selected university was also sought before embarking on the research.

Quantitative data concerning electrical energy consumption and energy saving measures was obtained from observation checklist and the structured questionnaires given to both staff and students in each of the universities involved in the research. On the other hand, the qualitative data concerning the electrical energy users' level of awareness of energy saving measures were obtained from structured interviews administered to students, staff and administrators. The observation check-list was used to obtain data concerning energy consumption of heating equipment, lighting fixtures and illumination levels, offices and process and production equipment in each of the universities.

3.10 Data analysis techniques

The data collected using questionnaires and some from the observation check-list was quantitative while the data collected using interviews and some from observation check-list was qualitative. The researcher was interested in collecting in-depth data and therefore undertook intensive interviews among the students, staff and administrators in each of the institutions. The qualitative data was analysed thematically. Themes refer to topics or major subjects that come up in discussions. This form of analysis categorizes related topics and by using it, major concepts or themes are identified (Kombo, 2009). The researcher went through the collected data and identified information that was relevant to the research questions and objectives; classified major issues; highlighted key quotations; placed the data under the major themes identified and lastly used descriptions and direct quotations to present the findings.

The first step in quantitative data analysis is to describe or summarize the data using descriptive statistics. The purpose of descriptive statistics is to enable the researcher to meaningfully describe a distribution of scores or measurements using a few indices or statistics (Mugenda, 1999). Answers to the questionnaires were analyzed using descriptive statistics and the computer program known as Statistical Package for Social Sciences (SPSS) and frequency and percentage tables were used to present the results. On the other hand, the data collected through observation check-list were analysed using the Microsoft office Excel computer program and values and percentages were used to present the results of the research.

3.11 Ethical consideration

The researcher firstly sought authority from National commission for science, Technology and Innovation (NACOSTI) before embarking on the research. Since this study required the participation of human respondents, certain ethical issues were addressed. This ensured the privacy and the integrity of the participants was taken care of. Some of the ethical issues included consent and confidentiality. To secure the consent of the participants, all important details of the study including its aim and purpose were exposed. The researcher made sure that the respondents comprehended the purpose of the study and gave them the opportunity to decline participation if they had any reservations. The confidentiality of the participant on the other hand, was guaranteed by not disclosing the name or personal information in the research. The respondents had the freedom to ignore items that they did not wish to respond to.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents the analysis and interpretation of data. It deals with observation checklist, university student and staff questionnaires, interviews for university staff, students and administrators.

4.2 Analysis of the observation checklist

To obtain more information on the use of electric energy consumption in the universities, observation method was used. Workshops, laboratories, hostels, offices and libraries were visited to ascertain the types and ratings of electric equipment and devices in each of these premises. This was an important move because it would identify those equipment and devices that needed replacement with more energy efficient types and therefore leading to electric energy saving which was the core business of this research.

4.2.1 Lighting loads at Universities in Kenya

Table 1: T8 linear fluorescent lamps replacement

The table below shows the ratings of LED lamps that can replace the linear fluorescent lamps.

T8 LINEAR FLUORESCENT LAMP	T8 LINEAR LED LAMP
18 W	10 W
36 W	18 W
58 W	25W

According to ELEDLIGHTS.com (2017), GOODLIGHT (2017) and MAXLITE (2017), linear T8 LED tubes can replace T8 linear fluorescent lamps as shown in table 1

Table 2: Energy saved by replacing the lighting loads in University X

The table below shows the energy that would be saved by replacing the existing fluorescent lighting loads in university X by LED lamps

Loads	Qty	Rating (kw)	Total power (kw)	Energy consumed /year (kwh)	T8 LED tube Replacement (kw)	Total power (kw)	Energy consumed /year (kwh)	Energy saved/ year (kwh)
T8 Fluorescent lamp (2ft)	5575	0.016	89.2	335347.4	0.01	55.75	209592.13	125755.27
T8 Fluorescent lamp (4ft)	5160	0.032	165.1	620768.64	0.018	92.88	349182.36	271586.28
T8 Fluorescent lamp (5ft)	2680	0.051	136.7	513848.46	0.025	67	251886.5	261961.96
TOTAL	13415	0.099	391	1469964.5	0.053	215.63	810661	659303.51 (44.9%)

The calculation in the table 2 was based on the following:

(a) Approximate time of usage per day: Lecture rooms = 12 hours, Offices = 9 hours, Library = 13 hours, Administration block = 9 hours, Labs and workshops = 9 hours and Students' hostels = 10 hours

Thus the average time of usage per day $= \frac{12+9+13+9+9+10}{6} = 10.3$ hours

Hence the number of hours in a year = 365 x 10.3 = 3759.5 hours

(b) Ballast factor: A normal ballast factor of 0.88 (Regency lighting, 2016) was used to calculate the total system wattage of T8 linear fluorescent lamps.

From table 2, a total of 659303.51 kWh (44.9%) of energy could be saved every year by replacing all T8 linear fluorescent lamps in the university with T8 linear LED lamps. The unit cost of electric energy for a commercial industrial one (CI1) consumer such as universities is Ksh. 9.20 (KPLC, 2017). Therefore the energy saved would translate to saving an amount of ksh (9.20x 659303.5) = Ksh. 6065592.20 per annum.

Suppose the existing T8 linear fluorescent lamps were not replaced and daylight sensors were installed in the university instead, how much electric energy would be saved from the lighting loads? Almost all the lamps in offices, laboratories, workshops, hostels and library were being left on throughout the day and therefore if daylight sensors were installed in these areas, lamps would be on in a day for about:4 hours in lecture halls, 2 hours in offices, 2 hours in administration block, 2 hour in laboratories and workshops, 5 hours in library and 6 hours in hostels. Lamps would therefore be on for an average of $\frac{4+2+2+2+5+6}{6} = 3.5$ hours per day. Hence in a year it will be 3.5 x 365 = 1277.5 hours. The energy saved would then be as shown in table 3

Table 3: Energy saved by using daylight sensors in university X

The table below shows the amount and percentage of electric energy that would be saved in university X by not replacing fluorescent lamps but installing daylight sensors in buildings instead

Loads	Quantity	Rating (kw)	Total (kw)	Energy consumed/ year (kwh)	Energy consumed /year (kwh) with day light sensors installed	Energy saved/ year (kwh)
T8 Fluorescent lamp (2ft)	5575	0.016	89.20	335347.40	113953	221394.40
T8 Fluorescent lamp (4ft)	5160	0.032	165.12	620768.64	210940.8	409827.84
T8 Fluorescent lamp (5ft)	2680	0.051	136.68	513848.46	174608.7	339239.76
TOTAL	13415	0.099	391	1469964.5	499503	970462 (66%)

From table 3, the energy saved in a year would be 970462 kWh (66%) which in terms of cost translates to Ksh. (970462 x 9.20) = Ksh. 8928250.40

Now suppose the T8 fluorescent lamps were replaced by the T8 LED lamps and at the same time the daylight sensors were installed in the university. How much electrical energy would then be saved? Table 4.4 shows the results.

Table 4: Energy saved by replacing T8 fluorescents lamps with T8 LED lamps and installing daylight sensors in university X

The table below shows the electric energy that would be saved in university X by replacing fluorescent lamps with LED lamps and at the same time installing daylight sensors in buildings

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed/year (kwh)	T8 LED tube replacement (kw)	Total (kw)	Energy consumed /year (kwh) with daylight sensors	Energy saved/ year (kwh)
T8 Fluorescent lamp (2ft)	5575	0.016	89.2	335347.4	0.01	55.75	71220.63	264126.78
T8 Fluorescent lamp (4ft)	5160	0.032	165.12	620768.6	0.018	92.88	118654.2	502114.44
T8 Fluorescent lamp (5ft)	2680	0.051	136.68	513848.5	0.025	67	85592.5	428255.96
TOTAL	13415	0.099	391	1469964.45	0.053	215.63	275467.33	1194497.18 (81.3%)

The energy saved as shown in table 4 would be 1194497.18kWh (81.3%) per year which translates to ksh (1194497.18 x 9.20) = Ksh. 10989374.10

The results shown above indicate that the highest amount (81.3%) of electric energy that could be saved in university X would be achieved by replacing T8 fluorescent lamps with T8 LED tubes and installing daylight sensors at the same time in university buildings. There is also a clear indication that more electric energy (66%) could be saved by installing daylight sensors than by replacing fluorescent lamps with LED lamps which would achieve (44.9%) of electric energy saving.

Table 5: Energy saved by replacing the lighting loads in University Y

The table below shows the amount of electric energy that would be saved in university Y by replacing fluorescent lamps with LED types.

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed /year (kwh)	T8 LED tube replacement (kw)	Total (kw)	Energy consumed /year (kwh)	Energy saved (kwh)
T8 Fluorescent lamp (4ft)	363	0.032	11.616	45578.28	0.018	6.53	25622.09	19956.19
T8 Fluorescent lamp (5ft)	232	0.051	11.832	46425.81	0.025	5.8	22757.75	23668.06
TOTAL	595	0.083	23.448	92004.1	0.043	12.33	48379.8	43624.3 (47.4%)

The calculation in the table 5 was based on the following:

(a) Time of usage per day: Lecture rooms = 12 hrs, Offices = 9 hrs, Library = 13 hrs, Labs and workshops = 9 hrs

Thus the average time of usage per day $= \frac{12+9+13+9}{4} = 10.75 hrs$

Number of hours in a year = 365 x 10.75 = 3923.75 hrs

(b) Ballast factor: A ballast factor of 0.88 was used to calculate the total system wattage of T8 fluorescent lamps.

From table 5, it is seen that 43624.3 kWh (47.42%) could be saved every year by replacing all linear T8 fluorescent lamps in the University with linear T8 LED lamps.

Taking the unit cost of electricity to be Ksh 9.20/kWh, this translates to saving Ksh (9.20 x 43624.3) = Ksh. 401343.60

Suppose the existing T8 linear fluorescent lamps were not replaced and daylight sensors were installed in university Y how much electrical energy would be saved from the lighting loads? Almost all the lamps in lecture halls, offices, laboratories, workshops and library were being left on throughout the day and therefore if daylight sensors were installed in these areas, the lamps would be on in a day for about: 4 hours in lecture halls, 2 hour in offices, 2 hour in laboratories and workshops and 5 hours in the library. Lamps would therefore be on for an average of $\frac{4+2+2+5}{4} = 3.25$ hours per day. The energy that would be saved is as shown in table 6.

Table 6: Energy saved by using daylight sensors in university Y

The table below shows the amount of electric energy that would be saved in university Y by not replacing fluorescent lamps but installing daylight sensors instead

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed /year (kwh)	Energy consumed /year (kwh) with day light sensors installed	Energy saved/ year (kwh)
T8 Fluorescent lamp (4ft)	363	0.032	11.616	45578.28	13779.48	31798.8
T8 Fluorescent lamp (5ft)	232	0.051	11.832	46425.81	14035.71	32390.1
TOTAL	595	0.083	23.448	92004.1	27815.2	64188.9 (69.8%)

From table 6 it can be deduced that the electric energy that would be saved in a year is 64188.9 kWh (69.8%). This translates to ksh. (64188.9 x 9.20) = ksh. 590537.90

Now suppose the linear T8 fluorescent lamps were replaced by the T8 LED lamps and at the same time the daylight sensors were installed in the university. How much electric energy would then be saved? Table 7 shows the results.

Table 7: Energy saved by replacing T8 fluorescents lamps with T8 LED lamps and installing daylight sensors in university Y

The table below shows the amount of electric energy that would be saved in university Y by using both daylight sensors and replacement of fluorescent lamps

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed /year (kwh)	T8 LED tube replacement (kw)	Total (kw)	Energy consumed /year (kwh) with daylight sensors	Energy saved/ year (kwh)
T8 Fluorescent lamp (4ft)	363	0.032	11.616	45578.28	0.018	6.53	7746.213	37832.068
T8 Fluorescent lamp (5ft)	232	0.051	11.832	46425.81	0.025	5.8	6880.25	39545.56
TOTAL	595	0.083	23.448	92004.1	0.043	12.33	14626.5	77377.63 (84.1%)

The energy saved would then be 77377.63kWh (84.1%) per year as shown in table 7. In terms of amount of money saved, it would be ksh (77377.63 x 9.20) = Ksh. 711874.20.

It is a clear indication from the results shown above that the highest amount (84.1%) of electric energy that could be saved in university Y would be achieved by replacing T8 fluorescent lamps with T8 LED tubes and installing daylight sensors at the same time in university buildings. The results also revealed that more electric energy (69.8%) could be saved by installing daylight sensors rather than replacing fluorescent lamps with LED lamps which would achieve (47.42%) of electric energy saving.

Table 8: Energy saved by replacing the lighting loads in University Z

The table below shows the amount of electric energy that would be saved in university Z by replacing the fluorescent lamps with LED lamps.

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed /year (kwh)	T8 LED tube replacement (kw)	Total (kw)	Energy consumed /year (kwh)	Energy saved (kwh)
T8 Fluorescent lamp (2ft)	254	0.016	4.064	15278.61	0.01	2.54	9549.13	5729.478
T8 Fluorescent lamp (4ft)	1541	0.032	49.312	185388.5	0.018	27.738	104281	81107.45
T8 Fluorescent lamp (5ft)	129	0.051	6.579	24733.75	0.025	3.225	12124.39	12609.36
TOTAL	1924	0.099	59.96	225401	0.053	33.50	125955	99446.3 (44.1%)

The calculation in the table 8 was based on the following:

(a) Time of usage per day: Lecture rooms = 12 hrs, Offices = 9 hrs, Library = 13 hrs, Administration block = 9 hrs, Labs and workshops = 9 hrs and Students' hostels = 10 hrs

Thus the average time of usage per day $= \frac{12+9+13+9+9+10}{6} = 10.3$ hours

Number of hours in a year = 365 x 10.3 = 3759.5 hrs

(b) Ballast factor: A ballast factor of 0.88 was used to calculate the total system wattage of T8 fluorescent lamps.

Table 8, indicates that 99446.3 kWh (44.1%) of electric energy can be saved every year by replacing all linear T8 fluorescent lamps in the university with linear T8 LED lamps. Taking the unit cost of electricity to be Ksh 9.20/kWh, this translates to saving Ksh (9.20 x 99446.3) = Ksh. 914906

Suppose the existing lamps were not replaced and daylight sensors were installed in the university how much electrical energy would be saved from the lighting loads? Almost all the lamps in offices, laboratories, workshops, hostels and library are on throughout the day and therefore if daylight sensors were installed in these areas lamps would be on in a day for about: 4 hours in lecture halls, 2 hour in offices, 2 hour in administration block, 2 hour in laboratories and workshops, 5 hours in library and 6 hours in hostels. Lamps would therefore be on for an average of $\frac{4+2+2+2+5+6}{6} = 3.5$ hours per day. Hence in a year it will be 3.5 x 365 = 1277.5 hours. The energy saved would then be as shown in table 9.

Table 9: Energy saved by using daylight sensors in university Z

The table below shows the amount of electric energy that would be saved in university Z by replacing fluorescent lamps with LED types.

Loads	**Qty**	**Rating (kw)**	**Total (kw)**	**Energy consumed/year (kwh)**	**Energy consumed /year (kwh) with day light sensors installed**	**Energy saved/ year (kwh)**
T8 Fluorescent lamp (2ft)	254	0.016	4.064	15278.61	5191.76	10086.85
T8 Fluorescent lamp (4ft)	1541	0.032	49.312	185388.5	62996.08	122392.42
T8 Fluorescent lamp (5ft)	129	0.051	6.579	24733.75	8404.673	16329.0775
TOTAL	1924	0.099	59.955	225401	76592.5	148808.35 (66%)

The electric energy that could be saved is 148808.35 kWh (66%) per year as shown in table 9. This energy translates to ksh (148808.35 x 9.20) = Ksh. 1369036.80

Now suppose the T8 fluorescent lamps were replaced by the T8 LED lamps and at the same time the daylight sensors were installed in the university. How much electrical energy would then be saved? Table 4.10 shows the results.

Table 10: Energy saved by replacing T8 fluorescents lamps with T8 LED lamps and installing daylight sensors in university Z

The table below shows the amount of electric energy that would be saved in university Z by using both daylight sensors and replacement of fluorescent lamps

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed/year (kwh)	T8 LED tube replacement (kw)	Total (kw)	Energy consumed /year (kwh) with daylight sensors	Energy saved/year (kwh)
T8 Fluorescent lamp (2ft)	254	0.016	4.064	15278.61	0.01	2.54	3244.85	12033.76
T8 Fluorescent lamp (4ft)	1541	0.032	49.312	185388.5	0.018	27.738	35435.3	149953.2
T8 Fluorescent lamp (5ft)	129	0.051	6.579	24733.75	0.025	3.225	4119.938	20613.81
TOTAL	1924	0.099	59.955	225401	0.053	33.503	42800.1	182600.78 (81%)

From the results shown in table 10 the amount of electric energy saved would be 182600.78kWh (81%) per year which translates to ksh (182600.78 x 9.20) = Ksh. 1679927.20

The results depicted that the largest amount (81%) of electric energy that could be saved in university Z would be obtained installing daylight sensors and replacing T8 fluorescent lamps with T8 LED tubes The results also revealed that more electric energy (66%) could be saved by installing daylight sensors rather than replacing fluorescent lamps with LED lamps which would achieve (44.1%) of electric energy saving.

Table 11: Average electric energy that would be saved in the universities

The table below shows the average amount of electric energy that would be saved in the university X, Y and Z

Electric Energy in kWh saved by:	University			Average
	X	Y	Z	
Replacing T8 fluorescent lamps with T8 LED lamps	659303.51 (44.9%)	43624.3 (47.4%)	99446.3 (44.1%)	267458.04 (45.5%)
Installing daylight sensors	970462 (66%)	64188.9 (69.8%)	148808.35 (66%)	394486.42 (67.3%)
Replacing T8 fluorescent lamps and installing daylight sensors	1194497.2 (81.3%)	77377.63 (84.1%)	182600.78 (81%)	484825.2 (82.1%)

Table 11 shows that an average of 45.5% of electric energy could be saved by replacing fluorescent lamps with LED lamps, while 67.3% could be saved by using daylight sensors alone and the highest amount of electric energy (82.1%) could be saved in universities by replacing T8 fluorescent lamps with LED lamps and installing daylight sensors. It is therefore clear that more electric energy could be saved by installing daylight sensors than by replacing fluorescent lamps with LED lamps.

4.2.2 Production and processing loads at Universities in Kenya

Some production and processing equipment in the university workshops were found to be energy inefficient compared to the modern types manufactured by reputable companies like the Bhavya machine tools of India and the Dalian machine tools group corporation of China among others. These companies mainly deal in high quality Workshop Machineries, Sheet Metal Machines, Wood Working Machines, Automobile & Garage Machines, Plastic & Printing Machines, Welding Machines, Food Processing Machines as well as Special Purpose Machines. They have been innovating, reacting and embracing new technologies, changing developing mode, and carrying out large-scale technical reform. All of these have not only improved the numerical control technology, flexible manufacturing technology, and automatic detection technology; but also elevated the level of its design and manufacturing of high-speed CNC machine tools, high-speed machining centres, flexible production lines, and CNC function components (Dalian machine tools, 2017).

Calculations were therefore done on the basis of the difference in electric power rating of the existing production and processing equipment in the university and the energy efficient types that could do more or less the same job. Some of the equipment, however, were found to be the most efficient available and therefore there would be no energy saved and hence needless to replacement them.

Table 12: Production and processing loads in university X

The table below shows the amount of electric energy that would be saved in university X by replacing the old and poorly maintained power equipment with energy-efficient types.

Loads	**Qty**	**Rating (kw)**	**Total (kw)**	**Energy consumed/year (kwh)**	**Alternative rating (kw)**	**Total (kw)**	**Energy consumed/year (kwh)**	**Energy saved (kwh)**
Bench grinder	1	0.48	0.48	262.8	0.48	0.48	262.8	0
Bench drilling press	1	0.65	0.65	355.88	0.65	0.65	355.88	0
Lathe machine	2	6	12	6570	3.7	7.4	2025.75	4544.25
Lathe machine	1	2	2	2920	1.5	1.5	2190	730
Lathe machine	5	0.75	3.75	2053.13	0.75	3.75	2053.13	0
Shaper machine	1	5.5	5.5	3011.25	3.7	3.7	2025.75	985.5
Shaper machine	1	2.2	2.2	1204.5	1.5	1.5	821.25	383.25
Grinding machine	1	3	3	1642.5	1.1	1.1	602.25	1040.25
Milling machine	1	3	3	1642.5	3	3	1642.5	0
Pillar drilling machine	1	0.7	0.7	383.25	0.7	0.7	383.25	0
Power saw	1	3.3	3.3	1806.75	1.5	1.5	821.25	985.5
Cut-Off machine	1	2	2	1095	0.75	0.75	410.63	684.37
Welding machine	2	16	32	17520	13.5	27	14782.5	2737.5
Welding machine	3	4	12	6570	4	12	6570	0
Gullitine machine	1	5.5	5.5	3011.25	5.5	5.5	3011.25	0
Rolling machine	1	1.1	1.1	602.25	1.1	1.1	602.25	0
Spot welder	1	23	23	12592.5	17	17	9307.5	3285
Compressor	2	1.9	3.8	2080.5	1.5	3	1642.5	438
3-Phase measurement panel	1	1.3	1.3	711.75	1.3	1.3	711.75	0
Transformer trainer	1	0.57	0.57	312.08	0.5	0.5	273.75	38.33
3-phase supply panel	1	0.14	0.14	76.65	0.14	0.14	76.65	0
3-phase RLC load panel	1	1.5	1.5	821.25	1.5	1.5	821.25	0

D.C shunt Motor	1	0.25	0.25	136.88	0.25	0.25	136.88	0
Machine control panel	2	0.64	1.28	700.8	0.64	1.28	700.8	0
AC/DC motor	2	0.26	0.52	284.7	0.26	0.52	284.7	0
Cathode Ray Oscilloscope	2	0.04	0.08	43.8	0.04	0.08	43.8	0
Synchronous motor/Generator	1	2	2	1095	2	2	1095	0
Spectrophotometer	1	0.33	0.33	180.68	0.33	0.33	180.68	0
Incubator	1	2	2	17520	1.8	1.8	15768	1752
Digester	1	0.5	0.5	273.75	0.5	0.5	273.75	0
Water bath	1	0.16	0.16	87.6	0.16	0.16	87.6	0
Refrigerator	2	0.11	0.22	1927.2	0.11	0.22	1927.2	0
Multi-stirer	1	0.18	0.18	98.55	0.18	0.18	98.55	0
Water heater	1	2.4	2.4	1314	1.05	1.05	574.88	739.12
Sterilizer	1	2	2	1095	2	2	1095	0
Sediment transport	1	0.4	0.4	219	0.4	0.4	219	0
Tilting flume	1	2.5	2.5	1368.75	2.5	2.5	1368.75	0
Concrete mixer	2	1.8	3.6	1971	1.8	3.6	1971	0
Marshall testing machine	1	1	1	547.5	1	1	547.5	0
Compressive strength testing machine	1	1	1	547.5	1	1	547.5	0
Triaxial machine	1	0.5	0.5	273.75	0.5	0.5	273.75	0
Oven	3	1.8	5.4	2956.5	1	3	1642.5	1314
Computers (Desktop)	16	1.2	19.2	56064	0.36	5.76	16819.2	39244.8
Booster water pump	1	40	40	58400	29.84	30	43800	14600
TOTAL	**76**	**277.66**	**337**	**407072**	**245.09**	**417.2**	**333570**	**73501.9 (18.1%)**

In university X, workshop and laboratory machines were found to operate for an average of 1.5 hrs per day. Thus each operated for 365 x 1.5 = 547.5 hrs per year. Computers operated for an average of 8 hours per day. Thus each operated for 365 x 8 = 2920 hrs per year. Water pumps operated for an average of 4 hrs per day. They operated for 365 x 4 = 1460 hrs per year. Refrigerators and incubators were on for 24 hrs a day and hence 8760 hrs a year. From table 12 it is seen that 73501.87kWh (18.1%) of electric energy could be saved every year if the power equipment were replaced by energy efficient types. This translates to Ksh (9.20 x 73501.87) = Ksh. 676217.20 per year.

Table 13: Production and processing loads in university Y

The table below shows the amount of electric energy that would be saved by replacing the existing production and process power equipment in university Y

Loads	**Qty**	**Rating (kw)**	**Total (kw)**	**Energy consumed/year (kwh)**	**Alternative rating (kw)**	**Total (kw)**	**Energy consumed /year (kwh)**	**Energy saved (kwh)**
Sanding machine	1	3.7	3.7	2025.75	3.7	3.7	2025.75	0
Crosscutter	1	2.6	2.6	1423.5	0.75	0.75	410.63	1012.87
Power Band saw machine	1	3	3	1642.5	1.1	1.1	602.25	1040.25
Universal/Centre Lathe machine	20	12	240	131400	7.5	150	82125	49275
Universal Milling machine	10	14	140	76650	8	80	43800	32850
Cylindrical grinders	7	9.6	67.2	36792	1.5	10.5	5748.75	31043.25
General Surface grinder	10	9.2	92	50370	1.1	11	6022.5	44347.5
Shaper	10	3	30	43800	2.2	22	12045	31755
CNC-Lathe machine	20	14	280	153300	7.5	150	82125	71175
CNC-Milling machine	10	18	180	98550	11	110	60225	38325
CNC-Milling machine	10	22	220	120450	18	180	98550	21900
Bench drilling machine	2	1.1	2.2	1204.5	1.1	2.2	1204.5	0
Vertical drilling machine	2	0.86	1.72	941.7	0.86	0.72	941.7	0
Pedestal grinder	1	0.7	0.7	383.25	0.7	0.7	383.25	0
Compressor	40	5.5	220	120450	5.5	220	120450	0

Grinder	2	4	8	4380	4	8	4380	0
Power saw	1	2	2	1095	2	2	1095	0
Arc welding machine	3	3	9	4927.5	3	9	4927.5	0
Electric cooker	6	1.8	10.8	5913	0.9	5.4	2956.5	2956.5
Refrigerator	3	0.18	0.54	4730.4	0.11	0.33	2890.8	1839.6
Oven	2	9.6	19.2	10512	1.8	3.6	1971	8541
Food warmer	1	1.5	1.5	821.25	1.5	1.5	821.25	0
Deep freezer	1	1.4	1.4	12264	1.4	1.4	12264	0
Motor rewinder	2	0.55	1.1	301.13	0.55	1.1	301.13	0
Three-phase synchronous motor	1	0.5	0.5	273.75	0.5	0.5	273.75	0
TOTAL	**167**	**143.79**	**1537.16**	**884601.2**	**86.27**	**975.5**	**548540.3**	**336061 (38%)**

In university Y, workshop and laboratory machines operated for an average of 1.5 hours per day. Thus each operated for 365 x 1.5 = 547.5 hours per year. Computers operated for an average of 8 hours per day. Thus each operated for 365 x 8 = 2920 hours per year. Water pumps operated for an average of 4 hours per day. They operated for 365 x 4 = 1460 hours per year. Refrigerators and deep freezers were on for 24 hours a day and hence 8760 hours a year. From table 13 it is seen that 336061kWh (38%) of electric energy could be saved every year if the power equipment were replaced by energy efficient types. This translates to Ksh (9.20 x

336061) = Ksh. 3091761.20 per year. Some of the equipment were found to be the most efficient available and therefore there would be no energy saved, that is, there was no need replace them.

Table 14: Production and processing loads in University Z

The table below shows the amount of electric energy that would be saved in university Z by replacing the production and process power equipment with energy-efficient types

Loads	Qty	Rating (kw)	Total (kw)	Energy consumed/ year (kwh)	Alternative rating (kw	Total (kw)	Energy consumed/ year (kwh)	Energy saved (kwh)
Water bath	1	1.05	1.05	383.25	0.16	0.16	58.4	324.85
Water Heater	1	0.55	0.55	200.75	0.55	0.55	200.8	0
Microscopes	21	2.5	52.5	19162.50	2.5	2.5	912.5	18250
Incubator	3	1.88	5.64	2058.60	1.88	5.64	2058.6	0
Printer	10	1.5	15	5475.00	1.5	1.5	547.5	4927.5
Microwave	4	1.34	5.36	1956.40	0.9	3.6	1314.0	642.4
Sewing machine	1	0.1	0.1	36.50	0.1	0.1	36.5	0
Fridge	9	0.6	5.4	1971.00	0.11	0.99	361.4	1609.65
Electric Kettle	1	2.2	2.2	803.00	2.2	2.2	803.0	0
Blender	1	1.3	1.3	474.50	0.3	0.3	109.5	365
Mixer	3	3.6	10.8	3942.00	0.2	0.6	219.0	3723
Electric Cookers	5	12.3	61.5	22447.50	7.2	36	13140.0	9307.5
Washing machines	4	6.4	25.6	9344.00	6.4	25.6	9344.0	0
Potato peeler	1	1.1	1.1	401.50	1.1	1.1	401.5	0
Slicer	1	0.6	0.6	219.00	0.6	0.6	219.0	0
Cold room	1	3.5	3.5	1277.50	3.5	3.5	1277.5	0
X-ray machine	1	0.83	0.83	302.95	0.83	0.83	303.0	0
Computers	137	0.5	68	99280.00	0.36	49.32	72007.2	27272.8
Freezer	1	0.215	0.215	78.48	0.215	0.215	78.5	0
Drill press	1	1	1	365.00	0.65	0.65	237.3	127.75

Mig welder	1	0.575	0.575	209.88			0.0	209.875
Arc welder	3	6	18	6570.00	4	12	4380.0	2190
Band saw	1	4	4	1460.00	3	3	1095.0	365
Table saws	3	3.4	10.2	3723.00	2	6	2190.0	1533
Grinder	1	0.5	0.5	182.50	0.48	0.48	175.2	7.3
Battery charger	1	0.95	0.95	346.75	0.95	0.95	346.8	0
Instant water heaters	41	4.5	184.5	67342.50	4	164	59860.0	7482.5
Water pump motor 1	1	11	11	4015.00	11	11	4015.0	0
Water pump motor 2	1	7.5	7.5	2737.50	7.5	7.5	2737.5	0
Single phase milking motor	1	1	1	365.00	1	1	365.0	0
Compressor	2	3	6	2190.00	1.8	3.6	1314.0	876
Three-phase induction motor	1	6	6	2190.00	4	4	1460.0	730
Total	**264**	**91.49**	**512.5**	**26152**	**70.99**	**349.5**	**181567**	**79944.1 (30.6%)**

In university Z, workshop and lab machines operated for an average of 1 hour per day. Thus each operated for 365 x 1 = 365hours per year. Computers operated for an average of 8 hours per day. Thus each operated for 365 x 8 = 2920 hours per year. Water pumps operated for an average of 18 hours per day and hence 365 x 18 = 6570 hours per year. Fridge, cold room and freezer were on for 24 hours a day and hence 8760 hours a year. From table 14, the total amount of energy saved by replacing the existing equipment with the energy saving types would be 79944.13 kWh (30.6%)which translates to ksh (79944.13x9.20) = ksh 735486

Table 15: Average electric energy that would be saved in universities by replacing power equipment with energy-efficient types

The table shown below indicates the average electric energy that would be saved in universities X, Y and Z every year by replacing the production and process power equipment with energy-efficient types

Electric Energy in kWh saved by:	**University**			**Average**
	X	Y	Z	
Replacing existing power equipment with energy-efficient types	73501.87 (18.1%)	336061 (38%)	79944.13 (30.6%)	163169 (28.9%)

Table 15 reveals that university Y had the highest amount of electric energy that could be saved by replacing the existing old and poorly maintained power equipment with the more energy-efficient types.

4.2.3 Unauthorised loads in universities

Table 16: Number of electric coils and working hrs per day at hostels in university X

The table below shows the number of electric coils and average working hours of the coils per day in university X

No	Building	No. of Rooms	Answers from various respondents to the question of : How long in HOURS does the coil(s) operates in their various rooms within a day?					
			Respondent **V**	Respond **W**	Respon **X**	Respon **Y**	Respon **Z**	**Avg Time in Hrs**
1	Hostel **A**	409	2	1	1.5	2	1	**1.5**
2	Hostel **B**	151	1	2	1	1	1.5	**1.3**
3	Hostel **C**	147	1	1	1	1	2	**1.2**
4	Hostel **D**	156	2	1	1	2	2	**1.6**
5	Hostel **E**	407	2	1	1	2	1	**1.4**
6	Hostel **F**	72	2	2	3	1	1	**1.8**
7	Hostel **G**	79	2	1	2	1	2	**1.6**
8	Hostel **H**	81	1	1	2	1.5	2	**1.5**
9	Hostel **I**	73	2	2	2	1	2	**1.8**
10	Hostel **J**	254	1	2	1	1	2	**1.4**
11	Hostel **K**	405	1.5	2	2	1	1	**1.5**
12	Hostel **L**	408	1	2	2	1	1	**1.4**
13	Hostel **M**	324	2	1	1	2	2	**1.6**
TOTAL		**2966**						**19.6**

Table 16 shows that there were a total of 2966 rooms in the hostels and from the checklist, each room had at least one electric coil meaning that there were a total of 2966 electric coils in the hostels. From the table, each coil is on for an average of $\frac{19.6}{13} = 1.5$ hours per day. Each coil was rated at 1800 W and therefore the total energy consumed by the coils each year would be 2966 x 1.8 x 1.5 x 365 = 2922993 kWh (60.9%). In terms of cost, the total amount of money would be Ksh (2922993 x 9.20) = ksh 26891535.60 per year. This electric energy consumption was unnecessary because it was being consumed by unauthorised loads. These loads were being connected to the ordinary socket outlets which were not designed to carry such loads as electric cookers and therefore were also posing dangers to the users. The large power demand in hostels also meant that a large size supply cable was needed to meet the demand otherwise it would overheat and may cause fire. The larger the cable size the more it becomes expensive and this would add to the already expensive cost of electricity in the institution.

The results imply that university X wasted 60.9% of its electric energy through unauthorised electric loads which could be avoided by using alternative green energy sources like biogas system that are relatively cheaper to set up and run. There was also a great need to raise awareness level of students on energy saving measures because with such knowledge they could likely make more efforts to reduce energy wastage in the university and in turn would have a major impact on the cost of electric energy.

4.3 Analysis of data from questionnaires

Questionnaires were randomly distributed to students in the university and were requested to fill and return them. The analysis of these questionnaires was as follows:

4.3.1Analysis of questionnaires for university X students

Table 17: The gender, age and school of university X students

The table below gives the gender, age and the school of students in university X

	Frequency	Percent
Gender		
Male	171	53.9
Female	146	46.1
Total	317	100
Age Range		
15 – 20 yrs	96	30.3
21 – 26 yrs	216	68.1
27 yrs and above	5	1.6
Total	317	100.0
School/Faculty		
Engineering	6	1.9
Education	172	54.3
Arts & social sciences	58	18.3
Biological & Physical sciences	42	13.2
Business & Economics	35	11.0
Information science	4	1.3
Total	317	100.0

Table 17 shows that majority of respondents were: male; in the age bracket of 21 to 26 years; and from school of Education.

Table 18: The usage of electric lighting loads by university X students

The table below shows how university X students made use of lighting loads

	Frequency	Percent
Lamp type		
Ordinary bulbs	44	13.9
Linear fluorescent lamp	265	83.6
Compact fluorescent lamp	4	1.3
Light emitting diode lamp	4	1.3
Total	317	100.0
Switching off unnecessary lamps		
Yes	232	73.2
No	85	26.8
Total	317	100.0
Use of natural light		
Yes	213	67.2
No	104	32.8
Total	317	.100

Table 18 shows that: The most commonly used lamp in the hostels was the linear T8 fluorescent lamp; a majority of the respondents switched off unnecessary lamps and many of them made use of natural light during the day.

Table 19: The usage of electric heating loads by university X students

The table below indicates how electric heating loads were used by university X students

	Frequency	Percent
Type of appliance		
Electric cooker	100	31.5
Water heater	162	51.1
Iron box	48	15.2
Microwave oven	7	2.2
Total	317	100.0
Timers & thermostats well set		
Yes	81	25.6
No	236	74.4
Total	317	100.0
Time appliance is on per day		
Less than 1 hr	126	39.7
2 - 3 hrs	139	43.8
4-5 hrs	43	13.6
More than 5 hrs	9	2.8
Total	317	100.0
Plug off appliance not in use		
Yes	260	82.0
No	57	18.0
Total	317	100.0
Servicing of appliance		
Regularly	40	12.6
Rarely	130	41.0
Not at all	147	46.4
Total	317	100.0
Energy efficient appliance		
Yes	129	40.7
No	56	17.7
I do not know	132	41.6
Total	317	100.0

Table 19 indicates that: Water heater was the most commonly used heating appliance in student hostels; majority of the respondents had not set timers/thermostats of their appliances accordingly; a large number of respondents plugged off the appliances from the socket outlets and also rarely serviced their appliances.

Table 20: Responses on electric energy saving questions by university X students

The table below shows responses to questions on electric energy saving by university X students

	Frequency	**Percent**
Living in energy crisis		
Yes	257	81.1
No	60	18.9
Total	317	100.0
Trained on energy saving		
Yes	96	30.3
No	221	69.7
Total	317	100.0
Motivation on energy saving		
Increase in cost	131	41.3
Environmental reasons	129	40.7
Public relations	57	18.0
Total	317	100.0
Attitude on energy saving		
Positive	259	81.7
Neutral	55	17.4
Negative	3	0.9
Total	317	100.0

As shown in table 20, most of the respondents accepted that there was energy crisis and that a majority of them had never had any training on energy saving techniques.

Also, the important factors that would motivate users to save electric energy were the cost of electricity and the environmental impacts.

4.3.2 Analysis of the questionnaires for university Y students

Table 21: The Gender, Age and School of university Y students

The table shown below outlines the gender, age and school of university Y students

	Frequency	Percent
Gender		
Male	166	84.7
Female	30	15.3
Total	196	100.0
Age Range		
15 – 20 yrs	14	7.1
21 – 26 yrs	174	88.8
27 yrs and above	18	4.1
Total	196	100.0
School/Faculty		
Engineering	122	62.2
Information science	74	37.8
Total	196	100.0

Table 21 indicates that the majority of respondents were male and fell in the age bracket of 21 and 26 years. Also, most of them were from school of engineering.

Table 22: The usage of electric lighting loads by university Y students

The table below shows the usage of electric lighting loads by university Y students

	Frequency	Percent
Lamp type		
Ordinary bulbs	20	10.2
Linear fluorescent lamp	174	88.8
Compact fluorescent lamp	0	0.0
Light emitting diode lamp	2	1.0
Total	196	100.0
Switching off unnecessary lamps		
Yes	155	79.1
No	41	20.9
Total	196	100.0
Use of natural light		
Yes	141	71.9
No	55	28.1
Total	196	100.0

Table 22 reveals that a majority of lamps used in the hostels were the linear fluorescent type and most users switched off unnecessary lights. The results also show that those who switched off unnecessary lamps could have been taking advantage of natural light during the day.

Table 23: The usage of electric heating loads by university Y students

The table below shows the usage of electric heating loads by university Y students

	Frequency	Percent
Type of appliance		
Electric cooker	18	9.2
Water heater	83	42.3
Iron box	89	45.4
Microwave oven	6	3.1
Total	196	100.0
Timers & thermostats well set		
Yes	74	37.8
No	122	62.2
Total	196	100.0
Time appliance is on per day		
Less than 1 hr	149	76.0
2 - 3 hrs	45	23.0
4-5 hrs	2	1.0
More than 5 hrs	0	0.0
Total	196	100.0
Plug off appliance not in use		
Yes	170	86.7
No	26	13.3
Total	196	100.0
Servicing of appliance		
Regularly	25	12.8
Rarely	115	58.7
Not at all	56	28.5
Total	196	100.0
Energy efficient appliance		
Yes	114	58.2
No	25	12.8
I do not know	57	29.0
Total	196	100.0

Table 23 indicates that a majority of the respondents: Used iron boxes and electric cookers in their hostels; did not set appliance timers/ thermostats appropriately; their appliances were on for less than one hour per day; plugged off appliances from the socket outlets when not in use; rarely serviced their appliances and declared that their appliances were energy efficient.

Table 24: Responses on electric energy saving questions by university Y students

The table below analyses the responses from university Y students on the questions on energy questions

	Frequency	Percent
Living in energy crisis		
Yes	169	86.2
No	27	13.8
Total	196	100.0
Trained on energy saving		
Yes	41	20.9
No	155	79.1
Total	196	100.0
Motivation on energy saving		
Increase in cost	77	39.3
Environmental reasons	90	45.9
Public relations	29	14.8
Total	196	100.0
Attitude on energy saving		
Positive	173	88.3
Neutral	21	10.7
Negative	2	1.0
Total	196	100.0

As shown in table 24, a majority of the respondents accepted that there was energy crisis and that the important factors that would motivate users to save electric energy were the cost of electricity and the environmental impacts.

4.3.3 Analysis of the questionnaires for university Z students

Table 25: Gender, Age and School of university Z students

The table below indicates the gender, age and school of university Z students

	Frequency	Percent
Gender		
Male	45	48.9
Female	47	51.1
Total	92	100.0
Age Range		
15 – 20 yrs	40	43.5
21 – 26 yrs	49	53.3
27 yrs and above	3	3.2
Total	92	100.0
School/Faculty		
Engineering	14	15.2
Education	10	10.9
Arts & social sciences	9	9.7
Biological & Physical sciences	45	48.9
Business & Economics	14	15.2
Total	92	100.0

Table 25 indicates that a majority of respondents were female; in the age bracket of 21 and 26 years and from school of Biological and physical sciences.

Table 26: Usage of electric lighting loads by university Z students

The usage of the lighting loads by university Z students are shown in the table below

	Frequency	Percent
Lamp type		
Ordinary bulbs	13	14.1
Linear fluorescent lamp	77	83.7
Compact fluorescent lamp	2	2.2
Light emitting diode lamp	0	0.0
Total	92	100.0
Switching off unnecessary lamps		
Yes	77	83.7
No	15	16.3
Total	92	100.0
Use of natural light		
Yes	69	75
No	23	25
Total	92	100.0

Table 26 shows that most commonly used lamp in the hostels is the linear fluorescent lamp; a majority of the respondents switched off unnecessary lamps and many of them made use of natural light during the day.

Table 27: Usage of electric heating loads by university Z students

The table below shows the usage of electric heating loads by university Z students

	Frequency	Percent
Type of appliance		
Electric cooker	4	4.3
Water heater	32	34.8
Iron box	56	60.9
Microwave oven	0	0
Total	92	100.0
Timers & thermostats well set		
Yes	30	32.6
No	62	67.4
Total	92	100.0
Time appliance is on per day		
Less than 1 hr	74	80.4
2 - 3 hrs	15	16.3
4-5 hrs	2	2.2
More than 5 hrs	1	1.1
Total	92	100.0
Plug off appliance not in use		
Yes	89	96.7
No	3	3.3
Total	92	100.0
Servicing of appliance		
Regularly	23	25
Rarely	44	47.8
Not at all	25	27.2
Total	92	100.0
Energy efficient appliance		
Yes	47	51.1
No	2	2.2
I do not know	43	46.7
Total	92	100.0

Table 27 reveals that most of the respondents: used iron boxes and water heaters in their hostels; did not set timers and thermostats appropriately; had their appliances being on for less than an hour every day; plugged off appliances from socket outlets when not in use; rarely serviced their appliances and those who declared that their appliances were efficient and those who did not know the efficiency of their appliances were almost equal in number.

Table 28: Responses on electric energy saving by university Z students

The table shown below analyses the responses from university Z students on energy saving questions

	Frequency	Percent
Living in energy crisis		
Yes	71	77.2
No	21	22.8
Total	92	100.0
Trained on energy saving		
Yes	23	25
No	69	75
Total	92	100.0
Motivation on energy saving		
Increase in cost	46	50.0
Environmental reasons	36	39.1
Public relations	10	10.9
Total	92	100.0
Attitude on energy saving		
Positive	62	67.4
Neutral	30	32.6
Negative	0	0.0
Total	92	100.0

As shown in table 28, a majority of the respondents: Accepted that there was energy crisis; had never been trained on energy saving techniques and would be motivated by two factors to save energy, that is, the cost of electricity and the environmental impacts.

4.3.4 Analysis of the questionnaires for university X staff

Table 29: Gender, Age, education, department and work experience of university X staff

The table below shows the gender, age, education level, department and the work experience of university X staff

	Frequency	Percent
Gender		
Male	21	47.7
Female	23	52.3
Total	44	100.0
Age Range		
26-33	14	31.8
34 years and above	30	68.2
Total	44	100.0
Level of education		
Std 8	0	0.0
Form 4	17	38.6
University	27	61.4
Total	44	100.0
Department		
Central services	6	13.6
Catering	6	13.6
Academic	5	11.4
Administration	8	18.2
Technical	19	43.2
Total	44	100.0
Years of working		
0-1	1	2.3
2-5	3	6.8
5-30	40	90.9
Total	44	100.0

Table 29 reveals that most of the respondents: were over 34 years old; university graduates, working in technical service department and that the number of males and females were equal.

Table 30: Usage of electric lighting loads by university X staff

The table below shows the usage of electric lighting loads by university X staff

	Frequency	Percent
Lamp type		
Ordinary bulbs	2	4.5
Linear fluorescent lamp	42	95.5
Compact fluorescent lamp	0	0.0
Light emitting diode lamp	0	0.0
Total	44	100.0
Switching off unnecessary lamps		
Yes	38	86.4
No	6	13.6
Total	44	100.0
Use of natural light		
Yes	33	75
No	11	25
Total	44	100.0

The results shown in table 30 indicate that a majority of the respondents used linear fluorescent lamps for lighting in their place of work and also that most of them took advantage of natural light during the day and hence switched off the artificial light and that time.

Table 31: Usage of electric heating loads by university X staff

Shown in the table below is the usage of electric heating loads by university X staff

	Frequency	Percent
Type appliance		
Electric cooker	0	0.0
Water heater	24	54.5
Iron box	2	4.5
Microwave oven	1	2.3
Toaster	8	18.2
Arc welding	9	20.4
Total	44	100.0
Timers & thermostats well set		
Yes	24	54.5
No	20	45.5
Total	44	100.0
Plug off appliance not in use		
Yes	41	93.2
No	3	6.8
Total	44	100.0
Servicing of appliance		
Regularly	9	20.5
Rarely	35	79.5
Not at all	0	0.0
Total	44	100.0
Energy efficient appliance		
Yes	20	45.5
No	4	9.1
I do not know	20	45.5
Total	44	100.0
Office equipment on energy saving mode		
Yes	11	25
No	23	75
Total	44	100.0

From table 31, it can be concluded that a large number of respondents: were using water heater; had set appliances timers and thermostats appropriately; plugged off appliances from the socket outlets when not in use; serviced their appliances less often and; had not put their appliances on energy saving mode.

Table 32: Responses on electric energy saving questions by university X staff

The table below shows the responses of university X staff on the question of energy saving

	Frequency	Percent
Living in energy crisis		
Yes	41	93.2
No	3	6.8
Total	44	100.0
Trained on energy saving		
Yes	4	9.1
No	40	90.9
Total	44	100.0
Motivation on energy saving		
Increase in cost	39	88.6
Environmental reasons	5	11.4
Public relations	0	0.0
Total	44	100.0
Attitude on energy saving		
Positive	40	90.9
Neutral	4	9.1
Negative	0	0.0
Total	44	100.0

According to table 32**,** it can be concluded that a majority of the respondents: accepted that there was an energy crisis in the world today; had not been trained on energy saving techniques; were motivated to save energy by the high cost of electricity and; had positive attitude towards energy saving measures.

4.3.5 Analysis of the questionnaires for university Y staff

Table 33: Gender, Age, education, department and work experience of university Y staff

The table shown below indicates the gender, age , education level and department of university Y staff

	Frequency	Percent
Gender		
Male	19	52.8
Female	17	47.2
Total	36	100.0
Age Range		
18 -25	1	2.8
26-33	22	61.1
34 years and above	13	36.1
Total	36	100.0
Level of education		
Std 8	0	0.0
Form 4	24	66.7
University	12	33.3
Total	36	100.0
Department		
Central services	1	2.8
Catering	20	55.6
Academic	2	5.6
Administration	3	8.3
Technical	10	27.8
Total	36	100.0
Years of working		
0-1	7	19.4
2-5	10	27.8
5-30	19	52.8
Total	36	100.0

Table 33 shows that most of the respondents were males; between 23 and 33 years old; had form four level of education; were from technical service department and; had worked in the university for between 5 to 30 years.

Table 34: Usage of electric lighting loads by university Y staff

The table below shows the usage of electric lighting loads by university Y staff

	Frequency	Percent
Lamp type		
Ordinary bulbs	10	27.8
Linear fluorescent lamp	26	72.2
Compact fluorescent lamp	0	0.0
Light emitting diode lamp	0	0.0
Total	36	100.0
Switching off unnecessary lamps		
Yes	19	52.8
No	17	47.2
Total	36	100.0
Use of natural light		
Yes	7	19.4
No	29	80.6
Total	36	100.0

Table 34 shows that a majority of the respondents used linear fluorescent lamps for lighting in their place of work. It is also evident that majority of the respondents did not take advantage of natural light during the day which was supported by the fact that most of them did not switch off unnecessary lights.

Table 35: Usage of electric heating loads by university Y staff

The table shown below indicates the usage of electric heating loads by university Y staff

	Frequency	Percent
Type of appliance		
Electric cooker	18	50.0
Water heater	7	19.4
Iron box	1	2.8
Microwave oven	0	0.0
Toaster	0	0.0
Arc welding	10	27.8
Other	0.0	0.0
Total	36	100.0
Timers & thermostats well set		
Yes	14	38.9
No	22	61.1
Total	36	100.0
Plug off appliance not in use		
Yes	21	58.3
No	15	41.7
Total	36	100.0
Servicing of appliance		
Regularly	8	22.2
Rarely	27	75.0
Not at all	1	2.8
Total	36	100.0
Energy efficient appliance		
Yes	10	27.8
No	19	52.8
I do not know	7	19.4
Total	36	100.0
Office equipment on energy saving mode		
Yes	13	36.1
No	23	63.9
Total	36	100.0

Table 35 indicates that most of the respondents: used electric cookers in their place of work; had not set the timers and thermostats accordingly; plugged off their appliances from socket outlets when not in use; rarely serviced their appliances; had energy inefficient appliances and; did not put their appliances on energy saving mode.

Table 36: Responses on electric energy saving questions by university Y staff

The table below analyses the responses of university Y staff on electric energy saving questions

	Frequency	Percent
Living in energy crisis		
Yes	32	88.9
No	4	11.1
Total	36	100.0
Trained on energy saving		
Yes	7	19.4
No	29	80.6
Total	36	100.0
Motivation on energy saving		
Increase in cost	17	47.2
Environmental reasons	13	36.1
Public relations	6	16.7
Total	36	100.0
Attitude on energy saving		
Positive	20	55.6
Neutral	15	41.7
Negative	1	2.8
Total	36	100.0

From table 36 shows, it can be concluded that a majority of the respondents: Accepted that people were living on energy crisis; had not been trained on energy saving techniques; were motivated to save energy by the high cost of electricity and; had positive attitude towards energy saving measures.

4.3.6 Analysis of the questionnaires for university Z staff

Table 37: Gender, Age, education, department and work experience of university Z staff

The table below shows the gender, age education level, department, and work experience of university Z staff

	Frequency	Percent
Gender		
Male	20	62.5
Female	12	37.5
Total	32	100.0
Age Range		
26-33	21	65.6
34 years and above	11	34.4
Total	32	100.0
Level of education		
Std 8	0	0.0
Form 4	20	62,5
University	12	37.5
Total	32	100.0
Department		
Central services	3	9.4
Catering	15	46.9
Academic	2	6.3
Administration	4	12.5
Technical	8	25.0
Total	32	100.0
Years of working		
0-1	6	18.8
2-5	4	12.5
5-30	22	68.8
Total	32	100.0

Table 37 shows that most of the respondents: were male; were between 23 and 33 years old; had form four level of education; wee from catering service department and; had worked in the university for between 5 to 30 years.

Table 38: Usage of electric lighting loads by university Z staff

The table below shows the usage of lighting loads by university Z staff

	Frequency	Percent
Lamp type		
Ordinary bulbs	9	28.1
Linear fluorescent lamp	23	71.9
Compact fluorescent lamp	0	0.0
Light emitting diode lamp	0	0.0
Total	32	100.0
Switching off unnecessary lamps		
Yes	24	75
No	8	25
Total	32	100.0
Use of natural light		
Yes	11	34.4
No	21	65.6
Total	32	100.0

Results shown in table 38 indicate that the majority of the respondents used the linear fluorescent lamps for lighting in their place of work. It is also evident that majority of the respondents did not take advantage of natural light during the day which actually was supported by the fact that most of them did not switch off unnecessary lights.

Table 39: Usage of electric heating loads by university Z staff

The table below shows the usage of electric heating loads by university Z staff

	Frequency	Percent
Type of appliance		
Electric cooker	9	28.1
Water heater	11	34.4
Iron box	1	3.1
Microwave oven	1	3.1
Toaster	4	12.5
Arc welding	6	18.8
Total	32	100.0
Timers & thermostats well set		
Yes	18	56.3
No	14	43.7
Total	32	100.0
Plug off appliance not in use		
Yes	25	78.1
No	7	21.9
Total	32	100.0
Servicing of appliance		
Regularly	6	18.8
Rarely	26	81.2
Not at all	0	0.0
Total	32	100.0
Energy efficient appliance		
Yes	9	28.1
No	12	37.5
I do not know	11	34.4
Total	32	100.0
Office equipment on energy saving mode		
Yes	13	40.6
No	19	59.4
Total	32	100.0

Table 39 indicates that most of the respondents: used water heaters in their place of work; had set the timers and thermostats accordingly; plugged off their appliances from socket outlets when not in use; rarely serviced their appliances; had energy inefficient appliances and; did not put their appliances on energy saving mode.

Table 40: Responses on electric energy saving questions by university Z staff

The table shown below indicates the responses given by university Z staff on electric energy saving questions

	Frequency	Percent
Living in energy crisis		
Yes	29	90.6
No	3	9.4
Total	32	100.0
Trained on energy saving		
Yes	9	28.1
No	23	71.9
Total	32	100.0
Motivation on energy saving		
Increase in cost	20	62.5
Environmental reasons	8	25
Public relations	4	12.5
Total	32	100.0
Attitude on energy saving		
Positive	23	71,9
Neutral	8	25
Negative	1	3.1
Total	32	100.0

From table 40, it can be concluded that a majority respondents believed that there was energy crisis. Also, most of them had not been trained on energy saving techniques. It is also clear that the high cost of electricity motivated most respondents to change behaviour so as to save electric energy. Lastly a majority of the respondents had a positive attitude towards energy saving.

4.4 Interview schedules

In order to establish the level of awareness of electric energy saving measures of the university community, some university students, staff and administrators in different sections and departments were interviewed.

4.4.1 Results of interviews of students in university X

From the interview, a majority of the students: Accepted that there was energy crisis; used electricity in their hostels for lighting, cooking and powering electronic devices; were not aware of energy saving techniques and therefore could not answer the question of whether they were practicing energy saving measures. “If switching off unnecessary light is one of the energy saving measures, then I always do it” one of them said when asked whether they practiced any energy saving measures. Regarding the question of whether there was wastage of electric energy in the university, all respondents agreed that there was a lot of wastage and gave some of the areas where wastage occurred such as: Cooking and warming of rooms in hostels, leaving lights on throughout the day and night in hostels, lecture rooms, library, workshops and laboratories.

Some of the respondents suggested the following as measures to save electric energy in the university: Students should be educated on electricity use; measures should be put in place by the university to ensure that there is no wastage of electricity; people should be trained on energy saving measures; users could be made to pay for electricity and would be forced to conserve it; automatic switching off mechanism should be adopted; they should be made aware of energy saving measures; switches should be placed near beds because many students were lazy to wake up and switch off lights at night; People should be reminded to switch off unnecessary lights; there should be a comprehensive policy on energy saving in the university; Educate users on the importance of energy saving; Students should be motivated to save electricity; and each hostel should have energy regulators.

On the question of the key barriers to adoption of electric energy saving measures in the university, the respondents gave the following answers: “It is very difficult to control the usage of electric energy because the wastage is so rampant in the university” one of the interviewee said; ignorance or a do not care attitude among students and other users; the fact that they did not contribute towards electricity bill made them less concerned; it was difficult to control the switching off and on of lights because students study at different intervals in both lecture halls and hostels; lack of policy on energy saving; they did not know the outcomes of wasting electricity; lack of incentive; they said it was the business of university to deal with electricity issues; they felt that university had a lot of money and; students should be allowed to bring their own energy saving bulbs and this would save a lot of energy. A majority of respondents gave the high cost of electricity as what would motivate them to change their behaviour to reduce energy consumption. Also, all the respondents had a positive attitude towards electric energy saving.

4.4.2 Results of interviews of students in university Y

A majority of students used electricity for lighting, charging phones and powering electronic gadgets. Most of them were not aware of energy saving techniques and therefore when asked whether they practice any technique some said

> "May be switching off unnecessary lights and machines."

A majority of them also agreed that there was a lot of wastage of electric energy in the university through unnecessary lighting and leaving on machines in the workshop for a long time.

Responding to the question of what should be done to save electric energy in the university, many of the respondents were for the opinion that everybody in the university should be taken for training on energy saving techniques. Some of them suggested that the university should come up with a clear policy on electric energy saving measures. Regarding the key barriers to adoption of energy saving measures in the university some of their responses included: university pays for electricity bills and therefore students did not feel it and; there was lack of incentives, that is, users should be rewarded according how much energy they save over a period of time. The high cost of electricity was also cited as the main motivating factor that would make user change their behaviour to reduce electric energy consumption. All respondents had a positive attitude towards electric energy saving.

4.4.3 Results of interviews of students in university Z

Most of the students used electric energy for lighting, water heating, ironing and powering electronic equipment. A majority of the respondents were not aware of electric energy saving techniques. Almost all the respondents agreed that there was a lot of wastage of electric energy in the university through lighting loads, water heaters and ironing that were left on for a long time each day. On the question of what should be done to save electric energy in the university, their responses included: people should be made aware of energy saving methods; clear instructions should be given on the use of electricity in the university; people should be trained on energy saving measures; those who wasted electricity should be penalized by being made to pay for it; people needed to be reminded about energy saving all the time.

The key barriers to the adoption of electric energy saving measures in the university as suggested by the respondents were: students paid fees so they believed that they should use all facilities including electricity to the fullest; ignorance about energy saving measures; they did not pay for electricity and therefore could not care about it. The cost of electricity also featured as a motivating factor for change of behaviour to reduce electric energy consumption.

4.4.4 Results of interviews of staff in university X

All the respondents accepted the fact that they were living under energy crisis. Generally, the respondents used electricity for lighting, powering laboratory and workshop equipment, arc welding, water heating, computers, photocopiers and printers. None of the respondents had undergone any training on energy saving techniques. On the question of how often they practiced energy saving measures, some of their answers were: put off lights and machines when not in use and; use energy saving bulbs.

Their responses to the question of wastage of electric energy in the university were as follows: “In students’ hostels over 90% of students used it for cooking and in fact there had been a lot of upgrading of supply cables to these hostels but still they overloaded them. Underground cable of 185 mm^2 was currently in use and 22 transformers have been installed to take care of the situation" one of them said. Another respondent answered that in lecture halls, lamps were being left on throughout the day and night and to make the matter worse, these lamps were fluorescent types not energy saving lamps. Security lights were also on even during the day. These security lamps were the flood light types.

What could be done to save electric energy in university according to the respondents included: people should be made aware of energy saving measures; buy low electric power consuming equipment; replace fluorescent lamps with energy saving lamps; close monitoring of students during workshop practice to ensure that they save energy for instance setting welding machines to the right current levels; students cooking in hostels should be discouraged; security lights timers should be set well as to put them off during the day; poor servicing of equipment contribute to power wastage; sensitizing people about electric energy saving measures; improve services in students' mess for example subsidise food prices, cook a variety of quality meals for the students so as to encourage them to eat from these facilities and would minimize cooking in hostels; use energy saving bulbs; train all university staff and other workers on electric energy saving techniques; rules and regulations governing student body should be adhered to; policy on energy saving should be developed so that people should not waste power and; computers and other energy consuming equipment should be put on energy saving modes.

Concerning the key barriers that made the university not to adopt energy saving techniques, most of the respondents cited ignorance, lack of funds and lack of commitment. High electricity bills were adversely mentioned as a motivating factor that made users change behaviour so as to reduce energy consumption. All respondents had a positive attitude towards energy saving.

4.4.5 Results of interviews of staff in university Y

All the respondents agreed that they were living in energy crisis. The respondents used electricity for: welding, carpentry, lighting, computers, sewing machines, Laptops, charging of phones, electric machines for laboratory exercises, projector in lecture rooms, powering machines such as lathe, shaper, cylindrical grinder, bench drill, power band saw, universal milling machine, metal arc sprayer, hand grinder, hand drill, office equipment such as computers, photocopier, water dispenser, cooling fan and electric kettle.

They all agreed that energy saving was an important issue. None of them had been trained on energy saving techniques and most of them mentioned switching off unnecessary light as the only thing they knew could save electric energy. Majority of them said there was a lot of wastage of electric energy in the university and gave the following areas as examples: in lecture rooms lights were being left on for many hours even during the day; desktop computers were being left on unattended for many hours; water pumps were being left on unattended for several hours; when students were performing practical in both laboratories and workshops they would leave machines on throughout the session even when they did not need them on and; in cafeteria cooking coils were being left on for a long time.

According to the respondents, what could be done to save electric energy in university included: People should be trained on energy saving techniques; there should be a staff responsible for switching off unnecessary lamps; machines and other equipment should be switched off when not in use; unnecessary generator tests should be avoided and scheduled testing adhered to; use alternative sources of energy such as solar for lighting; everybody should be made aware of the importance of energy saving; make use of biomass, solar and wind systems to reduce the cost of electricity; people should be sensitized on importance of energy saving through training; utilization of natural lighting; installation of energy saving bulbs; purchase of low energy consumption equipment and; each department should have its own energy meter to make it clear the consumption of energy per department.

The main barriers to adoption of energy saving techniques as mentioned by respondents were: little knowledge of staff on electric energy saving, that is, ignorance on the part of staff; initial cost of energy saving lamps; the large population made it difficult to control the switching off of lamps when not in use; lack of training; attitude of staff towards energy saving; no information on energy saving such as " switch off lights when not in use" displayed on all the necessary areas; and management might not have been willing to participate in energy saving campaign. Saving on electricity bill, training on energy saving and rewards for departments that save energy were mentioned as motivation to energy saving. All respondents had positive attitude to energy saving.

4.4.6 Results of interviews of staff in university Z

The university staff used electricity for: lamps, computers, photocopiers, phone charging, printers and scanners. They all accepted that energy saving was important to them. None of them had been trained on energy saving techniques. When asked whether they practiced any saving energy measure, most of them said they switched off lights when not in use. On the question of whether there was electric energy wastage in the university, a majority of the respondents agreed that surely there was a lot of wastage and gave the following areas as examples: In offices, classes and toilets lamps were left on even during the day; electrical gadgets were being left on even when not in use especially when people were out for lunch; water heaters would also be left on for a long time and; at night one could see lights on in offices.

Regarding what could be done to save electric energy in the university the respondents gave the following answers: people should be trained on energy saving techniques; use of green energy such as solar power and use of energy saving lamps; people should be made aware of energy saving such as switching off lights and equipment during lunch time. In fact, some of them said people admitted that they were lazy to switch gadgets on after lunch so they would rather leave them on.

They also mentioned the following as the barriers to adoption of energy saving measures in the university: energy saving is not yet in users' minds; financial constraints and; lack of knowledge on the importance of energy saving. High cost of electricity also motivated almost all respondents to reduce energy consumption. They all had positive attitude towards energy saving.

4.4.7 Results of interviews of administrators of university X

All the respondents agreed that they were living in energy crisis and that there was need to take action immediately to reduce energy consumption. Most of them said there were no programmes, policies and regulations in the university that directly addressed the issues of energy saving. One of them, however, said that there were plans to develop projects for dairy, planting fruits, flowers and poultry. On top of the sheds to be built, solar panels would be installed and this would reduce university electricity cost. Another one said: "there is no energy saving policy because if we had one, lights would not be left on for 24 hours in lecture rooms and even offices because the policy would guide on this."

Concerning the type of technologies used to improve electric energy saving in the university, most of the respondents were not aware of any. One of them however said there were plans to install power correction units and also solar panels in both staff quarters and students' hostels for use in lighting and water heating. He further said that private developers were planning to put up large students' hostels that would make use of solar panels for lighting and heating. This would be in line with private public partnership (PPP) policy. On the question of whether university had a procurement policy, some respondents said: "University has a very strong procurement policy and in fact we do consultancy."

A majority of them however, were not aware of any procurement policy and they said if it were there then it was not being adhered to. For the question of whether university considers energy saving measures in the acquisition of new university buildings or renovation of existing buildings, most of them said university did not have such a policy one of the respondents said. One of them however, responded that:

> *"You know someone is given a contract to build and he/she may sub-contract the job so in the process the issue of addressing electric saving measures in buildings becomes a challenge."*

All respondents admitted that there had never been any training on energy saving for any university employee. On the usage of green energy sources in the university, they said that university did not make use of green energy sources. One said that some solar panels were installed in students' hostels and kitchens but never worked. Plans were underway to put up tall mast flood lighting that use LEDs within the university to assist in the part of security.

According to the respondents, some of the barriers to the adoption of energy saving measures in the university included: Lack of willingness do so; It was difficult to control students in what they did in their hostels such as cooking; and money for electricity bills came from ex-checker so no one was much concern about the cost of electricity.

4.4.8 Results of interviews of administrators of university Y

All the respondents accepted that they were living in energy crisis and said that there was need for action to be taken to reduce energy consumption. They also said that university had not prioritized electric energy saving so far. They never had any technology that would improve on electric energy saving in the university. There was no procurement policy that took care of purchasing electric energy consumption equipment. They all said that the university had not implemented any training on energy saving techniques. On the question of whether university addressed electric energy saving measures in the acquisition of new buildings or renovation of existing buildings, their responses were as follows: In a new building that was coming up, windows were made to take advantage of natural light; there was a plan to build a power sub-station to gather for the shortage of power in the university because some equipment consumed a lot of power; many of the lecture rooms had large windows, however, due to room partitions some natural light has been affected forcing people to put on light during the day.

There was no renewable energy source in the university. “I believe engineering students should assist in coming up with alternative energy sources” one of the respondents said. Some of the barriers to the adoption of the energy saving techniques according to the respondents were: Budgetary constraints; no policy for energy saving and; the university management had not given prominence the energy saving.

4.4.8 Results of interviews of administrators of university Z

All the respondents accepted that they were living in energy crisis and said that there was need for action to be taken to reduce energy consumption. One of the respondents said: “It is the priority agenda and in fact the university is campaigning for everyone to be concerned on energy saving such as switching off lights when not in use.” Another respondent said that there was neither no technology was used in the university to improve on energy saving measures nor clear policy on procurement yet they were very important. On the question of whether university addresses electric energy saving measures in the acquisition of new buildings or renovation of existing buildings, all respondents said there was none. Concerning staff training on energy saving measures, one respondent said: “There was some training in 2012 however attendance was very low and it never met the intended objectives”.

There was no renewable energy source in the university. Some of the barriers to the adoption of the energy saving techniques according to the respondents were: Maintenance department has been giving advice however reaction has been slow and; there was lack of initiatives.

CHAPTER FIVE

DISCUSSION OF THE FINDINGS

5.1 Introduction

This chapter presents a discussion of the findings of the study.

5.2 Discussion of findings

The general objective of this study was to determine the electric energy saving potential using energy saving techniques at universities in Kenya while the specific objectives were to: determine the amount of electric energy saved by applying the available electric energy saving technologies; find out the electric energy wasted through unauthorised electric loads; determine the electric energy saved through the use of alternative green sources of energy and establish the level of awareness of electric saving techniques of energy users. Discussions were made based on the objectives of this study.

5.2.1 Electric energy saved through application of lighting technologies

The findings of this study indicated that by replacing T8 fluorescent lamps with T8 LED lamps in universities an average of 26758.04 kWh (45.5%) of electric energy could be saved. This is a huge saving in when translated into money at the current of ksh 9.20 per unit (KPLC, 2017) it would be ksh 2,460,614 per year.

If on the other hand, the existing T8 linear fluorescent lamps were not replaced but daylight sensors were installed in universities, an average of 394486.42 kWh (67.3%) of electric energy could be saved. This translates to ksh 3,629,275 per year.

Electric energy that could be saved by replacing all the T8 linear fluorescent lamps by the T8 LED lamps and at the same time installing the daylight sensors in universities would be an average of 484,825.2 kWh (82.1%). This would translate to ksh 4,460,391.80 per year.

Generally, these findings indicate that a substantial amount of lighting energy could be saved in Kenyan universities by replacing fluorescent lamps with light emitting diode (LED) lamps and installing daylight sensors. In terms of the actual amount of electric energy that could be saved, university X had the highest value of 1194497.18 kWh followed by university Z with 182600.78 kWh and lastly university Y with a value of 77377.63 kWh. This difference was due to the nature of activities, size of the institution and the population of users in different universities. However, in view of the energy saving potential, there was no much difference across the universities. In fact each university had a potential of saving about 80% of electric energy regardless of whether it was a public or private.

The results from this study agreed with those found out by others who have done related research. Shigeru (2011) found out that if all the existing incandescent and fluorescent lamps were replaced by light emitting diode lamps, 92.2 TWh of energy could be saved, a figure accounting for 9% of the entire electricity consumption in Japan. Lighting dominates the potential electrical energy savings in the commercial sector of Ireland, with 74% of the total potential electricity savings attainable from efficient lighting (Excelsys Technologies Ltd, 2011). The study carried out by Roisin (2007) showed that electric lighting savings were high when regulating the light according to daylight availability and slightly depended on the orientation and location. In the study, an energy saving potential of between 45% and 61% of the annual power consumption was achieved. Daylighting saves 31% of the total annual energy use from the artificial lighting system (Krarti, 2004).

According to Galaşiu (2009), if luminaires integrated with occupancy sensors and light sensors (daylight harvesting), as well as individual dimming were used, an overall energy savings of 67% to 69% compared to the conventional lighting system would be achieved. Separately, occupancy sensors would save 35%, light sensors (daylight harvesting) 20%, and individual dimming 11%. An annual energy use savings of up to 60% associated with lighting can be achieved using dimming control strategy (Pyonchan, 2008).

5.2.2 Electric energy saved through use of energy efficient production and process equipment

The results of this study showed that if the power equipment in universities were to be replaced by energy-efficient types, an average of 163169 kWh (29%) of electric energy could be saved. In terms of cost, it would be ksh 1,501,154.80 per year. This therefore implies that by replacing the old and poorly maintained equipment, universities could save a sizable amount of electric energy and hence a reasonable amount of money that would go for electricity bills.

These results also revealed that university Y had both the highest potential (38%) for electric energy saving and the actual amount of electric energy (336061 kWh) that could saved compared to universities X and Z with 73501.87 kWh (18.1%) and 79944.13 kWh (30.6%) respectively. This was due to the fact that university Y had more and larger production and processing equipment compared to the others.

Other researchers in this field of study such as Abdelaziz (2010) postulated that energy saving technologies such as the use high-efficient motor driven machines and use of variable speed drives to match load requirement were cost-effective energy saving measures. According to Perrat (2010), the use of electric machines with motors that have high dynamic performance leads to saving up to 20% of electric energy. Saidur (2010) asserted that motors were not being used at full load and in most cases they were oversized that encouraged wastage of energy.

5.2.3 Energy wasted through unauthorised electric loads

In university X, 61% of electric energy was unnecessarily being consumed by unauthorized loads in students' hostels every year, which in terms of cost it would be Ksh. (2922993 x 9.20) = ksh 26,891,535.60 per year. In university Y the hostels were away from the main campus and a majority of the students lived in private quarters and the use of unauthorised loads could not be easily established. On the other hand, no student in university Z was allowed to connect any unauthorised electric load to the university power supply and therefore energy wasted in this regard was minimal if any.

This therefore implies that university X used a large portion of its budget in payment of electricity bills. To avoid this massive wastage of energy due to unauthorized loads, universities could design some kitchenettes that make use alternative green energy such as biogas for cooking which would not also save electric energy but also averts electric dangers that students were exposed to in the hostels. According to Faraz (2012), biogas energy can be used for heating purposes and is best suitable for hostels and residences. Also, biogas energy generation systems are cheaper and can be run with very low operating cost as was suggested by Amjid (2011). Research on biogas energy by Walekhwa (2009) found out that the adoption of biogas technology increases with the number of available cattle in a particular place. In the absence of biogas, electric energy efficient cookers (those with energy star labels) could be purchased for use in the kitchenettes and proper wiring done to take care of electric cookers that require larger cable sizes compared to ordinary socket outlets in the hostels where students use for cooking.

5.2.4 Energy saved through the use of green energy sources

This research revealed that none of the selected universities made use of green energy such as wind, solar or biogas as alternative sources of energy. Annually, university X would save 60.9% of electric energy currently consumed by unauthorised loads by utilising alternative green energy sources such as biogas for cooking. On the other hand, university Z could save 4.78% of electric energy currently consumed by electric kettles and cookers. Furthermore, by using solar water heaters instead of electric water heaters, university Z could save up to 13.87%. When carrying out interviews in this study, one of the respondents said that they had tried installing solar water heaters in hostels but they did not work after spending a lot of money on it. He further said that the reason why they did not work was the poor technology level then and many people were now not willing to put them up again.

The implication of these results is that the staff and students in universities might not have reached the point of understanding what needs to be done to save electric energy. There was also possibility of them lacking the necessary motivation to participate in the collective responsibility of reducing cost of electricity in universities through upholding the energy saving measures such as the use of green energy sources. It was first necessary to ensure that there was a collective appreciation of the changes in the economy and society that are needed to achieve sustainability and this could encourage them to act accordingly. Collective action could be mobilized by establishing green agendas as a norm in universities. This would pave way for developing a new culture in the institutions which would even guide those who bear responsibility of ensuring that energy wastage is reduced to minimum. The greening of institutions does not only add value to the normal institutional development process, it also stimulates progress towards learning and evolving community (UNESCO-UNIVOC, 2017).

According to Devabhaktuni (2012), solar energy is the most promising option among the many renewable energy sources since it is extensively available. Solar energy systems can be considered either as the power supply or applied directly to a process (Mekhilef, 2010). Large scale solar thermal systems with large collector fields are economically viable due to the usage of stationary collectors. Photovoltaic power systems will have an important share in the electricity of the future (Dincer, 2010).

5.2.5 Electric energy saved through raising users' level awareness

In this study, the results obtained from the questionnaires and interviews conducted among the university students, staff and administrators, revealed that a majority of the respondents: Accepted that there was a lot of wastage of electric energy in universities through lighting, cooking, electric machines and office equipment; had not been trained on electric energy saving measures and were therefore not aware of electric energy saving techniques and; agreed that there was no policy on energy saving that could guide the users. A few of the respondents said that they were aware of energy saving techniques, however, when asked whether they practice them in their daily undertakings they revealed that they rarely did it or not at all. Such responses support

Rogers (1962) argument that the rate of diffusion of innovations is usually low, that is, getting a new idea adopted, even when it has obvious advantages, is often very difficult and therefore a wide gap in many fields exists between what is known and what is actually put into use. It was also noted that the level of awareness of energy saving techniques of students, staff and administrators of both the public and private universities compared favourably.

These results clearly match with the other related research findings which show that a lot of energy is wasted due to lack of awareness of the end-users. Whittle, (2013) found out that the reason for high energy consumption in the university of Sheffield buildings was that the occupants cited a lack of awareness about the energy consumption of the building and a lack of personal control over and responsibility for energy conservation. Choong (2007) said that it is easier to change a participant's knowledge about energy and conservation than it is to change their attitudes. For instance, although many smokers are aware that smoking is harmful to their health, they still continue to smoke. In the similar circumstance, those who are aware of the importance of energy conservation and understand the energy conservation techniques may not practice them. According to Khan (2015), because of the unpredictable nature of human behaviour change, it is essential that long term individuals and organizational involvement is necessary for energy efficiency achievement. Some people may claim to favour energy efficiency, but do not follow through when it comes to changing their own behaviours (U.S department of energy, 2007).

Raising awareness informs and educates people about a topic or an issue with the intention of influencing their attitudes, behaviours and beliefs towards the achievement of a defined purpose or goal (Sayers, 2006). Energy awareness is the first step to achieve energy sustainability and without it, efforts to promote energy conservation can be difficult and lead to energy wastage. According to Choong (2010), the consumption of electricity in residential buildings is highly dependent on the behaviour of the residents. Energy is wasted each day due to lack of awareness among societies. Behavioural approach requires changes in human attitudes by using motivation, raising awareness and skill developing (Choong, 2007). Energy saving or energy conservation through the change of human behaviour only, without any capital cost can be a great option to meet demand instead of increasing generation (Khan, 2015). It is a fact that empowering the knowledge of staff contributes to sustainable energy savings (ESKOM, 2015).

In the past, education has played a role in bringing awareness regarding energy conservation and environmental issues, but has not necessarily resulted in sustained behavioural changes, for example, among students across university campuses (Emeakaroha et al., 2012). Energy awareness campaigns are a worthwhile investment. There is probably a limitless number of resources that can be put together to bring out the best of occupancy behaviour. These could range from energy awareness campaigns, incentives, punitive measures and technological among others (Masoso, 2009). According to Khan (2015), it is possible to save the electrical energy through behaviour change from 3% to 20%. A research carried out on families in military housing revealed that the total energy savings in family housing was 10%. Since military residents were not paying for their own utility bills, the reductions in energy use experienced resulted purely from behavioural changes and not from monetary gain (U.S department of energy, 2007). Experiments have shown that 5 to 10% of the domestic energy use can be saved by correct domestic behaviour (Loozen, 2001).

CHAPTER SIX

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the summary of the findings, conclusions which were drawn from the findings of the study and it also provides the recommendations which arose from the conclusions. Suggestions for further research are also included in this chapter.

6.2 Summary of the findings

From the analysis and interpretation of data, the major findings of this study revealed the following:

1. The electric energy that would be saved every year by replacing all T8 fluorescent tubes by T8 LED tubes in university X, Y and Z would be 659303.51 kWh (44.9%), 43624.3 kWh (47.42%) and 99446.3 kWh (44.1%) respectively. But if the existing fluorescent lamps were left in the system and daylight sensors were installed, the electric energy saved in university X, Y and Z would be 970462 kWh (66%), 64188.9 kWh (69.8%) and 148808.35 kWh (66%) respectively. On the other hand if the fluorescent lamps were replaced by LED lamps and daylight sensors installed at the same time, electric energy saved in university X, Y and Z would be1194497.18 kWh (81.3%), 77377.63kWh (84.1%) and 182600.78kWh (81%) respectively.
2. If the existing inefficient process and production equipment in university X, Y and Z were replaced with energy efficient types, 73501.87kWh (18.1%),

336061kWh (38%) and 79944.13 kWh (30.6%) of electric energy respectively could be saved every year.

3. The unauthorised loads connected to the power supply within the universities consumed about 2922993 kWh (60.9%) of electric energy every year.
4. The majority of lighting lamps were the T8 fluorescent type and that the most common heating appliances in the universities were water heaters, electric iron boxes and electric cookers. Those who declared that their appliances were efficient and those who did not know the efficiency of their appliances were almost equal in number and that most of them rarely serviced their appliances.
5. It is also evident that majority of the respondents did not take advantage of natural light during the day which was supported by the fact that most of them did not switch off unnecessary lights.
6. All respondents agreed that there was a lot of wastage of electric energy in universities and gave some of the areas of wastage as: Cooking and warming rooms in hostels; leaving lights on throughout the day and night in hostels, lecture rooms, library, workshops and laboratories.
7. According to most respondents, the key barriers to adoption of electric energy saving measures in universities include: Ignorance; do not care attitude among the end-users because they did not pay electricity bills; lack of policy on energy saving and lack of incentives. Most of the administrators admitted that: There were no programmes, policies and regulations in the university that directly addressed the issues of energy saving; they had not employed any technology that would improve on electric energy saving in the university, and the university had not implemented any training on energy saving techniques.

6.3 Conclusions

The study concluded that: there was electric energy saving potential of up to 82% at universities in Kenya that could be achieved through replacing T8 linear fluorescent lamps with the T8 LED lamps and installing daylight sensors in university buildings; as high as 29% of electric energy could be saved by replacing existing power equipment in universities with energy efficient types; up to 61% of electric energy could be saved by avoiding unauthorised electric loads and using alternative green energy sources instead; introducing policy on energy saving as well as training end-users on electric energy saving techniques could greatly assist to reduce energy consumption in universities.

There was therefore a very high potential for saving electric energy in Kenyan universities that could be achieved through the use of technological and behavioural techniques.

6.4 Recommendations

To save electric energy consumed at the universities, the following recommendations were made after conducting this research:

Kenyan universities should:

1. Replace all the linear T8 fluorescent lamps with T8 LED lamps and Install daylight sensors in buildings. Also replace the inefficient production, process and office equipment with energy efficient types.

2. Design kitchenettes that use alternative energy sources such as biogas for cooking. Electric energy efficient cookers could be purchased to be used in the kitchenettes in absence of alternative energy sources.
3. Integrate green skills and attitudes as part of curricula, training regulations and training programmes so as to promote the greening of the institutions. A collective action could be mobilized by establishing green agendas as a norm in the universities.
4. Implement a training and education strategy on energy saving techniques for all end-users. Also come up with procurement policies that take into account life cycle costing as opposed to only first costs when purchasing electric energy consuming equipment.

6.5 Suggestions for further studies

The following were suggestions for further studies:

1. A research on the pay-back time for the energy efficiency equipment, energy saving lamps, daylight sensors and the alternative green sources that could be purchased in the universities for the purpose of saving electric energy.
2. A research on the actual amount of electric energy saved at the universities through raising the level of awareness of the end-users.

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APPENDICES

APPENDIX I: KENYAN PUBLIC UNIVERSITIES AND UNIVERSITY COLLEGES

1. University of Nairobi
2. Kenyatta University
3. Moi University
4. Egerton University
5. Jomo Kenyatta University of Agriculture and Technology
6. Maseno University
7. Masinde Muliro University of Science and Technology
8. Technical University of Kenya
9. Technical University of Mombasa
10. Dedan Kimathi University of Technology
11. Pwani University
12. Chuka University
13. Kisii University
14. Maasai Mara University
15. Meru University of Science and Technology
16. South Eastern Kenya University
17. Jaramogi Oginga Odinga University of Science and Technology
18. University of Kabianga
19. Multimedia University of Kenya
20. Laikipia University
21. Karatina University
22. University of Eldoret

23. Kibabii University
24. Taita Taveta University College
25. Muranga University College
26. Kirinyaga University College
27. Co-operative University College of Kenya
28. Garissa University College
29. Rongo University College
30. Embu University College
31. Machakos University College
32. Kaimosi Friends University College
33. Tom Mboya University College

APENDIX II: KENYAN PRIVATE UNIVERSITIES AND UNIVERSITY COLLEGES

1. Africa International University
2. African Leadership University
3. Africa Nazarene University
4. Catholic University of Eastern Africa
5. Daystar University
6. Great Lakes University of Kisumu
7. Gretsa University
8. Inoorero University
9. International Leadership University
10. Kabarak University
11. KCA University
12. Kenya Highlands Evangelical University
13. Kenya Methodist University
14. Kiriri Women's University of Science & Technology
15. Mount Kenya University
16. Pan Africa Christian University
17. Pioneer International University
18. Regina Pacis University College
19. Riara University
20. Scott Christian University
21. St Paul's University
22. Tangaza University College
23. The East Africa University
24. The Management Univesity of Africa

25. The Presbyterian University of East Africa

26. United States International University

27. University of Eastern Africa, Baraton

28. Uzima University College

29. Umma University

30. Zetech University

Source: KUCCPS, 2016

APPENDIX III: TABLE FOR SAMPLE SIZE FOR FINITE POPULATION

N	**S**	**N**	**S**	**N**	**S**
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	546
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

NOTE: N is population size, S is sample size

Source: Krejcie & Morgan, 1970

APPENDIX IV: QUESTIONNAIRES

QUESTIONNAIRE 1 (FOR UNIVERSITY STAFF)

Directions:

[1] This is a survey research which aims at determining the electric energy saving potential in Kenyan universities using the available electric energy saving measures. This would play a major role in reducing the proportion of the budget on electricity bills in the universities.

[2] The data collected will be used for academic purposes only and therefore do not write your name anywhere in the questionnaire. All your responses will be treated with utmost confidentiality.

Kindly complete the questionnaire by ticking against the choices given.

1. Your gender?

   Male [ ]   Female [ ]

2. Your age?

   18 – 25 yrs [ ]   26 – 33 yrs [ ]   34 yrs and above [ ]

3. Your highest level of education?

   Standard 8 [ ]   Form 4 [ ]   University [ ]

4. Which department are you working?

Central services [ ] Catering [ ] Academic [ ] Administration [ ]

Technical [ ] Other (specify) ___________________________________

____

5. How long have you worked in the university?

Under 1 year [ ] 2 – 5 years [ ] Above 5 years [ ]

6 (i) What type of lamp do you use in your place of work?

Ordinary bulbs [ ] Fluorescent lamps [ ] Compact fluorescent lamps [ ]

LED lamps [ ] Others (specify) ________________________________

____

(ii) Do you switch off when not in use?

Yes [ ] No [ ]

(iii) Do you make use of natural light during working hours?

Yes [ ] No [ ]

If yes, how do you do it? ____

7(i) Which heating device do you use in your place of work?

Electric cooker [ ] Water heater [ ] Iron box [ ] Microwave oven [ ]

Toaster [ ] Arc welding machine [ ] Other (specify) __________

____

(ii) Have you set the heating device timers and thermostats correctly?

Yes [ ] No [ ]

If yes, how have you done it? ____

If no, what is the reason? ____

(iii) Do you turn off the heating devices at the plug when not in use?

Yes [ ] No [ ]

8 (i) Do you leave electric equipment at stand-by mode all the time?

Yes [ ] No [ ]

(ii) Do you turn off the electric equipment at the plug every end of the day?

Yes [ ] No [ ]

(iii) Have you set all electric equipment at energy-saving mode?

Yes [ ] No [ ]

If yes, state what you have done ____________________________________

If No, what is the reason? ____

For Laboratory/Workshop equipment

9 (i) How old are your electric equipment?

Under 5 yrs [ ] 6 – 10 yrs [ ] Over 10 yrs [ ]

(ii) How often do you service your equipment?

Regularly [ ] Rarely [ ] Not at all [ ]

(iii) Is your electric equipment energy efficient?

Yes [ ] No [ ] I do not know [ ]

10. At the moment we are being presented with a picture that we are living in an energy crisis. Do you think so?

Yes [ ] No [ ]

11. Do you think that electric energy saving is important to you?

Yes [ ] No [ ]

If yes, state the reason(s) ______________________________________

12. Have you been trained on electric energy saving techniques?

Yes [ ] No [ ]

13. What would motivate you to change your behaviour to reduce electric energy consumption?

Increasing cost of it [ ] Environmental reasons [ ] Public relations [ ] other (specify) ______________________________________

____

14. What is your general attitude to electric energy saving?

Positive [ ] Neutral [ ] Negative [ ]

QUESTIONNAIRE 2 (FOR UNIVERSITY STUDENTS)

Directions:

[1] This is a survey research which aims at determining the electric energy saving potential in Kenyan universities using the available electric energy saving measures. This would play a major role in reducing the proportion of the budget on electricity bills in the universities.

[2] The data collected will be used for academic purposes only and therefore do not write your name anywhere in the questionnaire. All your responses will be treated with utmost confidentiality.

Kindly complete the questionnaire by ticking against the choices given.

1. Your gender?

    Male [ ]   Female [ ]

2. Your age?

    15 – 20 yrs [ ]   21 – 26 yrs [ ]   27 yrs and above [ ]

3. Which is your school/Faculty?

    Engineering [ ]   Education [ ]   Arts & social sciences [ ] Biological & Physical sciences [ ]   Business & Economics [ ]   Human resource [ ]   Other (specify) ___________________________________

4.(i) What type of lamp do you use in your hostel?

Ordinary bulbs [ ] Fluorescent lamps [ ] Compact fluorescent lamps [ ] LED lamps [ ] Others (specify) ____________________

____

(ii) Are lamps switched off when not in use?

Yes [ ] No [ ]

(iii) Do you make use of natural light when in hostel?

Yes [ ] No [ ]

If yes, how do you do it? ____

5. (i) Which heating equipment do you use in your hostel?

Electric cooker [ ] Water heater [ ] Iron box [ ] Microwave oven [ ]

Other (specify) ____

(ii) Have you set the heating equipment timers and thermostats correctly?

Yes [ ] No [ ]

If yes, how have you done it? ____________________________________

____

If no, what is the reason? _______________________________________

____

(iii) How long do you leave your heating equipment on in a day?

Less than 1 hr [ ] 2 – 3 hrs [ ] 4 – 5 hrs [ ] More than 5 hrs [ ]

(iv) Do you turn off the heating equipment at the plug when not in use?

Yes [ ]   No [ ]

(v) How often do you service your heating equipment?

Regularly [ ]   Rarely [ ]   Not at all [ ]

(vi) Is your heating equipment energy efficient?

Yes [ ]   No [ ]   I do not know [ ]

6. At the moment we are being presented with a picture that we are living in an energy crisis. Do you think so?

Yes [ ]   No [ ]

7. Do you think that electric energy saving is important to you?

Yes [ ]   No [ ]

If yes, state the reason(s) ____

____

____

8. Have you been trained on electric energy saving techniques?

Yes [ ]   No [ ]

9. What would motivate you to change your behaviour to reduce electric energy consumption?

Increasing cost of it [ ]   Environmental reasons [ ]   Public relations [ ]

Other (specify) ____

____

10. What is your general attitude to electric energy saving?

Positive [ ]   Neutral [ ]   Negative [ ]

APPENDIX V: INTERVIEW SCHEDULES

INTERVIEW SCHEDULE 1 (FOR UNIVERSITY STAFF)

[a] In which department do you work?

[b] At the moment we are being presented with a picture that we are living in an energy crisis. Do you think so?

[c] What do you mostly use electricity for in your place of work?

[d] Do you think that electric energy saving is important to you?

[e] Have you been trained on electric energy saving techniques?

[f] How often do you practice electric energy saving techniques?

[g] Do you think there is wastage of electric energy in the university?

[h] What do you think should be done to save electric energy in the university?

[i] What are the key barriers to the adoption of electric energy saving measures in the university?

[j] What would motivate you to change your behaviour to reduce electric energy consumption?

[k] What is your general attitude towards electric energy saving?

INTERVIEW SCHEDULE 2 (FOR UNIVERSITY STUDENTS)

[a] Which is your department?

[b] Which year are you?

[c] What do you mostly use electricity for?

[d] Are you aware of electric energy saving techniques?

[e] Do you practice the energy saving techniques?

[f] Do you think there is wastage of electric energy in the university?

[g] What do you think should be done to save electric energy in the university?

[h] What are the key barriers to the adoption of electric energy saving measures in the university?

[i] What would motivate you to change your behaviour to reduce electric energy consumption?

[j] What is your general attitude towards electric energy saving?

INTERVIEW SCHEDULE 2 (FOR UNIVERSITY ADMINISTRATORS)

[a] At the moment we are being presented with a picture that we are living in an energy crisis. Do you think so?

[b] Do you think that action needs to be taken immediately to reduce energy consumption?

[c] What is the position of the university on the importance of electric energy saving and its strategic role in the creation of new programmes, policies and regulations?

[d] What type of technologies do you use to improve on electric energy saving/efficiency in the university?

[e] Does the university have a procurement policy that takes into account Life Cycle Costing as opposed to only First Costs when purchasing electric energy consuming equipment?

[f] In the acquisition of new university buildings or renovations of existing buildings, does the university have a policy that requires that it address electric energy saving measures?

[g] How has the university implemented a training and education strategy to ensure you have the capacity to achieve your electric energy saving objectives?

[h] Do you make use of renewable (green) electric energy sources in the university?

[i] What are the key barriers to the adoption of electric energy saving measures in the university?

APPENDIX VI: OBSERVATION SCHEDULE/CHECKLIST

Electric loads	**Qty**	**Power rating (kW)**	**Total power (kW)**	**Total energy consumed per year (kWh)**	**Alter native rating (kW)**	**Total (kW)**	**Energy consumed per year (kWh)**	**Energy saved per year (kWh)**
Fluorescent lamp								
Incandescent lamp								
Desktop Computer								
Portable Computer								
Photocopier								
Printers								
Electric Water heaters								
Electric Cooker								
Motor								
Drilling Machine								
Grinding Machine								
Lathe Machine								
Welding Machine								
Cutting Machine								
Unauthorise d load								
Cooling Fan								
Refrigerator								
Electric iron								
Water pump								
Compr essor								

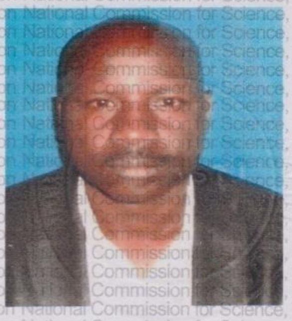
APPENDIX VII: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. WESLEY KIPROTICH MUTAI
of UNIVERSITY OF ELDORET, 4958-30100 ELDORET,has been permitted to conduct research in *Nairobi, Nandi , Uasin-Gishu Counties*

on the topic: *ELECTRIC ENERGY SAVING POTENTIAL IN KENYAN UNIVERSITIES*

for the period ending:
24th March,2018

Permit No : NACOSTI/P/17/13071/15734
Date Of Issue : 24th March,2017
Fee Recieved :ksh 2000



....
Applicant's Signature

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

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEACH CLEARANCE PERMIT

Serial No.A 13351

CONDITIONS: see back page

APPENDIX VIII: SOME PHOTOGRAPHS OF PROCESS AND PRODUCTION EQUIPMENT IN UNIVERSITIES

Source: Author, 2017

Source: Author, 2018

Source: Author, 2017

Source: Author, 2017

Source: Author, 2017

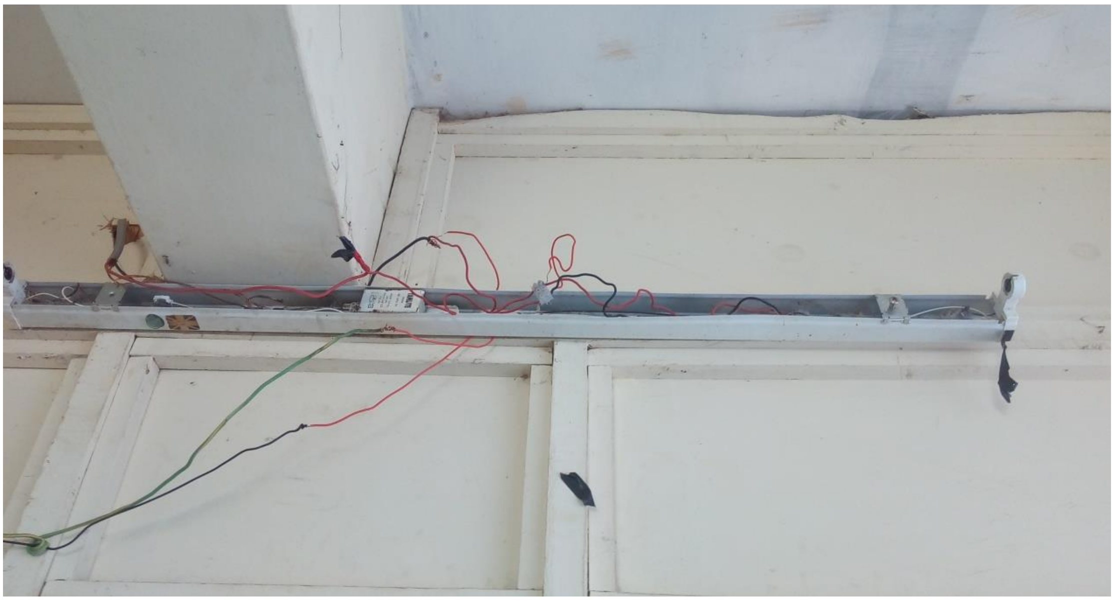
Source: Author, 2017

Source: Author, 2017

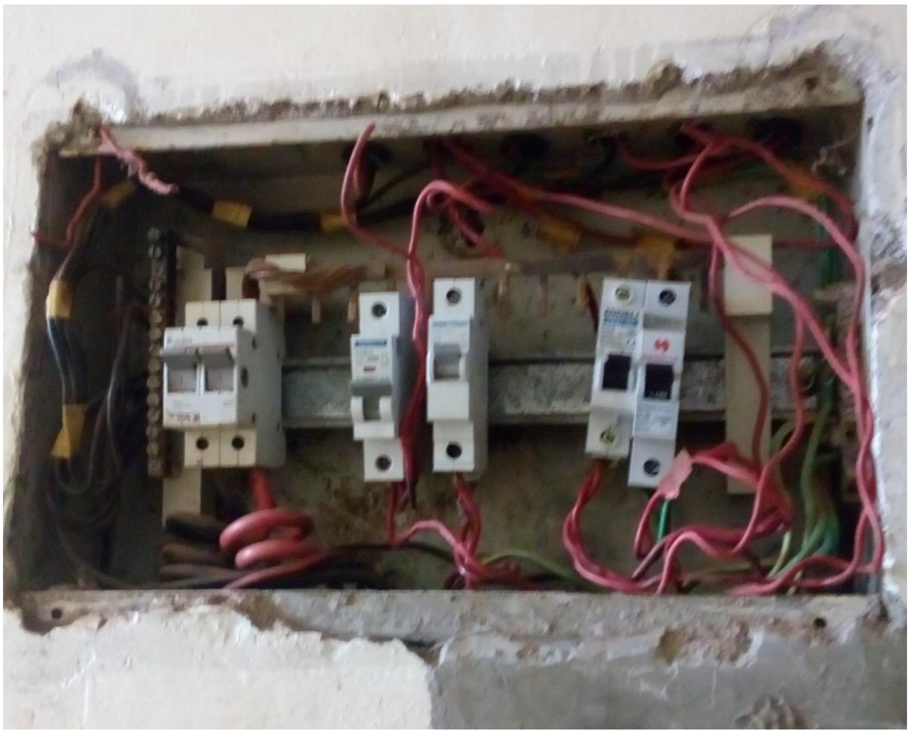
Source: Author, 2017

Source: Author, 2017

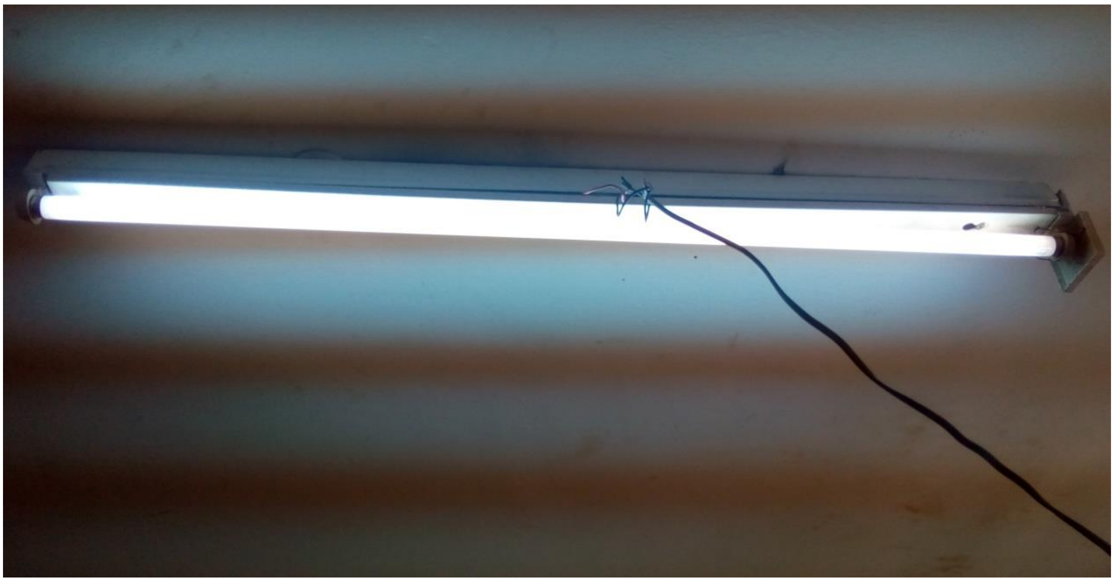
APPENDIX IX: SOME PHOTOGRAPHS OF CONNECTED UNAUTHORISED LOADS



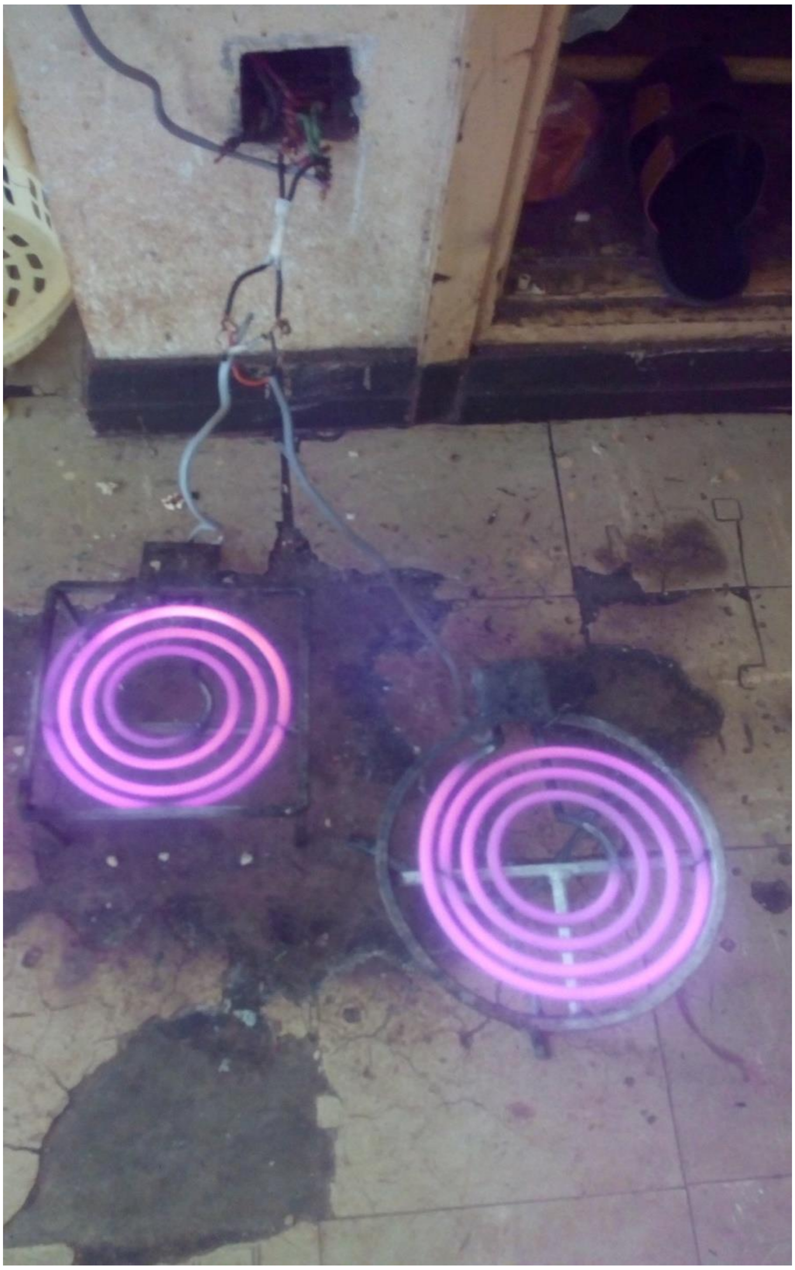
Source: Author, 2017



Source: Author, 2017



Source: Author, 2017



Source: Author, 2017