AN ASSESSMENT OF ELECTRICITY WASTAGE AND CONSERVATION STRATEGIES ADOPTED BY SELECTED MANUFACTURING INDUSTRIES WITHIN ELDORET MUNICIPALITY, KENYA

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ABSTRACT

Electricity is the most common and widely used type of energy globally because a large proportion of all the other types of energy are converted and distributed as electricity for end-users. In Kenya, electricity is the third most-used source of energy after fuel wood and petroleum products, and is second to petroleum fuels as a source of commercial energy. Currently, Kenya is experiencing high electricity demand that has exceeded its generation capacity. However, estimates by Kenya Power and Lighting Company indicated that 40% of electricity is wasted at end-use stages by Kenya's users indicating the need for electricity conservation strategies in all sectors. Eldoret Municipality is the fifth largest and one of the fastest growing industrial towns in Kenya yet information on electricity conservation strategies within its manufacturing industries is scarce. The study sought to identify sources of electricity wastage and identify electricity conservation strategies adopted to reduce the wastage by selected manufacturing industries within Eldoret Municipality. The specific objectives of the study were to: identify sources of electricity wastage; identify and analyse policies for electricity conservation; established the technological/operational strategies and; assess staff responsibilities in electricity conservation. Of the 690 registered manufacturing industries in Kenya, 25 of them are located within Eldoret Municipality. Eight of the 25 manufacturing industries within Eldoret Municipality were selected for the study. Purposive random sampling was used to select; (i) types of industries which included textile, paper manufacturing industry, wood industry, food processors, beverage industry and engineering firm and; (ii) 107 key informants who comprised of management, machine operators, electricians and other workers within each selected industry. Primary data was collected through the identification of expected consumption of electricity, scrutinizing monthly electricity bills, key informant interviews, observations, and administering questionnaires. Secondary data was obtained by review of relevant literature from internet, libraries, Sessional Papers and pamphlets from KPLC. Data analysis was conducted quantitatively using descriptive statistics namely frequencies and cross-tabulations and; qualitatively by coding and making scientific discussions. The findings of the study were presented in the form of tables, charts, plates and discussions. The selected industries were categorized as heavy or light according to electricity consumption. Ten sources of electricity wastage were identified in both heavy and light selected manufacturing industries within Eldoret Municipality. The study established that the selected manufacturing industries had adopted six policy and eight operational/technological strategies to reduce electricity wastage and conserve electricity. Each category of industry workers such as management, engineers, electricians, machine operators were individually responsible in the identification or implementation of the electricity conservation strategies within the selected manufacturing industries. However, inadequate training on electricity conservation, lack of proper communication channels, and inadequate staff motivation within industries hampered participation of industry workers in electricity conservation. The study recommended the establishment of effective monitoring systems of electricity consumption to enable easy identification of sources of electricity wastage and effectiveness of conservation strategies used; full enforcement of existing electricity conservation policies; training and creating awareness to all workers on sources of electricity wastage and electricity conservation strategies used to reduce electricity wastage. It is hoped that the findings of the study will benefit KPLC, manufacturing industries and government in implementing the identified electricity conservation strategies.

CHAPTER ONE

INTRODUCTION

1.1. Background to the Study

Energy refers to the capacity or power of a physical system to do work. It can exist in a variety of forms, such as kinetic, potential, radiation, electrical, mechanical, chemical, thermal, or nuclear, and can be transformed from one form to another. It is measured by the amount of work done, usually in joules or watts (Houghton Mifflin Company, 2009). GoK (2006a) also stated that energy means any source of electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, or thermal power for any use; and includes electricity, petroleum and other fossil fuels, geothermal steam, biomass and all its derivatives, municipal waste, solar, wind and tidal wave power.

Energy is central to the world's economy, providing power needed for industrial production, transportation and agricultural advancement (UNEP, 2000). According to WRI *et al* (1996), the energy sources include fossil fuels (coal, oil and natural gas), biomass (wood, dung), hydropower, solar power, wind power, tidal power, nuclear power and geothermal energy. Economic Watch (2000) underscored that the total consumption of energy in the world in 1999 was 6,753 million TOE. The proportion in which energy from different sources was consumed was Oil (42.7%); Natural gas (16%); Electricity (15.4%); Renewable combustible wastes i.e. animal products, fuel wood and industrial wastes (14.2%); Coal (8.2%); and Others (3.5%). Of the total consumption of energy, developed countries consume about 60% while developing countries with 80% of the global population consumes about 40% (UNEP, 2000). However, developing countries are expected to increase their share of world energy use to about 45% by 2020 due to industrialization. In Africa, biomass energy sources provide about 37% of the total energy used and; in East Africa, 84% of all energy used comes from biomass energy while commercial sources that encompasses electricity accounts for only 16% of the total consumption (UNEP, 2000).

Electricity refers to energy involving the use of electric current which may be produced either by mechanical, chemical, photovoltaic or any other means (Houghton Mifflin Company, 2009). Sources of electricity are divided into two main categories; renewable and non-renewable sources. Non-renewable sources of electricity are; fossil fuels (oil, natural gas and coal) and nuclear fuels. The renewable sources of electricity include: biomass, hydropower, wind power, solar power, geothermal energy, and tidal energy.

Electricity is the most common and widely used type of energy in the world as compared to the other types of energy (Khan, 1996). This according to UNEP (2000) is because a large proportion of primary energy is used for electric power generation. In Kenya, electricity accounts for 9 per cent of total energy use. It is therefore the third most used source of energy in Kenya after fuel wood (70%) and petroleum products (21%) and; is thus second to petroleum fuel as a source of commercial energy (GoK, 2009). The total installed capacity of electricity in Kenya, as of March, 2009 was 1245MW comprising of; 692MW hydropower, 163MW geothermal and 390MW thermal, which includes 146MW of emergency capacity (KPLC, 2009a). The key players in electricity sector are; KPLC, KENGEN, ERC, MOE, and independent power producers (IPPs). KPLC which is 48.4 per cent government-owned, is the only licensed public electricity transmitter and distributor in Kenya. The main electricity generating bodies in Kenya are the state-owned KENGEN; and three IPPs. KPLC purchases the power from KENGEN and the IPPs through signed contracts. GoK (2006a) reported that KENGEN's electricity generation accounts for more than 82 per cent of the country's total installed generation capacity and the IPPs' generation accounts for 18 per cent.

The high cost of energy particularly electricity is one of the biggest bottlenecks to economic activities in Kenya. 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 problem of high cost is also compounded by unreliability of supply caused by drought periods. On average, manufacturing companies in Kenya lose 9.5 per cent of production because of power outages and fluctuations. This excludes the losses from damaged equipment as a result of power interruptions, which were up to Ksh 1 million for a manufacturing company in 2001. Inefficiency in the use of energy is also one of the factors impeding the competitiveness of the Kenya's products in international markets (KIPPRA, 2005).

conservation of electricity for domestic users: For food refrigeration, one need to buy refrigerators or freezers in sizes that are just large enough for the family needs, condensers should be dusted after every three months. In addition, leisurely inspection of refrigerator contents should be discouraged and when taking holiday and; the refrigerators should be turned off, emptied, cleaned and its door left open. When cooking, cooking utensils should have lids to reduce cooking duration, pans and pot sizes should be matched with stove plates, prefer the use of microwave as it reduces electricity used up to 70%. For lighting, conservation strategies include: building new houses with large windows facing away from obstruction to let in as much natural light as possible, urging people to switch off lights when not in use, replacing incandescent bulbs with fluorescent bulbs and choosing light colours for decorations, and painting of walls, ceilings, floors and furniture to ensure maximum reflections. Other strategies for lighting are installation of dimming switches, cleaning lighting fixtures regularly and making sure that outdoor lighting is put off during day time. During laundering, clothes should always be dried outdoors, cold or lukewarm water should be used; front loading washing machines should be preferred as they use less energy than top loading machines. While ironing, an iron that is thermostatically controlled should always be used and the iron should be turned off every time there is an interruption or 5 minutes before all clothes have been ironed. In room heating, low voltage heaters with a thermostat should be used as well as keeping the doors closed for heated rooms. Generally, the power factor in the household should be ensured that it remains above 0.9 (KPLC, 2009b).

In the early 1980s, states and utilities promoted energy efficiency as one form of "demand-side management" to reduce the need for construction of new power plants. Many industries particularly manufacturing sectors re-engineered their processes to save energy. Conservation and efficiency were also championed by some as a lower-cost and more environmentally appealing way to achieve greater energy security than policies to boost supply (Bamberger, 2006). Itron (2008) highlighted the cross-cutting electricity conservation strategies currently used in industrial sectors such as: proper and regular maintenance of motors, replacement of motors with high-energy efficient ones, training all industrial workers on electricity conservation strategies, installation of electricity efficient lighting, for example, compact fluorescent with ballast and dimming switches, installation of pumps control switches so as to shut off unneeded pumps or, alternatively, to reduce pump load until needed. In addition, idle processing units should always be switched off every time possible. Energy audits are done regularly as a monitoring tool of achievements of the strategies and facilitate future improvements that ensure maximum savings.

The Government of Kenya, through the Sessional Paper No. 4 of 2004 on energy, recognizes that energy is a critical input into the country's development process. It thus encourages energy efficiency and conservation in all sectors of the economy in order to reduce cost and wastage, and also enhance competitiveness (GoK, 2004). With the increasing national focus on the scarcity and cost of energy, advocacy on stakeholder collaboration has been conducted to enable the achievement of the overall objective of energy conservation and efficiency. As a result, the private sector is now much more aware of the critical role it must play as the primary beneficiary of energy efficiency and conservation programmes which were, in the past, largely spearheaded by the public sector. The leading private player in the Kenyan industrial sector, the Kenya Association of Manufacturers (KAM), has reported that the industrial sector consumes a large proportion of the available commercial energy which is very costly. It is estimated that large commercial and industrial sectors in Kenya consume 60% of electricity generated (KAM, 2009). KAM is therefore keen in promoting energy efficiency and conservation among manufacturers and, in other sectors as well. Several projects that aimed at reducing energy use and reliance on oil imports have also been undertaken during the past 30 years in Kenya. These projects include; the World Bank project of the 1980s in which it financed the exploration of geothermal power as alternative energy source to hydropower and oil products, the UNIDO supported energy conservation programme executed through the KAM also implemented the IPMVP protocol as a policy strategy of conserving electricity while the GEF-KAM project launched in 2001 promoted the adoption of energy-efficiency technologies such as replacing incandescent bulbs with fluorescent bulbs.

FEES and Cook (1991) highlighted that electrical-energy savings at the household level is almost 18 times greater than the energy recovered through recycling. For instance, if a family of three reduces their waste steam by 10% using appliances that have lids/caps, approximately 77,400 BTUs of energy could be saved. Reducing electrical costs in the average home by 10% could mean a savings of 1,365,000 BTUs at the power plant. Kilawatts Partners (2003) also reported that it used electricity efficient and conservation technologies such as energy saving bulbs and brightly-painted walls of houses to produce electricity savings of 32-43% in commercial buildings in Vermont, USA. These savings were real KWh reductions calculated by comparing monthly utility bills to baseline bills.

In Kenya, KPLC has launched an electricity saving campaign titled 'Using Electricity Efficiently' in which it gives strategies to the clients on how to conserve electricity and make 40% in monetary savings from their monthly electricity bills. The strategies of KPLC include replacement of incandescent lamps with compact fluorescents lamps, switching off un-needed lights and electrical appliances and regular maintenance or replacement of inefficient electrical appliances. According to KAM (2004), the GEF-KAM Industrial Energy Efficiency Project in the Kenyan industrial sector in 2001-2003 revealed that the energy saving potential for the sector is 14% of its total energy consumption. The participating industries in the project adopted strategies such as the use of high-efficiency motors, high-efficiency induction furnaces for heating, upgrading lighting systems to fluorescent bulbs with computerized switches, training staff to switch off all the equipment and lights when not in use, encouraging the use of natural light, redesigning buildings to allow maximum uptake of sunlight and introduction of annual rewards for industries that achieves highest electricity saving using the cost-effective strategies. The highest of the savings as expressed in monetary terms were that of electricity as illustrated in the Figure 1 below:

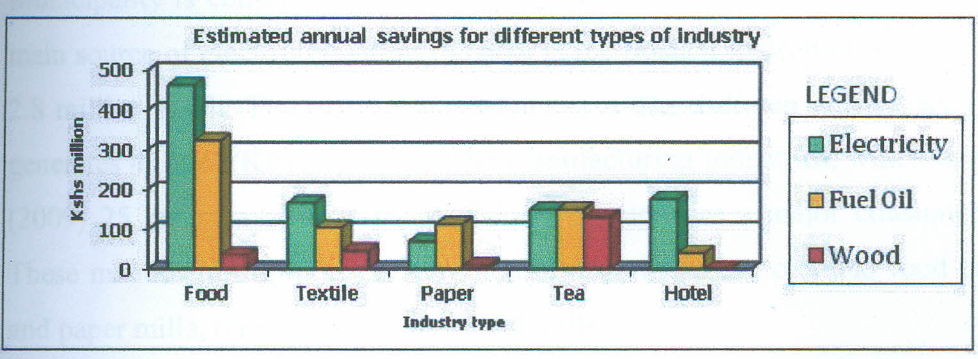


Figure 1: Annual monetary savings for conserving energy in industrial sector

Source: Kenya Association of Manufacturers (KAM), 2004

Electricity conservation has several benefits that include reducing power rationings, increase distribution of power to more households thus promoting developments in both rural and urban areas which further alleviate poverty. KPLC (2009) stated that at the household level, electricity conservation leads to reduced expenditures in electricity bills without sacrificing comfort and convenience. Furthermore, electricity conservation will lead to reduced conversion of fossil fuels to generate electricity hence decreased emission of greenhouse gases.

The manufacturing industries particularly six SMEs (General Motors, Spin Knit, Haco, Farmers Choice, Pwani Oil and Chandaria Tissue Papers Manufacturers) in Nairobi have successfully implemented retrofit (i.e. addition of new technologies or features to an older system to allow new or updated parts to be fitted to old or outdated assemblies) energy efficiency projects within their industry plants. The retrofit technologies include: emission controls for diesel engines, occupancy sensors to replace manual switches, integration of photo-sensors to exterior or security lights, replacement of hydraulic power systems by electrical systems and replacement of incandescent lights with Compact Fluorescent Lamps (CFL). The projects have achieved reduction in electricity savings by between 10 and 40 percent

The electricity conservation strategies vary across various sectors of Kenyan economy and it is on this basis that this study focuses on the assessment of electricity conservation strategies adopted by selected manufacturing industries within Eldoret Municipality. The Municipality is considered the fifth largest and one of the fastest growing in Kenya. The main source of electricity within the area is the Sosiani hydropower station which supplies 2.8 million KWh. The other major source is a diesel-driven emergency power plant that generates 43MW (KPLC, 2009). The manufacturing industries, which according to KAM (2009) 25 are members of KAM Eldoret chapter, are a major consumers of electricity. These manufacturing industries are textile manufacturers; oils and food processers, wood and paper mills, tyre retreading and steel mills.

1.2. Statement of the Problem

Eldoret Municipality is the fifth largest and is one of the fastest growing industrial towns in Kenya and yet information of sources of electricity wastage and conservation strategies within its manufacturing industries is scarce. This study therefore sought to identify electricity wastage and conservation strategies adopted by selected manufacturing industries within Eldoret Municipality. Unlike previous studies which examined the energy-efficient technologies in conserving all the energy types consumed in SMEs of Kenya (KAM, 2004 and DSCLES, 2009), the study sought to identify the sources of electricity wastage in selected manufacturing industries within Eldoret Municipality and identify conservation strategies applied to reduce the wastage. The results of the study are expected to benefit manufacturing industries and energy policy makers in the development of electricity conservation policies.

1.3. Research Objectives

The general objective of the study was to assess the electricity wastage and conservation strategies adopted by selected manufacturing industries within Eldoret Municipality. Specific objectives of the study were;

(i). To identify sources of electricity wastage in the selected manufacturing industries within Eldoret Municipality

(ii). To identify and analyze policies for electricity conservation used by selected manufacturing industries within Eldoret Municipality

(iii). To establish the technological/operational strategies for electricity conservation used by selected manufacturing industries within Eldoret Municipality

(iv). To assess the staff responsibilities in the electricity conservation processes in selected manufacturing industries within Eldoret Municipality

1.4. Research Questions

The study was guided by the following research questions:

(i). What are the sources of electricity wastage in the selected manufacturing industries within Eldoret Municipality?

(ii). Are there policies for electricity conservation used by the selected manufacturing industries within Eldoret Municipality?

(iii). What are the technological/operational strategies for conservation of electricity by selected manufacturing industries within Eldoret Municipality?

(iv). What are the responsibilities of various industry staff in electricity conservation of selected manufacturing industries within Eldoret Municipality?

1.5. Justification/Significance of the study

A survey conducted in 2003 by KAM on various projects in SMEs within Nairobi namely General Motors, Chandaria Ltd, Spin Knit Ltd, Haco Ltd, Pwani Oil and Farmers Choice estimated that, wastage of electricity ranged between 10% and 30% of the primary electricity input, but the adoption of conservation strategies led to savings of 10% of electricity within a short period of less than six months (DSCLES, 2009 and KAM, 2004). However, information of electricity wastage and conservation strategies adopted by manufacturing industries in Kenya remain scarce. This prompted the study which is expected to fill the existing knowledge gaps by; identifying sources of electricity wastage and conservation strategies adopted by manufacturing industries within Eldoret municipality. The results of the study are expected to benefit the energy sector, policy makers in manufacturing industries and other institutions such as universities and schools within Eldoret Municipality and nationally in developing and implementing policy and technological/operational strategies for electricity conservation.

1.6. Scope and Limits of the Study

The scope of the study was based on manufacturing industries within Eldoret Municipality, Kenya. The study chose to identify sources of electricity wastage and conservation strategies adopted by eight (8) selected manufacturing industries. The selected manufacturing industries included; food processing industries, textile manufacturers, pulp and paper mills and metal engineering firm. The average distance of the selected manufacturing industries from each other is approximately one (1) kilometer.

1.7. Review of Related Literature

1.7.1. Introduction

This section examines studies related to the topic of research. It is aimed at highlighting researches and projects that have been done on related issues and the lessons that have been or can be learnt. The section also identifies critical gaps of knowledge on the research topic based on past researches. The section has been divided into sub-sections that are in line with the research objectives and the conceptual framework of the study.

1.7.2. Sources of electricity wastage

Electricity wastage in transmission and distribution networks represents the single biggest problem in any electricity system. Globally average wastage in the electric network system is 8.8%. The electricity losses start at the beginning of the electricity supply chain, with the combustion efficiency of the primary energy. But the big losses occur in a thermal power station where the conversion efficiency of heat to electricity is subject to thermo-dynamical limits (Leonardo Energy, 2008). Power is also lost in the supply network resulting from the use of equipment of lower efficiency. Campero (2008) however stated that network losses of electricity related to infrastructure and operation require remedies such as the upgrading of installations, better and new equipment for load control, better generation and transmission response control. These solutions maintain the level of electricity losses as low as technically possible.

The electrical energy is also wasted at the end-use stages. Lovins (2005) listed the end-use sources of electricity wastage especially in manufacturing industries as:

(i). Distribution losses of end-use devices such as high resistant cables, inefficient bulbs, inefficient motors and engines of the plants;

(ii). Undesired or useless services, such as leaving equipment or lights on all the time even when it serves no useful purpose;

(iii). Misused services, such as space-conditioning rooms that are open to the outdoors;

(iv). Conflicting services, such as heating and cooling the same space simultaneously;

(v). Misplaced efficiency, such as doing with energy-using equipment, however efficiently, a task that doesn't need the equipment.

1.7.3. Industrial electricity utilization and conservation policies in Kenya

Kenya has in the past set in action a number of policies to address energy issues in support of its development challenges (GoK, 2006a). One such policy is the National Energy Policy. The policy has a number of broad objectives including ensuring the adequate, reliable, cost effective and affordable supply of energy to meet development needs, while protecting and conserving the environment. The seventh specific objective of the national energy policy is to 'promote energy efficiency and conservation as well as prudent environmental practices'. The achievement of this seventh objective is relevant to a study of energy conservation mechanisms and particularly; a study of electricity conservation strategies adopted by Kenyan electricity users.

The Energy Policy in Kenya has evolved through Sessional Papers, regulations and Acts of Parliament (GoK, 2006a). The landmark policy paper that set the basis for development of the country, Sessional Paper No. 10 of 1965, dwelt on the Electric Power Act (CAP 314) that had been used to regulate the electricity sector. Sessional Paper No. 1 of 1986, which was another landmark policy blueprint, however did not focus much on the power sector. Instead, it called for the establishment of the Department of Price and Monopoly Control (DPMC) within Ministry of Finance to monitor acts of restraint of trade and to enforce pricing in the various sectors including petroleum. The next significant legislative development came in 1997. The Electric Power Act of 1997 was legislated to replace Electric power Act (Cap 314 of Laws of Kenya) and take on board new developments, and to facilitate private sector participation in the provision of electricity (GoK, 1997). Nevertheless, the Act was still inadequate in terms of providing incentives to the private sector and accelerating electrification in the country. The Electric Power Act of 1997 led to the establishment of Energy Regulatory Board in 1998, with the objective of regulating the generation, transmission and distribution of electric power in Kenya. The same Act unbundled generation from transmission and distribution of power, functions that were at the time being carried out by KPLC. Consequently, KENGEN was established in 1998. The Electric Power Act 1997 also provided for rural electrification on a limited scale using renewable energy technologies. The Electric power Act 1997 mandated the Electricity Regulation Board to set, review and adjust tariffs for all persons who transmit or distribute electrical energy and; to investigate tariff structure even when no specific application for a tariff adjustment has been made. The Act therefore promoted efficient supply and use of electricity through licensing suppliers, monitoring the supply and prescribing electricity consumption prices (GoK, 1997).

According to GoK (2006a) a major development in the energy sector had been the Sessional Paper No. 4 of 2004 on Energy. But the Sessional Paper had its focus on petroleum products rather than any other energy source in Kenya including electricity. The Energy Policy proposed the replacement of Petroleum Act Cap 116 with new legislation consistent with a liberalized petroleum sub sector that would, *inter alia*, establish a one stop shop for licensing importers and wholesalers of petroleum fuels, establish an inspectorate to enforce compliance with petroleum regulations, and oversee petroleum industry operations. The petroleum industry was liberalized in 1994 just like most markets in Kenya at that time (GoK, 2004). The Energy Act, 2006 was therefore enacted by parliament to amend and consolidate the law relating to energy, to provide for the establishment, powers and functions of the Energy Regulatory Commission and the Rural Electrification Authority (GoK, 2006). Energy Regulatory Commission was mandated by the Act to regulate importation, exportation, generation, transmission, distribution, supply and use of electrical energy.

In 2001, an industrial energy efficiency programme was launched by MOE, Government of Kenya with support from UNDP-GEF. The five year program called GEF-KAM Industrial Energy Efficiency Project was operated by the project management unit (PMU) set up at the KAM. The project implemented the IPMVP protocol in selected industries in Kenya. The main components of this program included; strengthening industry to undertake energy management activities and working with Government and other stakeholders to develop national policy, strategy and institutions for Energy Efficiency development. In 2003; three (3) SMEs namely; a tissue paper manufacturer (Chandaria), an engineering firm (General Motors) and a textile-processing unit (Spin Knit) were identified by GEF-KAM project as demonstration for the project. According to DSCLES (2009) three other SMEs namely; a plastic manufacturer (Haco), a meat processing unit (Farmers Choice) and an edible oil unit (Pwani Oil) were identified by GEF-KAM for the implementation of the energy efficiency demonstration project in its second phase. DSCLES (2009) also noted that all the six (6) industries that participated in GEF-KAM Industrial Energy Efficiency Project achieved about 10% savings in energy in a short period of less than six months.

The results achieved by implementing the retrofit demonstration projects have been widely disseminated among SMEs in Kenya. Success of these demonstration projects resulted in the need to develop an ESCO in Kenya, the formation of which is in progress. The CEEC at KAM has also built on the gains made by the GEF-KAM Energy Project to implement all future activities related to energy efficiency and conservation. The major achievements of GEF-KAM Project include the training of industry personnel in energy management and increasing awareness of energy conservation.

1.7.4. Technologies for efficient electricity utilization and conservation

End-use devices operate at a wide range of efficiencies to perform the desired work, from a few percentages for traditional light bulbs, to close to a perfect 100% for resistive heating, to effective efficiencies greater than 400% for certain types of heat pumps (Electric Power Research Institute, 2008). FEES and Cook (1991) pointed out that lighting efficient technologies are universal not only to industries but also to other users as well. Lighting efficiency is usually expressed in lumens per watt (lumen = about 1 candle). FEES and Cook (1991) illustrated that changing incandescent to compact fluorescent lighting is beneficial to everyone. Both energy and money are saved when one turns off fluorescent lights, even for a short period. When fluorescent lights were first introduced, starters were required along with ballast systems that required a heavy amount of start-up energy. Life was severely shortened by repeated on-off switching. However, beginning in 1976, fluorescent bulbs and ballasts became much more efficient. Consequently, both energy and money are saved when fluorescent lights are switched off even for a relatively short period, such as when going to the bathroom. Although bulb life is shortened slightly, the savings in energy is more and would compensate for the shortened lifespan of the bulb.

Itron (2008) in their study of Assessment of the Feasible and Achievable Levels of Electricity Savings from Investor Owned Utilities in Texas gave a list of the electricity efficiency measures in industries. The study concluded that advanced technologies such as sensor-switches, compact fluorescent lamps for lighting, servo motors and servo controllers (controls motions to high-energy efficient levels) in textile manufacturing, JetAir direct-drive blowers used in soft drinks industries such as Coca cola or Nestle companies, promised significant reductions in energy use, and implementing them may be less costly compared to generating electricity through supply expansions, taking into consideration the environmental costs associated with new installations. From this study, it is clear that technologies vary and are unique to a type of industry depending on its activities. However, the study highlighted the energy efficient measures that were cross-cutting to the entire industrial sector of Texas. Some of the measures include the following: The replacement of existing motors with high-efficiency motors to reduce energy losses through; improved design, better materials, tighter tolerances, and improved manufacturing techniques; installation of switch off sensors and training personnel to switch off lights (and other equipment) when not needed. In addition, matching adjustable speed drives (ASDs) with motor speed of loading leads to significant energy savings compared to constant speed motors. Energy efficiency and saving is also achieved by motor practices/proper motor maintenance.

Itron (2008) however, did not distinguish the mechanized technologies from the behavioural measures of energy efficiency and conservation. IEEJ (2004) and Nakatani (2006) also elaborated that, newly developed high-efficiency electrical equipment or combined technologies, which are about 'power electronics', 'microcomputers' and 'motion control' in addition to the progress of sensing devices and monitoring systems, bring both energy saving and high productivity in the factory. The technology trend of new factory facilities is concerned about changing power sources from pneumatic (compressed air) or hydraulic power (oil system) to electrical direct-driven servomotor systems, which have the technical characteristics of fine-grained and regenerative control. These technologies are able to reduce and recover idling (standby) power consumption during the holding period at the production stage in the factory.

Capacitor-technology is also applied to reduce electricity wastage by correcting the low power factor of large utilities such as large scale industries and commercial enterprises to 1 or nearly 1. Electrotek Concepts (2002) defined power factor as the ratio between active power and apparent power and is between 0 and 1. Active power is measured in kilowatts (KW) and reactive power is measured in Kilovolt-Amperes-Reactance (KVAR). Active power and reactive power together make up apparent power, which is measured in kilovolt-amperes (KVA). Active power does work while reactive power produces an electromagnetic field for inductive loads. It also stated that power factor is a measurement of how efficiently a facility uses electrical energy. A high power factor (1) means that electrical capacity is being utilized effectively, while a low power factor indicates poor utilization of electric power. Schneider Electric (2009) explained that, a load with low power factor draws more current than a load with a high power factor for the same amount of useful power transferred in an electric power system. Low power factor can cause equipment overloads, low voltage conditions, greater line losses, and increased heating of equipment that can shorten service life. Most importantly, low power factor can increase an electric bill with higher total demand charges and cost per kWh. This is because, for the wasted electrical energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

Electrotek Concepts (2002) stated that low power factor is generally solved by adding power factor correction capacitors to a facility's electrical distribution system. The power factor correction capacitors supply the necessary reactive portion of power (KVAR) for inductive devices. By supplying its own source of reactive power, a facility frees the utility from having to supply it. This generally results in a reduction in total customer demand for electricity and a significant reduction in power charges. Individual motor or lamp loads may have capacitors for power factor correction, or larger sets of capacitors (usually with automatic switching devices) may be installed at a load center within a building or in a large utility substation (often referred to as a capacitor bank).

1.7.5. Responsibilities of staff on energy conservation

Energy conservation within an industry is not a responsibility of only one individual or a selected few individuals within an industry, but it is a collective responsibility of all employees of an industry. According to Energy Conservation Centre, ECC (2007), all levels of employees working in an industrial factory, particularly operational workers who work closely with energy usage are collectively responsible for energy conservation. It is therefore essential that all industrial workers are aware of energy conservation measures and committed to executing them all the time during the operations of the industry to ensure maximum results of conservation.

According to EECA (2009), the responsibilities of high level managers and administrators in electricity conservations are:

(i). Identification of electricity conservation policies and the main targets and goals of electricity conservations;

(ii). Monitoring and supervising the various activities of electricity conservation so that they are being implemented in accordance with established policies;

(iii). Reviewing and considering recommendations from electricians and power managers.

The responsibilities of middle-level industry workers that include power managers are:

(i). Identification of areas of improvement in electricity conservations and identification of staff to implement the improvements

(ii). Monitoring, advising and assisting lower level staff in implementing the electricity conservation strategies

(iii). Regularly reporting the progress of the electricity conservation activities, including recommendations to high level managers and administrators

ECC (2007) states that the responsibilities of electricians are:

(i). Effectively and successfully implement strategies of electricity conservation

(ii). Regularly report the progress of electricity conservation activities within the industries

(iii). Seek assistance and advice from power mangers and high-level managers and administrators

EECA (2009) and ECC (2007) highlighted the staff responsibilities in implementation of policies of electricity conservations. However, industry staff has individual responsibilities in electricity conservations. These responsibilities include opening window curtains instead of switching on lights, switching off equipments such as computers, printers, fridges when not in use and, unplugging adapters and chargers of phones, cameras and laptops from sockets.

1.8. Conceptual Framework

Energy supply analyses are divided into two parts; energy resource assessment and energy technology evaluation. Both resource assessment and technology evaluation are divided into three components: non-renewable energy, renewable energy and electricity systems. End-use technology assessment of electricity system would give viable results for conservation and efficiency mechanisms put in place for energy savings (Siddayao, 1990). The framework adopted for the study was identification of electricity conservation strategies and their outcomes such as reduced unnecessary electricity consumptions, reduced electricity wastage and reduced cost of electricity (Figure 2). GEF (2004) states that, electricity saving is the ultimate outcome of the strategies and these will further yield impacts such as reduction in monetary spending on electricity bills

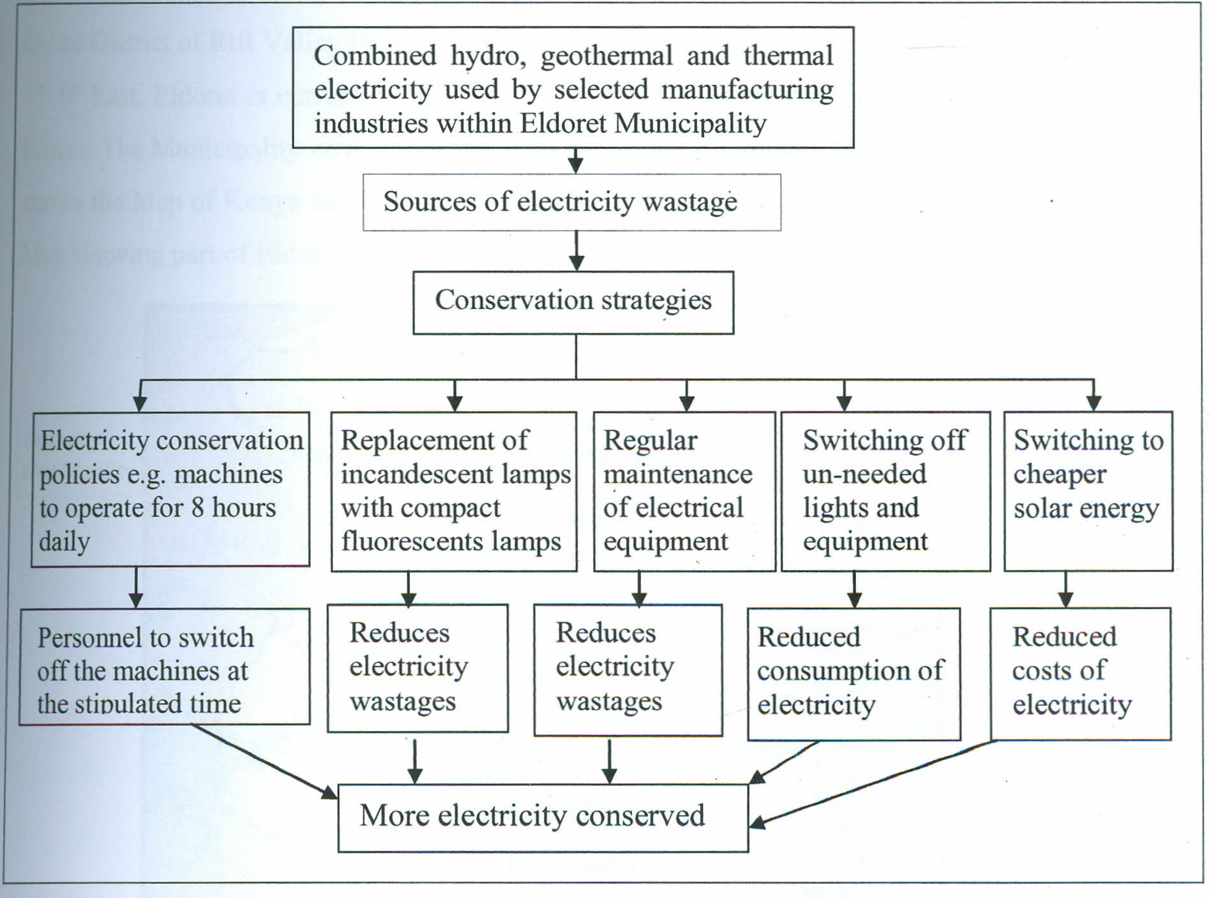


Figure 2: Conceptual framework for electricity conservation strategies

Source: Derived from Literature, 2010

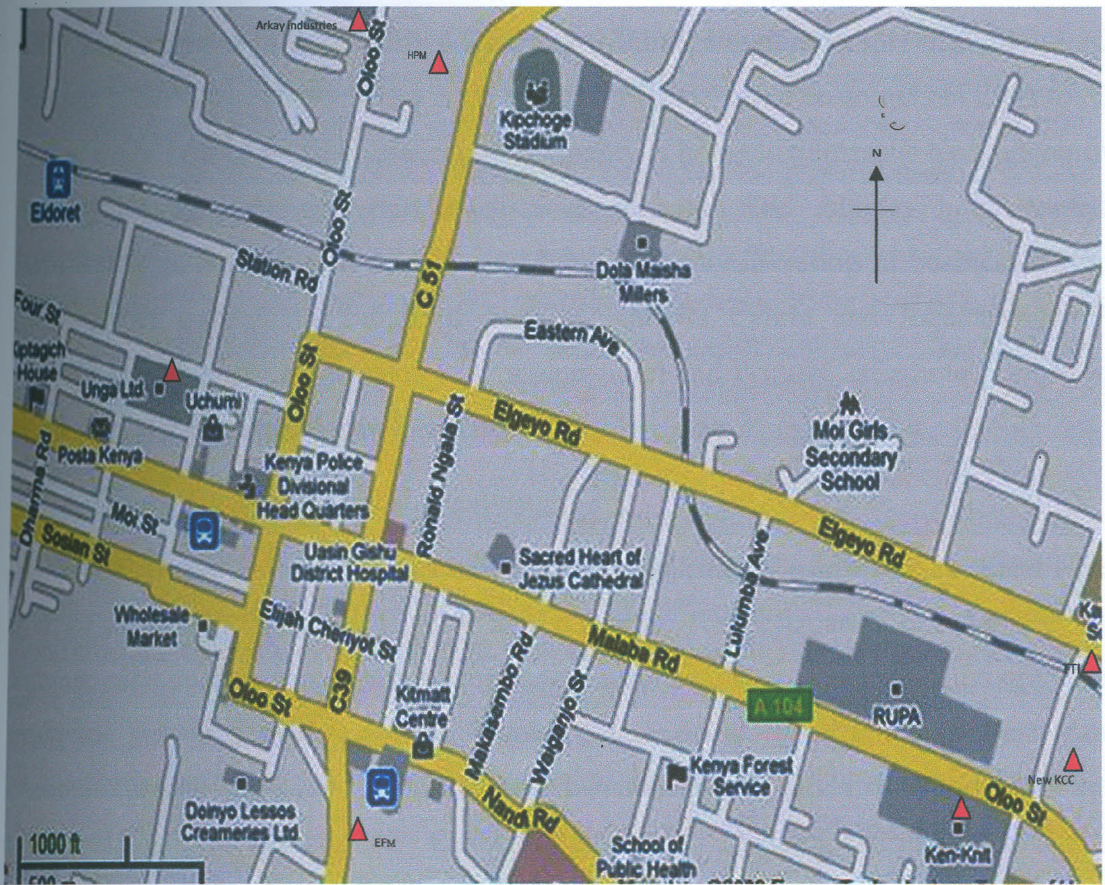
CHAPTER TWO

STUDY AREA

2.1. Location and Size

Eldoret Municipality is located in western Kenya and is the administrative centre of Uasin Gishu District of Rift Valley Province. Its geographical coordinates are 0° 31' 0" North, 35° 17' 0" East. Eldoret is currently the fifth largest and the fastest growing industrial town in Kenya. The Municipality covers an area of 147.9 square kilometers (MCE, 2008). Figure 3 shows the Map of Kenya showing the location of Eldoret Municipality and Figure 4 shows Map showing part of Eldoret Municipality showing the selected manufacturing industries.

Figure 3: Map of Kenya showing location of Eldoret Municipality
Source: About.com, 2011



Key: ▲ - Selected Manufacturing industries

Figure 4: Map of part of Eldoret Municipality showing the selected manufacturing industries

Source: Google maps.com, 2010

2.2. Population

The population of Uasin Gishu County in which Eldoret Municipality is situated stood at 894,179 persons in 2009 (Kenya National Bureau of Statistics, 2010). MCE (2010) stated that approximately 500,000 persons of Uasin Gishu County, in 2010, were residents of Eldoret Municipality and most of these residents of Eldoret Municipality work in institutions such as hospitals, schools, colleges/universities and; commercial enterprises, and manufacturing industries within Eldoret Municipality. Emasit *et al* (2009) stated that the population growth within Eldoret Municipality has been attributed to rural-urban migrations because of employment opportunities offered by the rapid industrial growth within the Municipality. The increasing population and rapid industrial growth within Eldoret Municipality have increased demand for energy consumption particularly electricity for domestic, commercial and industrial purposes. KPLC North Rift Region

(2010) reported that the electricity consumers within the region comprising Eldoret, Kitale, Kapsabet and Kabarnet towns had risen by 33.3% from 60,000 customers in 2006 to 80,000 customers in February, 2010. Eldoret Municipality is home to numerous Kenya's renowned athletes mainly long and middle distance runners. The athletes have contributed significantly to the economy of Eldoret Municipality by investing in business enterprises that includes commercial buildings such as Komora Centre and Johannesburg Plaza, residential estates and hotels such as Grandpri hotel and White Castle hotel - these further leads to increased demand for electricity.

2.3. Major infrastructure and Economy

The Trans-African highway passes through Eldoret Central Business District and is named as Uganda Road. The town is also served by the Kenya-Uganda railway, the Eldoret International Airport, and has a pipeline terminus. The transport infrastructure has promoted industrial growth within Eldoret Municipality by offering efficient transport channels for raw materials to industries and manufactured goods from industries to both local and international markets. Other infrastructures include; institutions such as Moi Teaching and Referral Hospital which is the second largest referral hospital in Kenya, Moi University, Eldoret Polytechnic, and several secondary and primary schools. The institutions use electricity for their normal operations therefore have increased the demand for electricity within Eldoret Municipality. KPLC North Rift attributed the rise in electricity supply to the increased connections of electricity to new customers who include manufacturers, individual households, and institutions such as schools, colleges, and administrative headquarters of the newly established districts (KPLC North Rift, 2010).

2.4. Land use

Eldoret Municipality is surrounded by a rich agricultural hinterland favourable for both livestock keeping (beef and milk cattle) and crops farming. The main crops grown within Eldoret's hinterland include: maize and wheat grown in most parts within Uasin Gishu District and in the neighbouring districts of Keiyo, Nandi and Trans-Nzoia; sunflowers and pyrethrum grown mainly in the neighbouring Trans-Nzoia district and rose flowers for export grown in farms such as Sirgoek and Equator Farms within Eldoret Municipality. UN Habitat (1991) explains that land uses within Eldoret hinterland supply adequate raw materials to the manufacturing industries, especially food processing industries namely;

Unga Ltd whose raw materials include wheat and maize; New KCC Ltd whose raw material is milk; and Arkay industries Ltd which manufactures cooking oil whose raw materials is sunflowers.

2.5. Industrial Development

The industrial prospects of Eldoret Municipality have grown notably. According to (Makabila, 2007), the government of Kenya helped in setting up many of the manufacturing industries within Eldoret Municipality and by encouraging international and private investments in manufacturing. KAM (2010) documented twenty five (25) manufacturing industries within Eldoret Municipality which include: National Cereal and Produce Board (NCPB), Timber Treatment International (earlier known as East African Tanning and Extract Company Limited), New Kenya Cooperative Creameries, Unga Mills, Maize Ltd, Cheese Factory, Raymond Woolen Mills (RUPA), Rift Valley Textile Limited (Rivatex), Ken-Knit (K) Ltd, Rai Plywood Ltd, Rift Valley Bottlers, Arkay Industries, Eldoret Oil Mills Ltd, Corn Products Ltd, Turbo Feeds Manufacturing Ltd, Highland Paper Mills Ltd, Tyre Retreading Plants and Eldoret Steel Mills Ltd. KPLC (2010) estimates that the manufacturing industries within Eldoret Municipality consumes 180 MW per day of electricity accounting for 50% of electricity supply to the Municipality. KAM (2004) estimated that 10% to 30% of electricity is wasted at end use stages that include manufacturing industries, therefore wastage of electricity of between 18 MW and 54 MW of electricity per day occurs in the manufacturing industries within Eldoret Municipality.

2.6. Electricity Supply and Consumption

Eldoret Municipality is supplied with electricity mainly from the national electricity grid distributed by KPLC. The Municipality contributes about 43.4 MW of electricity to the national grid, that is 0.4MW from Sosiani hydro-power Station and 43MW from emergency diesel generator which is operated by Aggreko Company. Eldoret Municipality and Kitale town are served by one electricity feeder line from Lessos KPLC control station. The feeder line supplies an average of 24MW of electricity per hour translating to 576MW per day (Table 1). Table 1 shows the hourly supply of electricity by Eldoret- Kitale feeder line from 2nd March to 15th March, 2010.

Table 1: Hourly Electricity supply by Eldoret-Kitale feeder line for 15 days (2^{nd} March to 15^{th} March, 2010)

	Hourly electricity supply in Megawatts (MW)														
Day / Time	Tue 2nd	Wed 3rd	Thurs 4th	Fri 5th	Sat 6th	Sun 7th	Mon 8th	Tue 9th	Wed 9th	Thurs 10th	Fri 11th	Sat 12th	Sun 13th	Mon 14th	Tue 15th	Mean
0000	18	20	18	16	16	12	18	20	18	20	16	16	14	16	16	16.9
0100	20	18	20	18	18	14	18	18	18	18	18	18	16	18	18	17.9
0200	18	18	20	18	18	12	20	18	18	20	18	18	16	18	18	17.9
0300	20	18	20	18	20	12	18	18	18	18	18	18	18	20	18	18.1
0400	18	18	20	18	22	12	20	18	18	20	18	18	16	18	20	18.3
0500	20	20	18	20	20	14	22	18	18	20	20	20	18	22	18	19.2
0600	20	18	20	22	22	16	26	18	20	22	22	18	16	24	22	20.4
0700	22	22	22	22	24	18	28	22	24	24	18	18	20	20	24	21.9
0800	24	22	22	24	26	20	28	24	24	24	22	22	22	32	42	25.2
0900	28	24	26	26	28	20	28	22	28	24	24	24	20	32	24	25.2
1000	30	28	30	28	34	20	32	30	30	26	26	24	24	34	26	28.1
1100	28	30	28	28	36	24	34	28	32	26	24	26	20	34	24	28.1
1200	28	34	32	30	34	26	36	28	34	28	28	26	24	32	26	29.7
1300	32	36	32	32	32	24	34	32	34	32	28	28	22	36	28	30.8
1400	30	34	30	34	34	24	34	34	30	30	28	30	24	34	32	30.8
1500	32	34	28	32	32	26	32	36	28	28	32	32	26	30	28	30.4
1600	30	32	24	28	32	18	30	34	28	28	26	34	24	28	32	28.5
1700	22	28	22	28	28	20	28	32	26	28	26	36	22	28	34	27.2
1800	24	26	24	28	28	18	30	30	24	28	26	32	22	30	28	26.5
1900	26	26	26	24	26	22	28	28	24	26	26	30	18	26	26	25.5
2000	28	26	26	26	26	22	26	28	26	26	26	30	16	26	24	25.5
2100	24	24	26	24	26	24	26	26	24	24	26	28	14	26	26	24.5
2200	20	20	24	22	24	20	24	26	22	22	24	24	18	22	24	22.4
2300	16	18	18	18	18	16	18	16	16	16	18	20	16	16	20	17.3
Total	**578**	**594**	**576**	**584**	**624**	**454**	**638**	**604**	**582**	**578**	**558**	**590**	**466**	**622**	**598**	**576.4**

Source: KPLC North Rift, 2010

KPLC (2010) reported that 360 MW (62.5%) of the daily supply of electricity by Eldoret-Kitale feeder line was consumed within Eldoret Municipality. The manufacturing industries within the Municipality consume 50% (180 MW per day) of the electricity supplied to the Municipality. According to KPLC North Rift Sub-Region (2010) electricity supplied by Eldoret-Kitale feeder had increased from an average of 18MW per hour (216 MW per day) in 2008 to the current (2010) hourly average of 24MW (576 MW per day). KPLC North Rift (2010) attributed the rise in electricity demand to connections of new customers to supply grid. The electricity customers had increased in Eldoret sub-region by 33.3%, that is, from 60,000 customers in 2006 to 80,000 customers in February, 2010. KPLC (2009b) stated 40% of electricity is lost or wasted at end-use stages by Kenya's electricity users therefore; adoption of electricity conservation strategies by electricity consumers within Eldoret Municipality would achieve up to 40% saving of electricity.

CHAPTER THREE

METHODOLOGY

3.1. Research Design

The study adopted the cross-sectional descriptive research design. A representative sample was selected first from the target population of manufacturing industries. A basic audit that encompassed document reviews, observations, photography and interviews was conducted to establish the areas of electricity wastage and; existing policy, operational, technology and personnel responsibility strategies to electricity conservation by each of the selected manufacturing industries. Scenarios analysis for electricity wastage and conservation strategies adopted was finally done quantitatively and presented as charts, tables and plates that clearly describe them.

3.2. Population and Sample

The total number of manufacturing industries within Eldoret Municipality was twenty five (25). Kothari (2003) gave the following formula for calculating representative sample size of a finite (known) population:

$$n = \frac{Z^2.p.q.N}{e^2 (N-1) + Z^2.p.q}$$

Where: Z = Standard variate at a given confidence level;
p = Sample proportion;
q = 1 – p;
N = Total population;
e = Precision or accepted error

The value of p = 0.5 in which case 'n' will be maximum and the sample will yield at least the desired precision (Kothari, 2003). The population of the study was 25 manufacturing industries. At confidence level of 95.5% estimated within 30% of the true value, the sample size was given by:

$$n = \frac{2.005^2 \times 0.5 \times 0.5 \times 25}{0.3^2 (25-1) + 2.005^2 \times 0.5 \times 0.5}$$

Z = 2.005 (at confidence level of 95.5%);
N = 25; p = 0.5; q = (1- 0.5) = 0.5; e = 0.3

$= \underline{7.94} \approx \underline{8 \text{ industries}}$

The resultant sample of eight (8) manufacturing industries conformed to the 30% rule of selecting sample size when the population is below 500. Ratios were then used to select the manufacturing industries by types to ensure representativeness as shown in Table 2.

Table 2: Selected manufacturing industries within Eldoret Municipality

Industry types	Population	Ratio calculations	Sample size	Specific names and types of industries Selected
Food processing	13	$^{13}/_{25}\times 8 = 4.16$	4	(1). New KCC Ltd (Beverage) (2). Unga Ltd (Grain milling) (3). Arkay Industries, (Cooking oil), (4). Turbo Feeds Ltd (Animal feeds)
Textile	3	$^{3}/_{25}\times 8 = 0.96$	1	(1). Ken Knit Ltd (Textile manufacturing)
Wood and Paper	6	$^{6}/_{25}\times 8 = 1.92$	2	(1). Highlands Paper Mills (Paper mills) (2). Timber Treatment International Ltd (Wood preservation)
Metal	3	$^{3}/_{25}\times 8 = 0.96$	1	(1). Eldoret Farm machinery Ltd (Engineering Firm)
Total	**25**	**8.00**	**8**	-

Purposive random sampling was used to select the key informants from a population of 354 of industry management, electricians, machine operators, supervisors, clerks and security officers within the selected manufacturing industries (Researcher's preliminary survey, January 2010). A total of 107 respondents (representing 30%) were selected in conformity with Wright (2010) who stated that, for a small population of less than 500, one needs to sample between 10-30% of the population. The respondents were selected proportionately depending on the number of target staff in the selected manufacturing industries (Table 3).

Table 3: Number and percent of respondents sampled per selected manufacturing industry to make 107 respondents

No	Name of industry	No. of target staff	No. of selected Respondents	Percentage (%)
1.	Beverage (New KCC Ltd)	57	17	16
2.	Grain millers (Unga Ltd)	47	14	13
3.	Cooking oil (Arkay industries)	34	11	10
4.	Animal feeds (Turbo Feeds Ltd)	46	14	13
5.	Ken Knit Ltd	40	12	11
6.	Paper (Highlands Paper mills)	45	14	13
7.	Wood (Timber Treatment International, TTI)	39	12	11
8.	Engineering Firm (Eldoret Farm Machinery, EFM)	46	13	13
	Total	**354**	**107**	**100**

Source: Field Study, 2010

3.3. Methods of Data Collection

Primary data for the study was collected by application of the following data collection methods:

3.3.1. Identification of mean electricity consumptions

The mean consumption of electricity for Eldoret Municipality and its environs was sought from KPLC regional office while electricity consumptions for each of the selected manufacturing industries were identified using the monthly electricity bills.

3.3.2. Scrutiny of monthly electricity consumptions

Electricity consumptions data for each of the selected manufacturing industries for the last 12 months (May 2009 to April 2010) were obtained from KPLC North Rift office database. This was done to establish the expected electricity consumption trends in each of the selected manufacturing industry.

3.3.3. Key Informant Interviews

KPLC officers for the North Rift Region that included Assistant Human Resource Manager, Transmission Engineer, Customer Service Engineer, 'Large power section' Manager and the officers at the KPLC Control Station in Lessos were interviewed to establish the electricity consumption of Eldoret Municipality and conservation strategies adopted by manufacturing industries. In the selected manufacturing industries, a total of 30 key informants that comprised of Plant managers, Production Managers, Personnel Managers, Plant Engineers, and Chief Electricians were interviewed. These were the industry workers who were well informed of the policy, operational/technological strategies used in each of the selected industry to conserve electricity. In addition, Chief Executive Officer for KAM Eldoret chapter was also interviewed. The key informants provided in-depth information on sources of electricity wastage, policy strategies, staff responsibilities and technological strategies of electricity conservation.

3.3.4. Structured Questionnaires

Structured questionnaires with both closed and open ended questions were administered to the 107 purposively selected workers in each of the selected manufacturing industry. All the questionnaires were self-administered by the researcher to avoid misunderstanding of the questions by respondents. The information gathered by the questionnaires was on electricity wastage, electricity conservation policies/regulations, technological and operational strategies and individual staff responsibilities in the conservation of electricity in each of the selected manufacturing industry. Thus, the questionnaires helped in obtaining comprehensive data that focused on the objectives of the study from the sampled population. A sample of the questionnaires administered is attached as Appendix I.

3.3.5. Participant observation and Photography

Participant observation of the activities and machines used by each selected manufacturing industry were undertaken so as to fully establish the existing strategies used for electricity conservation in various sections of each industry. This helped the researcher to identify sources of electricity wastage and operational strategies used to reduce the wastages. Photographs were taken to show some salient features relevant to the study such as existing infrastructure that included the capacitor banks, roof skylights sheets, electric motors and types of machines used in the manufacturing processes by selected manufacturing industries.

3.3.6. Secondary sources of Data

Relevant literature on electricity conservation strategies in manufacturing industries was sought from both published and unpublished sources such as textbooks, journals, newspapers, conference proceedings, company's energy reports and policy papers, sessional papers, pamphlets, theses and project reports on topics related to electricity conservation. The materials were obtained from Maseno and Moi University libraries; documentary files of KPLC and; websites of various institutions such as CEEC, KAM, Ministry of Energy (MOE), GEF and ERC. Secondary data gave an insight into the research topic and also facilitated the comparisons of a variety of researches on industrial electricity consumption and conservation strategies. The secondary data also assisted in the identification of existing knowledge gaps and the best practices that should be recommended for adoption on electricity conservation.

3.4. Data Analysis and Presentation

Both quantitative and qualitative data analysis techniques were used.

(i). Quantitative data analysis

Questionnaires and interview schedules were first arranged and authenticated. Authentication involved scrutinizing the raw field data in order to identify and correct errors. The questionnaires were then classified per industry type and according to sections of each of the industries. Coding of the classified questionnaires was done and the information from each questionnaire was entered into Statistical Package for Social Sciences (SPSS) and Excel sheets for storage. Descriptive data analysis was done by running the stored data in SPSS sheets using descriptive statistics on computer command options of frequencies and cross-tabulations (cross tabs).

a) Frequencies or frequency distribution

Frequencies were applied when the summary of responses on a single variable was necessary. It provided a summary of how respondents answered a question by giving frequencies and percent under the sets of answers. Frequencies also enable the data to be presented in form of tables, bar graphs and pie charts.

b) Cross-tabulation (cross tabs)

Cross-tabulations were mainly used to relate respondents' answers on one or more variables within and between the different types of manufacturing industries.

(ii). Qualitative data analysis

Field notes that comprised of directly observed variables and responses not captured by the questionnaires were grouped into themes and discussed. Observations were aided by the digital photographs taken in the field. The relevant photographs that were taken during the field work were uploaded to the computer and edited by use of Microsoft Office Picture Manager and imported to Microsoft office Word for presentation.

(iii). Presentation of data

The synthesized data from SPSS and Excel sheets were presented in a discussion form, statistical figures (graphs and charts), tables and plates (photographs).

3.5. Constraints to the Study

There were constraints encountered during the study. These included:

i. Difficulty in accessing industries premises even after getting the permission from the management. Security personnel had to contact the management at every visit to the premises by the researcher. This sometimes took long hence delaying the process of data collection.

ii. Lack of proper records in the selected manufacturing industries on electricity consumption. This forced the researcher to make several visits to the industries and KPLC offices in search of electricity consumption data for the selected industries.

iii. The management in some industries could not permit some categories of workers (especially casual workers) to participate in data collection research activity apart from the assigned duties. This forced the researcher to reschedule the interviews and administration of questionnaires to these workers during free time such as lunch time.

iv. Some key informants could not honour appointments as scheduled. This led to long waiting or rescheduling of appointments, thus delaying the data collection period.

v. Some respondents could only be found during night shifts. The researcher was forced to visit the industries at night, thus being exposed to security risks.

RESULTS AND DISCUSSION

CHAPTER FOUR

SOURCES OF ELECTRICITY WASTAGE IN SELECTED MANUFACTURING INDUSTRIES WITHIN ELDORET MUNICIPALITY

4.0. Introduction

The chapter contains results on; (i) selected manufacturing industries, (ii) consumption of electricity by the selected manufacturing industries, (iii) role of industry management in electricity consumption and (iv) sources of electricity wastage in the selected manufacturing industries within Eldoret Municipality. The chapter therefore addresses objective one (1) of the study which intends to: identify sources of electricity wastage in selected manufacturing industries within Eldoret Municipality.

4.1. The selected manufacturing industries

Eight (8) manufacturing industries within Eldoret Municipality were selected for the study. The study grouped the selected manufacturing industries into two categories namely: (a) heavy manufacturing industries and (b) light manufacturing industries to conform to KPLC's electricity supply grouping of electricity consumers. The study established that KPLC had categorized electricity consumers into two broad groups namely: large power consumers and small power consumers. Large power consumers comprised of large manufacturing industries and commercial enterprises whose monthly electricity consumptions exceeded 7,000KWh. Examples of large power consuming industries included (i) Unga Ltd, (ii) Ken-Knit Ltd, (iii) New KCC Ltd, (iv) Arkay industries Ltd, and (v) Highlands Paper Mills Ltd (KPLC North Rift, 2010). The consumers were supplied with electricity metered at 415 volts three phase four-wire, 11Kv, 33Kv or 66Kv and were charged per KVA of electricity consumed per a billing period. The small power electricity consumers referred to the electricity consumers whose monthly consumption was less than 7,000 KWh. This group of electricity consumers were supplied with electricity metered at 240 volts or 415 volts and; were charged per the number of KWh consumed during the billing period. Examples of small power consuming industries included (i) Turbo Feeds Ltd, (ii) Timber Treatment International Ltd and (iii) Eldoret Farm Machinery Ltd (KPLC North Rift, 2010). The Municipal Council of Eldoret (2008) stated that Eldoret Municipality was home to two types of industries namely; heavy industries such as textiles manufacturers, food processing, steel mills, paper manufacturers and light industries which included animal feeds manufacturers and engineering firms. Therefore, in consistency with categorization of industries by Municipal Council of Eldoret (2008), the study re-categorized large power industries to heavy manufacturing industries while the small power industries were categorized as light manufacturing industries. Table 4 shows the categories and names of the selected manufacturing industries.

Table 4: The category and names of selected manufacturing industries

Industry category	Name of industry
(a). Heavy manufacturing industries	(i). Unga Ltd
	(ii). Ken Knit Ltd
	(iii). New KCC Ltd
	(iv). Arkay Industries Ltd
	(v). Highlands Paper Mills Ltd
(b). Light manufacturing industries	(i). Turbo Feeds Ltd
	(ii). Timber Treatment International Ltd
	(iii). Eldoret Farm machinery Ltd

Source: Survey data, 2010

4.2. Electricity consumption by the selected manufacturing industries

4.2.1. Electricity consumption for heavy manufacturing industries

The study established that KPLC collects and records units (kWh) of electricity consumed from installed electricity meters at the heavy manufacturing industries premises. The electricity meters installed consisted of two scales; the high rate scale for metering electricity usage at on-peak load periods and the low rate scale for metering usage at off-peak periods. Syed (2009) supports the findings by stating that time of usage metering of electricity involves dividing the day into tariff slots generally with higher tariff rates at on-peak load periods and low tariff rates at off-peak load periods. The total electricity consumption for each industry referred to sum of the electricity data recorded by the high rate scale and low rate scale [i.e. Total Consumption (TC) = High Rate (HR) Scale + Low Rate (LR) Scale]. The study collected electricity consumption data for each of the heavy industries for the last 12 months to the time of study in May 2010. The 12-month period was consistent with LEA (2009) recommendation that consumption or utility bills should be collected for a period of between 12 and 36 months to allow for establishment of the facility's electricity usage profiles. Table 5 shows a 12-month electricity consumption data for each of the five (5) selected heavy industries, that is, Unga Ltd, Ken Knit Ltd, New KCC Ltd, Highlands Paper Mills Ltd and Arkay Industries Ltd.

Table 5: Electricity consumption for each of the heavy manufacturing industries for a period of 12 months (from May 2009 to April 2010)

Name of Industry	Rate Scale	Monthly electricity consumption in KWh												
		Year 2009								Year 2010				
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Mean
Unga Ltd	LR	307500	308340	279370	282700	301072	294776	358332	372948	316668	217100	272720	378236	**307480.2**
	HR	223280	249540	209980	197940	218476	200964	298736	254820	269868	204804	253188	287768	**239113.7**
	TC	**530780**	**557880**	**489350**	**480640**	**519548**	**495740**	**657068**	**627768**	**586536**	**421904**	**525908**	**666004**	**546593.9**
Ken Knit Ltd	LR	91900	94810	100830	104920	103810	82140	100558	75060	72874	97626	88976	100834	**92861.5**
	HR	128420	126010	131680	127830	132234	104806	133308	95412	98674	120346	114594	127718	**120086.0**
	TC	**220320**	**220820**	**232510**	**232750**	**236044**	**186946**	**233866**	**170472**	**171548**	**217972**	**203570**	**228552**	**212947.5**
New KCC Ltd	LR	24631	45912	43305	42761	25852	44042	72211	102212	86875	107416	91947	104009	**65931.1**
	HR	21659	40086	43087	34146	23346	40678	57315	67028	77656	80996	69905	77648	**52795.8**
	TC	**46290**	**85998**	**86392**	**76907**	**49198**	**84720**	**129526**	**169240**	**164531**	**188412**	**161852**	**181657**	**118726.9**
Highlands paper mills Ltd	LR	17294	30092	18869	23675	25333	21366	20825	23873	15900	22012	22795	16916	**21579.2**
	HR	33414	23645	13238	19099	17760	16938	20408	18519	16480	19348	18594	14455	**19324.8**
	TC	**50708**	**53737**	**32107**	**42774**	**43093**	**38304**	**41233**	**42392**	**32380**	**41360**	**41389**	**31371**	**40904.0**
Arkay industries Ltd	LR	12620	10735	1029	4119	10761	1223	2207	12158	10003	26068	28363	4124	**10284.2**
	HR	13120	14142	17838	1292	8210	10698	2265	8898	13609	29240	26229	6760	**12691.7**
	TC	**25740**	**24877**	**18867**	**5411**	**18971**	**11921**	**4472**	**21056**	**23612**	**55308**	**54592**	**10884**	**22975.9**

Key: LR: Low rate HR: High Rate TC: Total Consumption (LR+HR)
Source: KPLC North Rift (2010)

The study established that during the 12-month period (from May 2009 to April 2010), Unga Ltd recorded the highest average monthly consumption of electricity among the heavy manufacturing industries with 546,593.9 KWh while Arkay Industries Ltd recorded the lowest average monthly electricity consumption among the heavy industries of 22,975.9 KWh as shown in Table 5. The average monthly electricity consumption for Ken-Knit Ltd was 212,947.5 KWh, New KCC Ltd was 118,726.9 KWh and Highlands Paper Mills Ltd was 40,904.0 KWh for the same period from May 2009 to April 2010. The difference in electricity consumption between the heavy industries was because of production activity of each industry. The study established that Unga Ltd had the highest production activity, followed in order by Ken-Knit Ltd, New KCC Ltd, Arkay Industries Ltd and; Highlands paper mills which had the lowest production activity. Natural Resources Canada (2008) supports the findings of the study by stating that the electricity consumption in the manufacturing sector is influenced by its activity. For the manufacturing sector, activity is often represented by indicators, such as Gross Domestic Product (GDP), Gross Output (GO) and physical outputs. Activity is used as a measure of the production of manufacturing industries (Natural Resources Canada, 2008).

The study established that KPLC charged the heavy manufacturing industries per KVA of electricity consumed per every billing period. This is because the electricity consumption of heavy industries was determined by power factor of machines. Therefore the electricity consumptions units used to calculate the monthly electricity bills for the heavy manufacturing industries were in KVA. Table 6 shows the electricity consumption for the heavy manufacturing industries as were carried by the electricity bills issued by KPLC for a period of twelve (12) months from May, 2009 to April, 2010. The 12-month period of electricity consumption was used so as to establish the consumptions trends and profiles for each of the 12 months of the year. Figure 5 is a graph showing a 12 month consumption trends of the heavy industries based on the data shown in Table 6.

Table 6: Electricity consumption (in KVA) for heavy manufacturing industries for 12 months (May, 2009 to April, 2010)

No	Name of Industry	Electricity consumption in KVA												
		Year 2009								Year 2010				
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	Mean
1	Unga Ltd	1558	1561	1557	1557	1554	1551	1564	1568	1560	1556	1554	1558	**1558.2**
2	Ken-Knit Ltd	497	496	496	498	509	491	495	506	493	494	490	496	**496.8**
3	New KCC Ltd	252	254	254	251	248	245	265	254	249	243	248	251	**251.2**
4	Arkay Industries Ltd	170	171	173	172	170	168	172	171	170	174	176	175	**171.8**
5	HPM Ltd	88	92	88	85	87	88	91	90	93	89	91	90	**89.3**

Source: Survey data, 2010

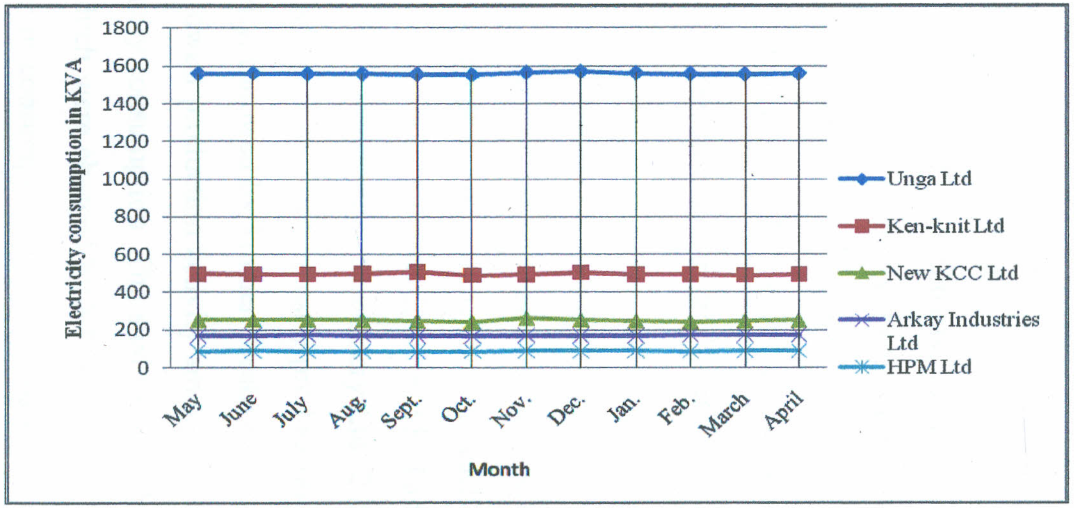


Figure 5: Electricity Consumptions trends for the heavy industries for a period of 12 months
Source: Survey data, 2010

During the period (from May 2009 to April 2010), the average monthly consumptions in KVA for each of the selected heavy industries were: Unga Ltd, 1558.2 KVA; Ken-Knit Ltd, 496.8 KVA; New KCC Ltd 251.2 KVA; Arkay Industries Ltd 171.8 KVA; and Highlands Paper Mills Ltd, 89.3 KVA as shown by Table 6. According to Natural Resources Canada (2008), electricity consumption in the manufacturing sector is influenced by its activity. Thus, the study established that Unga Ltd which recorded the highest electricity consumption (1558.2 KVA) had more activity, followed in second place by Ken-Knit Ltd, New KCC Ltd (third), Arkay Industry Ltd (fourth), and; fifthly by Highlands Paper Mills Ltd which had the lowest activity since it recorded the least average monthly KVA readings (89.3 KVA) among the heavy during the 12- month period.

4.2.2. Electricity consumption for light manufacturing industries

Table 7 shows electricity consumption (in KWh) for the three selected light manufacturing industries, that is, Turbo Feeds Ltd, Timber Treatment International Ltd and Eldoret Farm Machinery Ltd for a period of 1 year (12 months) from May 2009 to April 2010. During the period, the average monthly consumption of electricity for each of the light manufacturing industries were as follows: Turbo Feeds Ltd, 5,231 KWh; Timber Treatment International (TTI) Ltd, 2,423 KWh; and Eldoret Farm Machinery Ltd, 2,250 KWh. The difference in electricity consumption was as a result of industry production activity. Thus, Turbo Feeds Ltd had the highest activity, followed by Timber Treatment International Ltd. Eldoret Farm Machinery Ltd had the lowest production activity among the light industries because it recorded the lowest electricity consumption. The study established that, unlike the heavy manufacturing industries which were charged by KPLC per KVA of electricity consumed to incorporate power factor in consumption, the light manufacturing industries were charged by the KWh of electricity consumed per a billing period. This was because the power factor was not incorporated in the consumptions due to its insignificance effects (Energy-In-Motion, 2010). Therefore, the monthly electricity bills issued by KPLC to each of the light manufacturing industries were based on the KWh units of electricity consumptions as shown in Table 7. Figure 6 is a graph showing a 12 month consumption trends of the light industries based on the data shown in Table 7.

Table 7: Electricity consumption (in kWh) for light manufacturing industries 12 months (from May, 2009 to April, 2010)

No	Name of Industry	Electricity consumption in KWh												
		Year 2009								Year 2010				
		May	June	July	Aug.	Sept.	Oct.	Nov.	Dec	Jan.	Feb.	March	April	Mean
1	Turbo Feeds Ltd	5,187	5,149	5,263	5,366	5,256	5,288	5,424	5,020	5,150	5,258	5,234	5,176	**5,231**
2	TTI Ltd	2,364	2,484	2,649	2,348	2,360	3, 320	2,392	2,388	2,546	2,426	2,345	2,354	**2,423**
3	Eldoret Farm Machinery Ltd	2,234	2,264	2,271	2,219	2,200	2,256	2,310	2,342	2,180	2,246	2,238	2,241	**2,250**

Source: Survey data, 2010

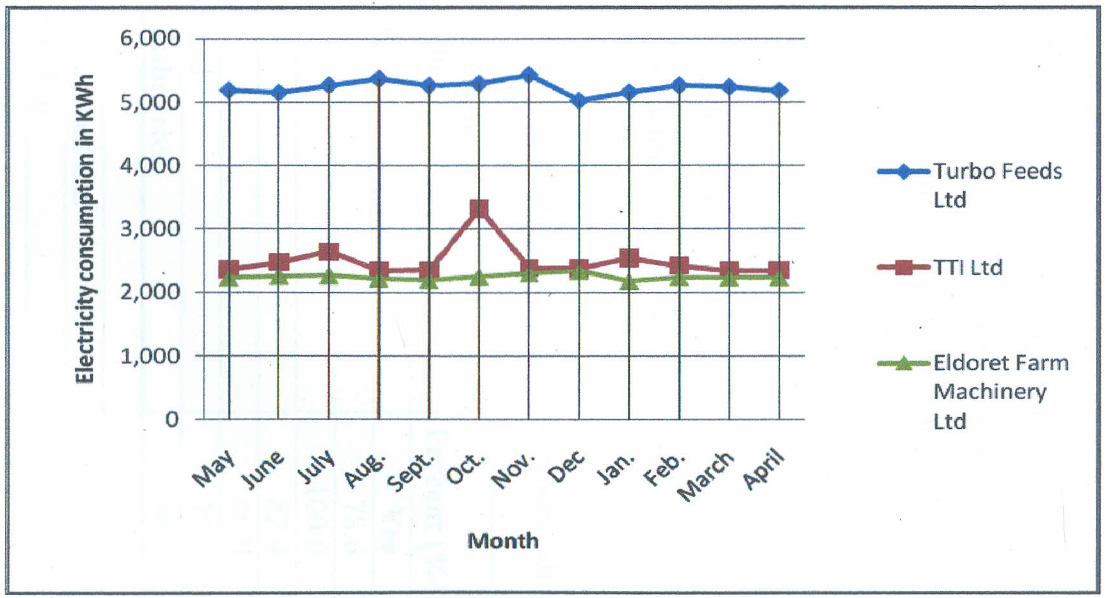


Figure 6: Electricity Consumptions trends for the light industries for a period of 12 months
Source: Survey data, 2010

4.3. Role of Management staff in consumption of electricity

The study established that management staff of the selected manufacturing industries were the first detectors of anomalies in consumption of electricity when the consumption bills were issued by KPLC. Table 8 shows that 82.2 per cent of the respondents reported that the management of the selected manufacturing industries had communicated to the industry workers about unusual electricity bills. The heavy manufacturing industries had 86.1 per cent average respondents indicating that the management had made communication to workers on unusual electricity bills with Ken-Knit Ltd recording 100 per cent response, Arkay industries Ltd (90.9%), New KCC Ltd (82.4%), Unga Ltd (78.6%) and Highlands Paper Mills Ltd (78.6%) as shown in Table 8. The results indicate that management of heavy manufacturing industries had communicated to majority of workers (86.1%) about high electricity bills. The communication created awareness to workers on high electricity bills thus making them participate in identifying the causes of the high bills and ways of reducing the bills.

Table 8: Industry workers responses on management staff communication about high electricity bills

	Industries' management communication to workers on electricity bills	**Percent (%) respondents**	
No.	**Name of the Industry**	**Yes**	**No**
1.	Unga Ltd	78.6	21.4
2.	Ken-Knit Ltd	100.0	0.0
3.	New KCC Ltd	82.4	17.6
4.	Arkay Industries Ltd	90.9	9.1
5.	Highland Paper Mills Ltd	78.6	21.4
Mean % response for heavy industries		**86.1**	**13.9**
6.	Turbo Feeds Ltd	85.7	14.3
7.	Timber Treatment International Ltd	75.0	25.0
8.	Eldoret Farm Machinery Ltd	69.2	30.8
Mean % response for light industries		**76.6**	**23.4**
Grant Mean		**82.2**	**17.8**

Source: Survey data, 2010

Table 8 shows that the mean percent responses on whether industry management of light manufacturing industries had communicated about electricity bills to workers were 76.6 per cent, that is, 85.7% response at Turbo Feeds Ltd, 75.0% at Timber Treatment International Ltd and 69.2% responses at Eldoret Farm Machinery Ltd. The study therefore established that management in heavy manufacturing industries had better systems of communicating electricity consumption at 86.1% effectiveness while light manufacturing industries had communication systems at 76.6% effectiveness. GoK (2009) states that high electricity bills results from factors such as: - decreased hydropower electricity due to droughts, high cost of generation from thermal generator units due to rise in global petroleum costs, high inflation rates that led to devaluation of the shilling and; electricity wastage which lead to imposition of power surcharge by ERC through KPLC to a customer. KPLC North Rift (2010) indicated that two of the factors stated by GoK (2009) directly affected electricity bills for industrial consumers. The two factors were; (i) high cost of electricity generation from thermal units due to high prices of diesel used by the thermal generators for electricity generation (AllAfrica Global Media, 2009) and (ii) power surcharges imposed due to electricity wastage caused by low power factor of below 0.9.

4.4. Rating of Electricity consumption

Electricity consumption refers to the maximum amount of electrical energy being used at a given time to do work. It is measured in both Kilowatts hours (KWh) and kilovolt amperes (KVA), depending on the rate tariff. The difference between the KWh and KVA terms is that KVA incorporates power factor while KWh do not include power factor (Shields Associates, 2010). The study established that normal electricity consumption for the selected industries referred to consumption that matches with the production activity of the industry and which do not exceed the supply limits as agreed by KPLC with the customer on the supply contract (KPLC large power administrator's personal communication, April, 2010). Therefore, electricity consumption becomes high when more electricity is used though industry activity did not increase. Itron (2008) supports the findings and states that the main cause of high consumption of electricity is wastages. The electricity bills issued to each of the selected industries refers to sum total of cost of each unit (KWh for light industries or KVA for heavy industries), Fixed Charge, Fuel Charge, FOREX adjustment, Inflation adjustment, ERC Levy, REP levy and VAT (KPLC, 2009).

The study established that the heavy manufacturing industries paid a monthly fixed charge of Kshs 2900 per month while light manufacturing industries paid Kshs 800 per month (ERC). Therefore, the cost of electricity consumed by each industry was obtained by subtracting fixed charges (Kshs 2900 for heavy industries and Kshs 800 for light industries) from the total electricity bill issued by KPLC to each customer (Table 9)

Table 9: Cost of electricity consumed by each of the selected manufacturing industries for 12 months (May 2009 to April 2010)

Industry Name	**Fixed charge**	**Cost of Electricity consumed in Kenya shillings (Kshs.)**												
		Year 2009								**Year 2010**				
		May	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb**	**March**	**April**	**Mean monthly**
Unga Ltd	2900	8,362,100	8,467,100	8,343,100	8,040,100	7,786,100	7,907,100	8,697,100	8,927,100	8,497,100	7,847,100	7,991,100	8,241,100	**8,258,850**
Ken Knit Ltd	2900	2,912,100	2,780,100	2,823,100	2,792,100	2,746,100	2,801,100	3,137,100	3,047,100	2,802,100	2,712,100	2,792,100	2,842,100	**2,848,933**
New KCC Ltd	2900	831,100	865,100	821,100	753,100	851,100	957,100	1,447,100	1,497,100	1,747,100	1,347,100	1,518,100	1,468,100	**1,175,267**
Arkay industries Ltd	2900	751100	790100	814100	742100	818100	791100	947100	832100	814100	794100	808100	810100	**809,350**
HPM Ltd	2900	782,100	761,100	742,100	694,100	717,100	710,100	1,097,100	897,100	817,100	721,100	782,100	802,100	**793,600**
Turbo Feeds Ltd	800	127,200	126,200	126,200	122,200	125,200	130,200	140,200	133,200	130,200	128,200	131,200	132,200	**129,367**
TTI Ltd	800	83,200	85,200	85,200	84,200	82,200	86,200	92,200	83,200	90,200	82,200	85,200	86,200	**85,450**
EFM Ltd	800	44,200	46,200	45,200	48,200	47,200	52,200	60,200	57,200	53,200	51,200	51,200	52,200	**50,700**

Key: HPM: Highlands Paper Mills TTI: Timber Treatment International EFM: Eldoret Farm Machinery

Source: Survey data, 2010

Cost of electricity consumed = Total amount of monthly bill – Fixed charges

Whereby: Total monthly bill = (Consumption+ Fuel Charge +FOREX adjustment +Inflation adjustment + ERC Levy +REP levy + VAT)

Table 9 shows that the average monthly costs of electricity for the heavy manufacturing industries were as follows: Unga Ltd, Kshs. 8,258,850; Ken-Knit Ltd, Kshs. 2,848,933; New KCC Ltd, Kshs. 1,175,267; Arkay Industries Ltd, Kshs. 809,350 and; Highlands Paper Mills Ltd, Kshs. 793,600. The average monthly costs of electricity on each of the light manufacturing industries were: Turbo Feeds Ltd, Kshs. 129,367; Timber Treatment International Ltd, Kshs. 85,450 and; Eldoret Farm Machinery Ltd, Kshs. 50,700 (Table 9). The results indicate that electricity consumption costs were proportionately related to monthly consumption units, the higher the units consumed, the higher the costs. Therefore, Unga Ltd which consumed the highest units of electricity 546,593.9 KWh per month (Table 5) also paid the highest amounts of Kshs. 8,258,850 per month while Eldoret Farm machinery Ltd which consumed the lowest electricity of 2,250 KWh per month (Table 7) paid the least amounts for electricity among the selected industries of Kshs.50,700 per month.

4.5. High Electricity bills

The study established that High electricity bills were calculated by subtracting expected normal electricity bills from an electricity bill of a specific month. When the percentage difference was over 5% the expected normal bills, then the bills was regarded as high (KPLC North Rift Customer Services Officer Personal Communication, April 2010). The study established that the expected normal bills were arrived at by finding the average of monthly bills in the past years. Therefore, the expected normal bills of each of the industries reported by industry engineers were:- Unga Ltd (Kshs. 8,000,000), Ken-Knit Ltd (Kshs. 2,800,000), New KCC Ltd (Kshs.1,200,000), Arkay Industries Ltd (Kshs.800,000), Highlands Paper Mills Ltd (Kshs.700,000), Turbo Feeds Ltd (130,000), Timber Treatment International Ltd (Kshs.85,000), Eldoret Farm Machinery Ltd (Kshs.54,000).

The study identified the bills that were higher than the expected normal bills in each of the industries and calculated the percentage of the increase as indicated in Table 10. For example, in November 2009, the bill for Unga Ltd was Kshs. 8,700,000. The study subtracted the expected normal bill of Kshs.8,000,000 from the bill to obtain Kshs700,000. The percentage increase of 8.7% was then obtained by dividing Kshs 700,000 by Kshs 800,000 and multiplying the result by 100.

Table 10: Percentage increase in electricity bills in the selected industries from May 2009 to April, 2010

No	Name of industry	Expected normal electricity bills (Kshs.)	High electricity bills recorded		% increase in bills
			Month & Year	Amount (Kshs.)	
1.	Unga Ltd	8,000,000	Nov, 2009	8,700,000	8.7
			Dec, 2009	8,930,000	11.6
			Jan, 2010	8,500,000	6.3
2.	Ken Knit Ltd	2,800,000	Nov,2009	3,140,000	12.1
			Dec, 2009	3,050,000	8.9
3.	New KCC Ltd	1,200,000	Nov,2009	1,450,000	20.8
			Dec,2009	1,500,000	25.0
			Jan, 2010	1,750,000	45.8
4.	Arkay Industries Ltd	800,000	Nov,2010	950,000	18.8
5.	Highlands Paper Mills Ltd	700,000	Nov, 2009	1,100,000	57.1
			Dec, 2009	900,000	28.6
			Jan, 2010	820,000	17.1
6.	Turbo Feeds Ltd	130,000	Nov, 2009	141,000	8.4
7.	Timber Treatment International (TTI) Ltd	85,000	Nov, 2010	93,000	9.4
			Jan, 2010	91,000	7.0
8.	Eldoret Farm Machinery (EFM) Ltd	54,000	Nov,2009	61,000	13.0
			Dec, 2009	58,000	7.4

Source: Survey data, 2010

MeterToCash.com (2010) stated that high electricity bills are caused by factors that include: increase in electricity consumption, hike in electricity prices, overcharge resulting from inaccurate bills and inaccurate electric meters. The study established that high electricity bills within selected manufacturing industries were caused by two of the factors stated by MeterToCash.com (2010), that is, increase in consumption of electricity and hike in electricity prices. For instance, the increase in electricity bills in New KCC Ltd by 45.8% in January 2010 (Table 10) was reported by the industry's engineer to have been caused by increase of consumption of electricity due to rise in milk production in the area, which, led to increased milk deliveries by farmers to the plant for processing. Bii (2010) supports the findings of the study and states that the daily milk deliveries to Eldoret's New KCC plant doubled from 40,000 litres in October, 2009 to 80,000 litres in January, 2010 therefore increasing requirement of electricity by about 50%. In addition, Highlands Paper Mills Ltd recorded an increase in electricity bills of 57.1% in November 2009 due to increase in processing activities of the industry due to high demand for papers boards and power surcharge imposed by KPLC to the industry because of power factor which fell below 0.9 (HPM industry power manager Personal Communication, March, 2010).

The study established that the high electricity bills in November, 2009 for all the selected industries were due to the hike in electricity prices resulting from rise in fuel cost charges in the bills (KPLC, 2010). The findings of the study were consistent with Aron and Mohammed (2009) report which stated that, KPLC had informed power consumers, through a Kenya Gazette Notice in October, 2009 that from November, 2009 electricity bills were to increase because of rise in fuel cost surcharge by 4.4% (from Kshs.7.43 per KWh of electricity consumed in October's electricity bills to Kshs. 7.75 per KWh) due to rise in world oil prices. KAM (2009) while confirming that high electricity bills were recorded in November 2009 recommended that Kenya Power and Lighting Company (KPLC) should be issuing consumers with a forecast guideline on fuel cost adjustment of over five percent (5%) variation for a period of time to cushion the manufacturing sector from shocks adjustments in electricity bills.

4.6. Knowledge of industry workers on electricity wastage

Table 11 shows that most industry workers (70.1%) had knowledge of electricity wastage in the selected manufacturing industries. However, 22.4% of the respondents reported that there was no electricity wastage in the selected manufacturing industries while 7.5% of the respondents were not aware of the electricity wastage in the selected industries.

Table 11: Workers knowledge on electricity wastage within the selected industries

		Percent (%) respondents on whether there was electricity wastage in the industry or not		
No	**Industry Name**	**Yes**	**No**	**Don't Know**
1.	Unga Ltd	85.7	7.1	7.1
2.	Ken-Knit Ltd	66.7	33.3	0.0
3.	New KCC Ltd	52.9	35.3	11.8
4.	Arkay Industries Ltd	81.8	18.2	0.0
5.	Highlands Paper Mills Ltd	64.3	35.7	0.0
6.	Turbo Feeds Ltd	64.3	21.4	14.3
7.	Timber Treatment International Ltd	91.7	0.0	8.3
8.	Eldoret Farm Machinery Ltd	61.5	23.1	15.4
Average % respondents		**70.1**	**22.4**	**7.5**

Source: Survey data, 2010

Table 11 also indicates that the industry which had the highest percent respondents who had knowledge of electricity wastage were in the Timber Treatment International industry with 91.7%, followed by Unga Ltd with 85.7% and Arkay Industries Ltd with 81.8%. The other manufacturing industries had percentage of respondents who had knowledge that electricity wastage in other industries were: 66.7% in Ken-Knit Ltd, 64.3% in Highlands

Paper Mills Ltd, 64.3% in Turbo Feeds Ltd, 61.5% in Eldoret Farm Machinery Ltd and 52.9% in New KCC Ltd. The study therefore noted that, though electricity wastage occurred within the selected manufacturing industries, 70.1% of the workers were aware of the electricity wastage within the industries. The study established that knowledge of electricity wastage enabled the workers to identify and report the sources that caused the wastage and actively participate in identifying strategies to reduce the wastage. EECA (2009) supports the findings by stating that gaining knowledge on electricity wastage ensures that all employees become familiar with conservation strategies to reduce the electricity wastage.

4.7. Sources of Electricity wastage

An average of 66.2 per cent of the respondents interviewed reported ten (10) sources of electricity wastage in the selected manufacturing industries within Eldoret Municipality. The study grouped the ten (10) sources of electricity wastage reported into three categories namely: (i) sources applicable to both heavy and light manufacturing industries, (ii) sources applicable to heavy manufacturing industries only, and (iii) sources applicable to light manufacturing industries only as shown in Table 12, Table 13 and Table 14 respectively.

Table 12: Sources of electricity wastage applicable to both heavy and light industries and percentage responses

No	Sources of electricity wastage	% respondents on source of electricity wastage per industry								
		Heavy industries					Light industries			Mean (%)
		Unga Ltd	Ken-knit	New KCC	Arkay industries	HPM Ltd	Turbo Feeds	TTI Ltd	EFM Ltd	
1.	Inadequate servicing of industry machines	86.8	76.0	88.5	73.8	86.8	79.7	76.0	93.7	**82.7**
2.	Unnecessary running of machines & equipment	71.2	83.2	76.3	90.1	78.4	64.1	75.0	46.0	**73.0**
3.	Unnecessary lighting	64.3	83.4	53.0	63.7	64.3	57.2	41.7	38.5	**58.2**
4.	Use of lighting lamps with low energy efficiency	50.0	58.3	41.2	63.6	21.4	35.7	41.7	38.5	**43.8**
5.	Use of blunt blades by cutting machines	0.0	83.3	0.0	0.0	78.5	0.0	91.7	92.4	**43.3**
6.	Improper calibration of meters	0.0	0.0	82.3	0.0	85.7	0.0	100	0.0	**33.5**

Source: Survey data, 2010

Table 12 shows that six (6) of the sources of electricity wastage were applicable to both heavy and light industries. The sources of wastage with percentage responses were: (i) inadequate servicing of industry machines (82.7%); (ii) Unnecessary running of machines and equipment (73.0%); (iii) unnecessary lighting (58.2%); (iv) use of lighting lamps with low energy efficiency (43.8%); (v) use of blunt blades by cutting machines (43.3%); (vi) improper calibration of meters (33.5%).

Table 13: Sources of electricity wastage applicable to heavy industries only and percentage responses

No	Sources of electricity wastage	% respondents on source of electricity per industry					
		Unga Ltd	Ken-Knit Ltd	New KCC Ltd	Arkay industries	HPM Ltd	**Mean (%)**
1.	Low power factor	92.8	91.7	95.0	91.0	92.8	**92.7**
2.	Leakage of compressed air	71.5	75.0	82.4	72.8	85.8	**77.5**
3.	Leakage of steam	78.7	75.0	64.8	91.0	0.0	**61.9**

Source: Survey data, 2010

Table 13 shows that three (3) of the sources of electricity wastage were applicable to heavy industries only. The sources of wastage with percentage responses were; (i) low power factor (92.7%); (ii) leakage of compressed air (77.5%); and (iii) leakage of steam (61.9%). The three (3) sources of electricity wastage were not applicable to light industries because the industries did not use steam and compressed air while power factor of light industries was not recorded due to its insignificant effects on electricity consumptions of light industries as stated by Energy-In-Motion (2010) that it does not cause changes in electricity consumptions.

Table 14: Hard start of motors as a source of electricity wastage in light industries only and percentage responses

No	Industry Name	% responses on hard start of motors causing electricity wastage
1	Turbo Feeds Ltd	92.8
2	Timber treatment International Ltd	100
3	Eldoret Farm Machinery Ltd	92.4
Mean % responses		**95.1**

Source: Survey data, 2010

Table 14 shows that only one (1) of the sources of electricity wastage, that is, hard start of motors with 95.1% mean respondents, was applicable to light industries only. The study established that, switching off and start of motors happened often frequently within light industries, unlike in heavy industries where motors run continuously for long time without stop.

4.7.1. Sources of electricity wastage applicable to both heavy and light industries

The study established that six (6) of the ten (10) sources of electricity wastage were applicable to both heavy and light industries. The sources of wastage were; (i) inadequate servicing of industry machines, (ii) unnecessary running of industry machines and equipment (iii) unnecessary lighting, (iv) use of lighting lamps of low energy efficiency, (v) use of blunt blades by cutting machines and, (vi) improper calibrations of industry meters as shown in Table 12.

(i). Inadequate servicing of industry machines

Servicing of machines refers to series of maintenance (necessary and basic support activities and repair) procedures carried at set time interval or after a machine has operated for a certain period of time. Servicing includes tasks such as lubricating, adjusting, and replacing parts of machines (Tooling University, 2009). Inadequate servicing occurs when machines are left to operate beyond the set time interval of servicing. Goldsberry (2010) stated that inadequately serviced machines become less energy-efficient, a condition which results into wastage of energy. Table 12 shows that the proportions of respondents who reported that inadequate servicing of industry machines was a source of electricity wastage in each of the selected manufacturing industries were: 86.8% in Unga Ltd; 76% in Ken-Knit Ltd; 88.5% in New KCC Ltd; 73.8% in Arkay Industries Ltd; 86.8% Highlands Paper Mills Ltd, 79.7% in Turbo Feeds Ltd; 76% in Timber Treatment International Ltd and; 93.7% in Eldoret Farm Machinery Ltd. Therefore, an average of 82.7 per cent of respondents in the selected industries reported inadequate servicing of industry machines as a source of electricity wastage (Table 12). This demonstrated that inadequate servicing was a major source of electricity wastage within both heavy and light industries within Eldoret Municipality.

To establish whether there was inadequate servicing of machines within both heavy and light industries, the study sought to identify the time interval of servicing machines. Table 15 shows that 43.9% of the respondents reported that servicing of machines was conducted only at the times when the machines had broken down; 25.2% of respondents stated that servicing was done annually; 20.6% of respondents stated servicing was done every 6 months; 7.5% of respondents stated servicing was done monthly while 2.8% stated servicing was done every 3 months. Since majority of the respondents (43.9%) reported that servicing was done only when machines break down, the study established that there was inadequate servicing of machines that caused electricity wastage within the selected manufacturing industries.

Table 15: Respondents knowledge on time intervals of servicing of industry machines

Duration after which servicing was conducted	Number of respondents	Percent (%)
Only during break down	47	43.9
Annually	27	25.2
6 months	22	20.6
Monthly	8	7.5
3 months	3	2.8
Total	107	100.0

Source: Survey data, 2010

Hess (2009) supports the findings of study and recommends that large industrial plants should perform regular servicing and maintenance works of machines in accordance with requirements set by the manufacturers of the machines and equipment to avoid electricity wastage. Large industrial plants must be shut down at regular time intervals to perform servicing and maintenance works.

(ii). Unnecessary running of industry machines and equipment

The term 'unnecessary running of machines and equipment' refers to instances where machines and equipment were left to operate when not adding value to the operation for which they were intended (KPLC, 2010). The electricity consumed by the machines or equipment during such times when not needed were regarded as wastage. An average of 73.0% of the respondents from both heavy and light industries stated that unnecessary running of machines were sources of electricity wastage (Table 12). The proportions of these respondents in each of the industries were: - 71.2% in Unga Ltd; 83.2% in Ken-Knit Ltd; 76.3% in New KCC Ltd, 90.1% in Arkay Industries Ltd; 78.4% in Highlands Paper Mills Ltd; 64.1% in Turbo Feeds Ltd; 75.0% in Timber Treatment International Ltd; and 46.0% of the respondents in Eldoret Farm Machinery Ltd as shown in Table 12. The results of the study demonstrated that unnecessary running of machines was a major source of electricity wastage within the selected industries. An example of unnecessary running of machines established by the study was at Highlands Paper Mills Ltd where industry engineer reported that water pumps sometimes were left to run for over 2 hours after storage tank had been filled. During the 2-hour duration of unnecessarily running of pumps, electricity consumed goes to waste because it did not produce any output. The results of the study were consistent with the findings of UNEP (1996) which stated that, end-user wastage of electricity included leaving equipment on when they serve no useful purpose. Itron (2008) supported the findings by indicating that 6% of electricity is wasted by unnecessary running of machines in large manufacturing industries.

(iii). Unnecessary lighting

Unnecessary lighting refers to keeping lights on when not needed or more than is needed in premises (KPLC, 2009). An average of 58.2% of the respondents from both heavy and light industries stated that unnecessary lighting was a source of electricity wastage (Table 12). The percentage of respondents who stated that unnecessary lighting was source to electricity wastage in each of the industries were: 64.3% in Unga Ltd; 83.4% in Ken-Knit Ltd, 53.0% in New KCC Ltd, 63.7% in Arkay Industries Ltd, 64.7% in Highlands Paper Mills Ltd, 57.2% in Turbo Feeds Ltd, 41.7% in Timber Treatment International Ltd and 38.5% in Eldoret Farm Machinery Ltd. The results indicated that unnecessary lighting was a major source of wastage in six industries namely Unga Ltd; Ken-Knit Ltd, New KCC Ltd Arkay Industries Ltd, Highlands Paper Mills Ltd, Turbo Feeds Ltd and Timber Treatment International Ltd because the source was indicated by majority of the respondents. However, the study established that unnecessary lighting was not a major source of wastage in Timber treatment International and Eldoret Farm Machinery Ltd because minority of respondents (41.7% and 38.5% respectively) reported the source of wastage.

The study established areas of unnecessary lighting within industries to include security lights left on during day time, office lights left on when there was adequate sunlight and lights left on un-occupied rooms (such as stores) and offices. The lights consumed electricity without useful purpose thus amounted to electricity wastage within industries. Lovins (2005) supports the findings of the study and states that lights left on all the time even when they serve no useful purpose is undesired service that caused electricity wastage at end-use stages. KPLC (2009) proposes two strategies of minimizing electricity wastage caused by unnecessary lighting by domestic, commercial and industrial electricity consumers that included manufacturers as follows:- (i) Turning off any lights that are not needed and (ii) Fitting exterior security lights with movement detectors and timer switches so that they are on only when needed.

(iv). Use of lighting Lamps with low energy efficiency

Table 12 shows that an average of 43.8 percent of respondents reported that use of lighting lamps with low energy efficiency was a source of electricity wastage within both heavy and light industries. The percent respondents in each of the selected manufacturing industries were: 50.0% in Unga Ltd; 58.3% in Ken-Knit Ltd; 41.2% in New KCC Ltd; 63.6% in Arkay Industries Ltd; and 21.4% in Highlands Paper Mills Ltd; 35.7% in Turbo Feeds Ltd; 41.7% in Timber Treatment International Ltd and; 38.5% in Eldoret Farm Machinery Ltd (Table 12). The results show that lighting lamps with low efficiency was a major source of electricity wastage in three industries namely; Arkay industries Ltd, Ken-Knit Ltd and Unga Ltd where majority respondents reported the source of wastage. However, New KCC Ltd, Highlands Paper Mills Ltd, Turbo Feeds Ltd, Timber Treatment International Ltd and Eldoret Farm machinery Ltd recorded minority respondents indicating that, use of lighting lamps with low efficiency was not major source of wastage of electricity wastage within the industries.

The study established that lamps with low energy efficiency especially incandescent lamps were a source of electricity wastage because they produce more heat to reach operational temperatures in the process of converting electrical energy to light. The findings were consistent with Green Energy Parks Partnership (2001) which states that lighting lamps with low efficiency operate at high temperatures than lamps with high efficiency. For instance, the operational temperature of incandescent lamps is 700°C while the operational temperature of Compact Florescent Lamps (CFL) is 100°C. The operational temperature of incandescent lamps is seven (7) times the operational temperatures of CFL. This indicates that, CFL uses a seventh (14.2%) of electricity compared to incandescent lamp to operate. KPLC (2009) supports the findings as it states that CFLs uses only 20% of electricity (saving 80%) for an equivalent amount of light produced by incandescent bulbs.

(v). Use of blunt blades by cutting machines

Table 12 shows that 43.3 per cent of respondents stated that electricity wastage was caused by use of blunt blades by cutting machines. The percent respondents from each of the industries were; 83.3% in Ken-Knit Ltd, 78.5% in Highlands Paper Mills Ltd, 91.7% in Timber Treatment International Ltd, 92.4% in Eldoret Farm Machinery Ltd. The study established that the four industries had cutting machines used to perform bulk of the works. The cutting machines included guillotine machines at Highlands Paper Mills Ltd; apparel/blanket cutting machines at Ken Knit Ltd; wood cutting saws at Timber Treatment International Ltd and shapers at Eldoret Farm Machinery Ltd. Electricians at the four manufacturing industries reported that, when the blades of the cutting machines became blunt, more electricity was required to enable them perform the cutting activity effectively. This was because the machines took longer time to perform cutting activity and consumed more electricity to drive the blunt blades through materials. This led to unnecessary consumption of electricity that was avoidable by sharpening or replacing blunt cutting blades with sharps ones. Thus, the electricians stated that regular sharpening of blades of the cutting machines was a major maintenance procedure without which cutting machines continues to waste electricity.

(vi). Improper calibrations of meters

The study established that improper calibration of meters was a source of electricity wastage in three manufacturing industries; two heavy industries and one light industry (Table 12). The heavy industries were; New KCC Ltd where 82.3% of its respondents reported that electricity wastage was caused by improper calibration of meters and; Highlands Paper Mills Ltd that had 85.7% of respondents who reported that improper calibration of machines meters was a source of electricity wastage (Table 12). The light industry, i.e., Timber Treatment International Ltd had 100% of respondents who stated that improper calibration of meters was a source of electricity wastage. The study established that improper calibration of meters had not been identified as a source of electricity wastage in five of the selected manufacturing industries namely Unga Ltd, Ken-Knit Ltd, Arkay industries Ltd, Turbo Feeds Ltd and Eldoret Farm Machinery Ltd because none (0%) of the respondents from industries reported the source of wastage.

Wastage of electricity occurred when the meters were calibrated to read higher values of temperature and pressure then more electricity was consumed unnecessarily (TTI Ltd Plant Manager's personal communication, March 2010). For example, respondents from Highlands Paper Mills Ltd reported that when the temperature meters of driers were set to higher values than required, papers were over dried and spoilt. The spoiled papers were reprocessed leading to consumption of electricity which could have been avoided if temperature meters of driers were set correctly. Therefore, the study established that improper calibration of meters led to unnecessary consumption of electricity. The findings of the study are in agreement with the findings of Itron (2008) which indicated that, 6% of electricity is lost in an industrial plant due to improper calibration of thermometers, occupancy sensors, and velocity meters of motors.

4.7.2. Sources of electricity wastage applicable to heavy industries only

Table 13 shows that three (3) of the ten (10) sources of electricity wastage were applicable to heavy industries only. The sources were (i) low power factor, (ii) leakage of compressed air and (iii) leakage of steam.

(i). Low power factor

Table 13 shows that the percentage of respondents in each of the heavy manufacturing industries who reported low power factor as a source of electricity wastage were: 92.8% in Unga Ltd, 91.7% in Ken-Knit Ltd, 95.0% in New KCC Ltd, 91.0% in Arkay Industries Ltd and 92.8% in Highlands Paper Mills Ltd. Therefore, an average of 92.7% of respondents reported low power factor as a source of electricity wastage in each of the heavy industries. The results indicated that low power factor was a major source of electricity wastage within the heavy manufacturing industries.

Power factor (PF) has been defined by Fairchild Semiconductor (2004) as the ratio of the real power (P) to apparent power (S). The power factor can vary between 0 and 1, and can be either inductive (lagging) or capacitive (leading). In order to reduce an inductive lag, capacitors are added until power factor equals 1. When the power factor is not equal to 1, the current waveform does not follow the voltage waveform and results in power losses. ERC (2008) stated on the Schedule of tariffs 2008 that power factor below 0.90 should be corrected to above 0.90 to avoid electricity wastage. Electrotek Concepts (2002) stated that a low power factor causes wastage of electricity by causing equipment overloads, greater line losses, and increased heating of equipment that can shorten service life. The result of low power factor would be an increase in electric bills with higher total demand charges and cost per unit of electricity consumed.

Large power electricity consumers particularly heavy manufacturing industries often experience low power factor because of the presence of inductive motors whose uptake of electricity was normally characterized by a low power factor (KPLC Customer Services Engineer's personal communication, April 2010). Electrotek Components (2002) concurs with the findings and states that one of the equipment that have worst and offensive low power factors are the loaded induction motors (examples included motors of saws, conveyors, compressors, grinders, and mills).

(ii). Leakage of compressed air

Table 13 shows the percentages of respondents in each of the heavy industries who reported leakage of compressed air were: 71.5% in Unga Ltd; 75.0% in Ken-Knit Ltd; 82.4% in New KCC Ltd; 72.8% in Arkay Industries Ltd; and 85.8% in Highlands Paper Mills Ltd. Therefore, an average of 77.5% of respondents in each of the heavy industries reported leakage of compressed air as a source of electricity wastage. The results of the study indicate that leakage of compressed air was a major source of electricity wastage within the heavy industries. The study established that, because electricity was used by compressor machines in generating compressed air, leakage of compressed air from broken pipes of the system translated into an indirect wastage of the electricity used by compressors to generate compressed air.

The study established that the main cause of leakage of compressed air was high pressure exerted pipe-systems which resulted into bursting of the pipes and consequent escape of the compressed air from the systems. KAM (2005) concurs with the findings of the study by explaining that leakage of compressed air can be reduced by generating air at the lowest acceptable pressure, that is, the higher the pressure the more air that will escape through leaks from loose valves and broken pipes.

(iii). Leakage of Steam

Table 13 shows that the percentage of respondents who reported that leakage of steam was a source of electricity wastage in each of the five heavy industries were; 78.7% in Unga Ltd, 75.0% in Ken Knit Ltd, 64.8% in New KCC Ltd, 91.0% in Arkay Industries Ltd, and 0% at Highlands Paper Mills Ltd. Among the five heavy industries, none (0%) of the respondents from Highlands paper mills Ltd reported leakage of steam was a source of electricity wastage despite steam being used in the industry. This was because boilers of Highlands Paper Mills Ltd used firewood instead of electricity thus no electricity wastage occurred in the steam generation process. The other four heavy industries had majority of respondents (between 64.8% in New KCC Ltd and 91.0% in Arkay Industries Ltd) stating that electricity wastage occurred due to leakage of steam. This indicated that leakage of steam was one of major sources of electricity wastage in the heavy industries. This was because electricity was used to boil water directly in the boilers.

The study established that when steam leakage occurred, more electricity was consumed to generate steam to replace the one lost (Ken-Knit Ltd trainer personal communication, April 2010). Therefore, leakage of steam translated to indirect wastage of electricity used to heat water in boilers to produce stream. The study established that leakage of steam occurred from broken pipe systems, open taps/valves and loose lids of tanks within the four heavy industries. Plate 2 shows an example of steam leakage where steam vapours escaped from a steaming house in the dyeing section of Ken Knit Ltd at the time of study. The study established that steaming house had openings and holes that allowed stream to escape.

Plate 1: Steam escapes from a steaming facility (house) at Ken Knit Ltd
Source: Field survey, 2010

The electrical engineers of the four heavy industries where leakage of steam was a source of electricity wastage reported that, apart from leakage of steam, the heat transferred by the steam was also being lost due to un-insulated pipe works. KAM (2005) supports the findings and states that 20% of heat energy is lost through poorly maintained steam distribution systems and also recommends that proper lagging or insulation of all pipe work of the steam distribution system could reduce 70% of the lost heat energy (KAM, 2005).

4.7.3. Source of electricity wastage applicable to light industries only

(i). Hard start of motors

Smart Energy User (1997) defined hard start of motors as the abrupt application of power to motors going from zero rotation per minute to full operating speed in minimum time. The initial uptake of electricity by an induction motor was 50% to 70% higher than the electricity consumed by the motor at maximum velocity. The duration of the high electricity uptake by the motors ranges from about 10 seconds to 5 minutes, depending on how long motors take to attain full velocity. Therefore, when motors took unusually longer time to reach maximum velocity, more electricity was unnecessarily consumed resulting to wastage.

Table 14 shows that the percentage of respondents who reported hard start of motors in each of the light industries were:- 100% of the respondents from Timber Treatment International Ltd; 92.8% of the respondents from Turbo Feeds Ltd; and 92.4% of the respondents from Eldoret Farm machinery Ltd. Therefore, an average of 95.1 per cent of respondents in each of the light industries reported that hard start of motors was a source of electricity wastage. The results of the study demonstrated that hard start of motors was therefore a major source of electricity wastage within light industries.

Electricians and machine operators of the light industries confirmed the results and indicated that extended time of hard start of motors was caused by loading of machines before motors attain maximum velocities and inadequate maintenances. Smart Energy User (1997), in agreeing with the findings, explained that hard start in motors results from mechanical and thermal stresses within the motor as well as mechanical stresses to the load (as was in the case of loaded motor before being started) and drive-train having any looseness or play due to inadequate maintenance. The extended time lead to unnecessary consumption of electricity hence a source of wastage. TECO (2000) confirmed that hard start of motors caused wastage of electricity recommends that motors should be started without load or with recommended initial loads for the hard-start time of motors to be kept at normal.

CHAPTER FIVE

POLICY STRATEGIES FOR ELECTRICITY CONSERVATION USED BY SELECTED MANUFACTURING INDUSTRIES

5.0. Introduction

This chapter addresses the second objective of the study which seeks to identify and analyze policies for electricity conservation within the selected manufacturing industries within Eldoret Municipality. The chapter contains results on; (i) workers knowledge on existence of electricity conservation policies, (ii) formulation of electricity conservation policies, and (iii) existing electricity conservation policies

5.1. Workers' Knowledge on Existing Electricity Conservation Policies

The study established that 86.0 per cent of the workers in the selected manufacturing industries were aware of the existence of policies that guided electricity conservation (Table 16). 8.4 per cent indicated that there were no electricity conservation policies in the industries while 5.6 per cent did not know whether policies for electricity conservation existed or not.

Table 16: Response on existence of electricity conservation policies

		Whether policies for electricity conservation existed in the industry (% respondents)		
No	Industry Name	Yes	No	Don't know
1.	Unga Ltd	12.1	0.9	0
2.	Ken Knit Ltd	10.3	0.9	0
3.	New KCC Ltd	14.0	1.9	0
4.	Arkay industries Ltd	9.3	0.9	0
5.	Highland Paper Mills Ltd	12.1	0.9	0
6.	Turbo Feeds Ltd	11.2	0	1.9
7.	Timber Treatment International Ltd	11.2	0	0
8.	Eldoret Farm Machinery Ltd	5.6	2.8	3.7
	Total	**86.0**	**8.4**	**5.6**

Source: Survey data

The study established that the positions or designations of industry staff influenced awareness on the existing policies of electricity conservation. Table 17 shows that 100 per cent of industry managers, 100 per cent of the engineers and 100 per cent of machines operators had knowledge of the existence of policies for electricity conservation used in the industries. The level of awareness on electricity conservation policies by other industry staff was 95.2 % of electricians, 64.0% of the supervisors, 40.0% of the secretaries/clerks, and 75.0% of other workers who included cleaners, packaging staff and security personnel.

Table 17: Knowledge of existence of electricity conservation policies and regulations according to designations/positions

No.	Designation of respondent in the industry	% respondents on the existence of policies for electricity conservation in the industry		
		Yes	No	Don't Know
1.	Managers	100	0	0
2.	Engineers	100	0	0
3.	Machine operators	100	0	0
4.	Electricians	95.2	4.8	0
5.	Supervisors	64	32	4
6.	Clerks/secretaries	40	0	60
7.	Other workers	75	0	25
	Mean (% of Total)	**86.0**	**8.4**	**5.6**

Source: Survey data, 2010

The results of the study (Table 17) indicates that designations of respondents in the industry influenced awareness on existence of electricity conservation policies used in the industries. Plant/general managers, engineers, electricians and machine operators were more aware of existence of electricity conservation regulations than other workers such as supervisors, secretaries/clerks, security guards. This was because the industry managers, in consultation with engineers, electricians and machine operators, were responsible for formulating, among other regulations, electricity conservation regulations for the industry but supervisors, secretaries/clerks, security personnel did not participate in formulation of regulations.

Table 17 shows that 32% of the supervisors stated that there were no policies for electricity conservation in the industries but 100% of industry managers had indicated that there were policies of electricity conservation. This indicates that not all the supervisors were responsible for implementing electricity conservation polices formulated by management regulations. The findings were contrary to EECA (2009) that states that the responsibilities of middle level industry workers such as supervisors were to implement policies as formulated by high-level managers.

5.2. Formulation of electricity conservation policies

Table 18: Percentage respondents on the persons who formulated electricity conservation policies per industry

Industry Name	% respondents on persons who formulates electricity conservation policies in each industry					Total (%)
	Management	Electricians	Supervisors	Engineers	KPLC	
Unga Ltd	64.3	21.5	7.1	0	7.1	100
Ken-Knit Ltd	58.3	0.0	16.7	16.7	8.3	100
New KCC Ltd	64.6	11.8	5.9	11.8	5.9	100
Arkay Industries Ltd	63.6	0.0	9.1	18.2	9.1	100
HPM Ltd	57.2	21.5	7.1	7.1	7.1	100
TTI Ltd	75.0	16.7	0	8.3	0	100
Turbo Feeds Ltd	50.0	35.7	7.2	0	7.1	100
EFM Ltd	61.5	7.7	30.8	0	0	100
Mean (% of total)	**61.7**	**15.0**	**10.3**	**7.4**	**5.6**	**100**

Source: Survey data, 2010

Table 18 shows that the percentage of respondents in each of the selected manufacturing industries who stated that electricity conservation policies were formulated by management were: 64.3% in Unga Ltd, 58.3% in Ken-Knit Ltd, 64.6% in New KCC Ltd, 63.6% in Arkay Industries Ltd, 57.2% in Highlands Paper Mills Ltd, 75.0% in Timber Treatment International Ltd, 50.0% in Turbo Feeds Ltd and 61.5% in Eldoret Farm Machinery Ltd. Therefore, an average of 61.7% of respondents stated that the existing electricity conservation policies were formulated by the management, thus, indicating that most of the electricity conservation policies were formulated by management. Some electricity conservation policies were formulated by: electricians as stated by 15% of the respondents, supervisors stated by 10.3% of respondents, engineers stated by 7.4% of respondents and; KPLC stated by 5.6% of respondents. The results of the study demonstrated that four categories of industry staff namely management, electricians, supervisors and engineers participated in formulation of policies for electricity conservation. The results were in agreement with the results of a study by EECA (2009), which established that the responsibilities of industry managers and administrators in electricity conservations were to identify electricity conservation policies and set the main targets/goals for electricity conservation.

5.3. Existing Electricity Conservation Policies

The study established that there were six (6) electricity conservation policies used by the selected manufacturing industries within Eldoret Municipality. Four (4) of the policies namely; (i) optimal use of electricity policy, (ii) energy saving lighting policy, (iii) regular maintenance of industry machines policy and (iv) machines retrofit policy were used by both heavy and light industries as shown in Table 19 while two (2) of the policies namely; (i) keeping power factor at above 0.90 policy and (ii) surcharging policy were used by heavy manufacturing industries only as shown in Table 20.

Table 19: Electricity conservation policies used by both heavy and light industries and percentage of respondents

No	Electricity conservation policy	**% respondents from each of the industries**								Mean %
		Heavy Industries					Light industries			
		Unga Ltd	Ken-Knit Ltd	New KCC Ltd	Arkay Industries Ltd	HPM Ltd	Turbo Feeds Ltd	TTI Ltd	EFM Ltd	
1.	Optimal use of electricity	50.0	66.7	52.9	63.6	71.4	50.0	58.4	53.8	**58.4**
2.	Energy saving lighting	28.6	75.0	41.0	72.7	57.1	64.3	66.7	61.5	**58.4**
3.	Regular servicing of industry machines	57.1	66.7	64.7	81.8	35.7	50.0	66.7	0.0	**52.8**
4.	Machines Retrofits	64.3	83.3	70.6	81.8	28.6	42.9	41.7	0.0	**51.6**

Source: Survey data, 2010

Table 19 shows that existing electricity conservation policies within both heavy and light industries were: (i) optimal use of electricity policy reported by 58.4% of the respondents, (ii) energy saving lighting policy reported by 58.4% of respondents, (iii) regular maintenance of industry machines policy reported by 52.8% of respondents and (iv) machines' retrofits policy reported by 51.6% of respondents.

Table 20: Electricity conservation policies used by heavy industries and percentage of respondents

No	Electricity conservation policy used in heavy industries	**% respondents from each of heavy industries**					
		Unga Ltd	Ken-Knit Ltd	New KCC Ltd	Arkay Industries Ltd	HPM Ltd	Mean %
1.	Keeping power factor at above 0.9	71.4	83.3	70.6	72.7	64.3	**72.5**
2.	Surcharging	64.3	83.3	58.8	63.6	64.3	**66.9**

Source: Survey data, 2010

Table 20 shows that electricity conservation policies used by heavy industries only were; (i) keeping power factor at above 0.90 policy reported by 72.5% of respondents and (ii) surcharging policy reported by 66.9% of respondents.

5.3.1. Electricity Conservation Policies applicable to both heavy and light industries

(i). Optimal use of electricity policy

Table 19 shows the percentage of respondents in each of the industries who stated that optimal use of electricity policy was used for electricity conservation were: 50.0% in Unga Ltd, 66.7% in Ken-Knit Ltd, 52.9% in New KCC Ltd, 63.6% in Arkay Industries Ltd, 71.4% in Highlands Paper Mills Ltd, 50.0% in Turbo Feeds Ltd, 58.4% in Timber Treatment International Ltd and 53.8% in Eldoret Farm Machinery Ltd. Therefore, an average of 58.4 percent respondents in each of the industries stated existence of optimal use of electricity policy for conservation of electricity. The results of the study indicated that the policy was of major use in all the selected industries for electricity conservation.

The study established that optimal use of electricity policy guided the selected manufacturing industries in carrying out operational activities such as switching off machines and lights not in use, maximizing the use of natural lights during day time; regular cleaning of machines, ensuring all machines operated at recommended loads (do not overload or under-load machines), regular maintenance of machines as spelt out in the manufacturers manuals and reporting malfunctioning or faulting machines to concerns persons. The activities promoted optimal use of electricity within the manufacturing industries hence achieving electricity conservation.

The study established that management of the selected manufacturing industries were responsible for disseminating information on how to achieve optimal electricity use. The study identified notice boards as one of the ways used by the industry management to disseminate information on electricity conservation to other workers. For example Plate 2 shows a notice board that contained operational instructions to all industry workers of Ken Knit Ltd formulated by general manager.

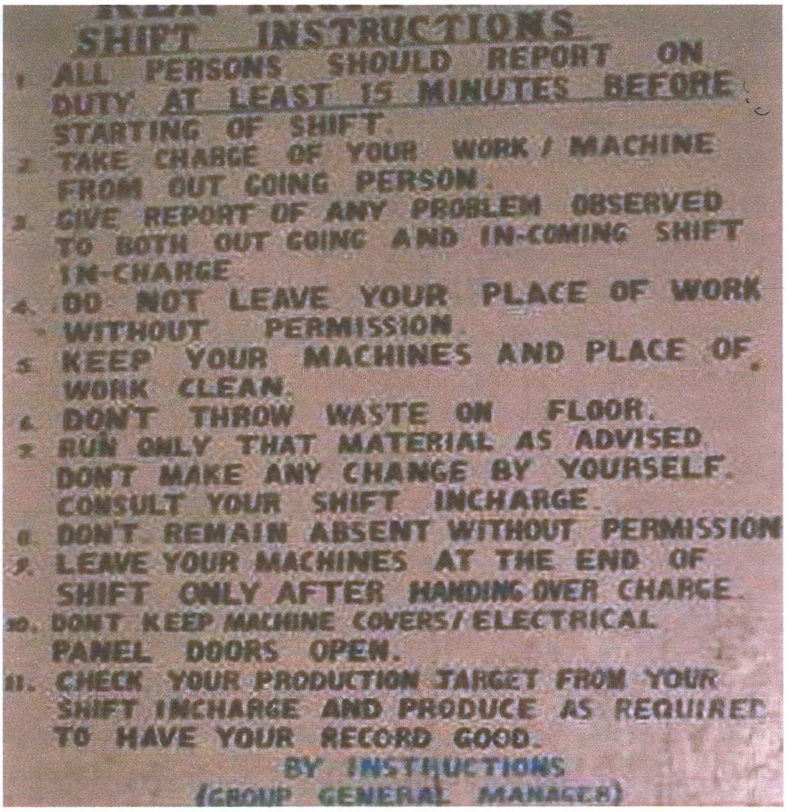


Plate 2: Notice board showing operational instructions of Ken-Knit Ltd
Source: Field Survey, 2010

The operational instructions shown in Plate 2 contained notes that address electricity conservation in the industry. For instance, note 5 'keep your machine and work place clean', note 9 'leave your machines at the end of shift only after handing over charge' and note 10 'do not keep machine covers/electrical panels open' were expected to reduce unnecessary running of machines and wastage of steam from boilers and dyeing machines of Ken-Knit Ltd.

The study established that, optimal use of electricity policy in electricity conservation was consistent with the provisions of Section 98 of the Electricity power Act of 1997 (GoK, 1997). Section 98 (1) of the Act stated that:-

> 'In any case where any consumer receiving a supply of electrical energy from a licensee, uses or permits be used such supply for any purpose or deals or permits it to be dealt with, in any manner so as to interfere unduly or improperly with the efficient supply of electrical energy by the licensee to any other consumer or endangers public

safety, the licensee may, if he thinks fit, discontinue to supply electrical energy to such consumer so long as the electrical energy is so used or deal with.'

Therefore, section 98 (1) of the Electric Power Act, empowered KPLC to discontinue supply of electricity to customers who use electricity in a manner as to interfere unduly or improperly with efficient supply of electricity to other customers.

(ii). Energy saving lighting policy

Table 19 shows that the percentage of respondents in each of the selected manufacturing industries who reported that energy saving lighting policy was used for electricity conservation were: 28.6% in Unga Ltd, 75.0% in Ken-Knit Ltd, 41.0% in New KCC Ltd, 72.7% in Arkay Industries Ltd, 57.1% in Highlands Paper Mills Ltd, 64.3% in Turbo Feeds Ltd, 66.7% in Timber Treatment International Ltd and 61.5% in Eldoret Farm Machinery Ltd. Therefore, an average of 58.4% of respondents in each of the heavy and light industries stated that energy saving lighting policy was used for electricity conservation. The results of the study indicated that energy saving lighting policy was of major use in the selected industries for electricity conservation.

The study established that the policy had enabled the industries to install roof skylights sheets to maximize uptake of natural sunlight during day time and, to replace incandescent bulbs with either compact fluorescent lamps or fluorescent tubes. KPLC (2010) supports the findings and states that replacing incandescent lamps with compact fluorescent lamps (CFL) enabled electricity consumers to save up to 80% electricity consumed in lighting. The selected manufacturing industries combined use of fluorescent tubes with roof sky lighting sheets in processing halls for lighting. This clearly demonstrated that the energy saving lighting policy had achieved implementation success in the selected manufacturing industries. However, the study established that the paints had been applied to roof skylight sheets in industries such as Ken-Knit Ltd and Turbo Feeds Ltd. The painting reduced the amount of sunlight that entered the industries during day time, thus, made the industries consume more electricity by keeping electric lights on during daytime to light the premises.

(iii). Regular servicing of industry machines policy

Table 19 shows that the percentage of respondents in each of the selected industries who reported existence regular servicing of industry machines policy were: 57.1% in Unga Ltd, 66.7% in Ken-Knit Ltd, 64.7% in New KCC Ltd, 81.8% in Arkay Industries Ltd, 35.7% in Highlands Paper Mills Ltd, 50.0% in Turbo Feeds Ltd, 66.7% in Timber Treatment International Ltd and 0% in Eldoret Farm machinery Ltd. Thus, an average of 52.8 percent of respondents in each of the selected manufacturing industries reported the use of regular servicing of industry machines policy for electricity conservation. The results indicated that the policy was not used in Eldoret Farm machinery Ltd and was used to low levels in Highlands Paper Mills Ltd. However, the level of use of the regular servicing of machines policy in other industries was high given that majority of respondents reported the use of the policy.

The study established that regular servicing of industry machines policy enabled selected industries to set and implement maintenance schedules for performing procedures such as cleaning, lubrications/greasing and tracking for repairs on industry machines. The maintenance schedules provided the time intervals for servicing or conducting maintenance on each of the industry machines. The maintenance time intervals ranged from 250 hours of operation for sumps and gearboxes on New KCC Ltd, 6 months operation for motors, to one year operations for machines such as weighing machines of Unga Ltd and blanket machine of Ken Knit Ltd. The study established that maintenance schedules for industry machines were set and implemented by industry engineers, electricians and machines operators.

(iv). Machines' Retrofit policy

Table 19 shows that the percentage of respondents in each selected industries who stated that machines retrofit policy was used for electricity conservation were: 64.3% in Unga Ltd, 83.3% in Ken-Knit Ltd, 70.6% in New KCC Ltd, 81.8% in Arkay Industries Ltd, 28.6% in Highlands Paper Mills Ltd, 42.9% in Turbo Feeds Ltd, and 41.7% in Timber Treatment International Ltd. Table 19 shows that an average of 51.6 per cent of respondents in each of the selected manufacturing industry reported use of machines retrofit policy for conservation of electricity. The results indicated that machines' retrofit policy was not used in Eldoret Farm Machinery Ltd because none (0%) of the respondents from the industry stated the existence of machines retrofit policy. Because minority respondents in Highlands Paper Mills Ltd Turbo Feeds Ltd, and Timber Treatment International Ltd reported the use of machines retrofit policy, the study concluded that level of use of the policy was low in the industries compared to industries that had majority of respondents who reported the policy.

The study established that machine retrofit policy had enabled the selected manufacturing industries to replace machines that had low energy efficiency with machines of high energy efficiency. For example, under the machines retrofit policy machines such as hand flapping machines had been replaced with 'universal' flapping machines at Ken Knit Ltd; Nichrome Filpack packaging machines replaced with manually operated packaging machines at New KCC Ltd and; pumps with manual valves replaced with auto-switch pumps at New KCC Ltd, Ken-Knit Ltd and Unga Ltd. DSCLES (2009) traced the origin of retrofit policy for manufacturers in Kenya to the GEF-KAM project on industrial energy efficiency programme launched by MOE, Government of Kenya with financial support from UNDP and GEF in 2001. The project had recommended the adoption of retrofit technology by all manufacturers in order to achieve 10 to 30% of electricity consumed (DSCLES, 2009). However, the management of the selected manufacturing industries indicated that the retrofit policy had been difficult to implement because of enormous financial resources required to purchase new machines to replace existing ones and to train or employ personnel who would use or operate the new machines.

5.3.2. Electricity conservation policies used by Heavy manufacturing industries only

(i). Keeping power factor at above 0.90 policy

Table 20 shows that the percentage of respondents in each of the heavy manufacturing industries who stated that keeping power factor at above 0.9 policy existed were: 71.4% in Unga Ltd, 83.3% in Ken-Knit Ltd, 70.6 % in New KCC Ltd, 72.7% in Arkay Industries Ltd and 64.3% in Highlands Paper Mills Ltd. Thus, an average of 72.5% respondents in each of the heavy industries reported that keeping power factor at above 0.9 policy was used for electricity conservation (Table 20). Therefore, because majority of respondents from each of the industries reported the use of the policy, the study concluded that keeping the power factor at above 0.9 policy was of major use in heavy industries. The findings of the study were in agreement with KPLC (2009) which stated that generally the power factor should be ensured that it remains above 0.9 at all times. The study established that Schedule of Tariff 2008 gave mandate to KPLC to monitor the implementation of the policy of keeping power factor above 0.9 by its customers. Part IV (a) of the Schedule of tariffs, 2008 states that 'in the event of the supply of electrical energy to the installation of any consumer having a power factor of less than 0.90, then KPLC may give to such consumer thirty days notice in writing requiring him/her to improve the power factor of his/her installation to or in excess of 0.90.'

The policy had enabled the heavy industries to install power factor correction capacitors at sub-stations referred to as capacitor banks so as to keep the power factor of industries at above 0.9. Fairchild Semiconductor (2004) stated that the purpose of making the power factor as close to 1.00 as possible was to make the load circuitry appear purely resistive, implying that, the apparent power was equal to real power hence conservation of electricity. EPCOS (2005) also noted that electric cables carry less reactive current when the power factor is improved thus reducing the conduction wastage in a transmission cables of an electricity system.

(ii). Surcharging Policy

Table 20 shows that the percentage of respondents in each of the heavy manufacturing industries who stated that surcharging policy existed were: 64.3% in Unga Ltd, 83.3% in Ken-Knit Ltd, 58.8% in New KCC Ltd, 63.6% in Arkay Industries Ltd and 64.3% in Highlands Paper Mills Ltd. Therefore an average of 66.9 per cent of the respondent from each of the heavy industries reported existence of surcharging policy. The results indicated that surcharging policy was a major electricity conservation policy used within heavy manufacturing industries.

The study established that the surcharging policy was contained in Part IV (a) of the Schedule of Tariffs 2008 which was formulated by ERC and implemented by KPLC. Upon critical analysis of the Schedule of tariffs 2008, the study established that the Schedule of Tariffs 2008 empowers KPLC to impose surcharge to customers under conditions that are spelt by the Schedule. Pursuant to Part IV (a) of the Schedule, KPLC is

5.4.1. The Electric Power Act, 1997

Electricity Power Act, 1997, was an act of parliament that was enacted to amend and consolidate the law relating to the generation, transmission, transformation, distribution, supply and use of electrical energy for lighting and other purposes, and for connected purposes (GoK, 1997). The date for commencement of the Act was 8th January, 1998. Part IV of the Act establishes the Electricity Regulatory Board (ERB) and mandated it to carry out the following statutory functions:-

(i). Set, review and adjust tariffs for all persons who transmit or distribute electrical energy;
(ii). Investigate tariff structure even when no specific application for a tariff adjustment has been made;
(iii). Enforce environmental and safety regulations in the power sub-sector;
(iv). Investigate complaints made by parties with grievances over any matter required to be regulated under the Act;
(v). Ensure that there is genuine competition where this is expected; and
(vi). Approve electric power purchase contracts and transmission and distribution service contracts between and among electric power producers, public electricity suppliers and large retail customers

The study established that Energy Regulatory Board had been given responsibility to address the issues that related to difference arising from improper use of electricity by customers. This is stated in section 98, subsection (2) of the Act as follows:

> 'If any difference arises as to any improper use of electrical energy, or as to any alleged defects in or as to unsuitable or as to necessary apparatus or protective devises, that differences shall be referred to the Board.'

The responsibility bestowed to ERB by section 98 (2) of the Act was in line with their core mandate of investigating complaints made by parties with grievances over any matter required to be regulated under the Act.

The study established that Electric Power Act, 1997 contained specific provisions on electric power conservation by the distributors and consumers. This was provided for in section 96 (1) of the Act which stated that; 'Any person who wilfully extinguishes or causes to be extinguished any public lamps or wastes or improperly uses any of the electrical energy supplied by the licensee shall for each default forfeit to the licensee any sum not exceeding thirty thousand shillings, in addition to the amount of the damage done.' The study however noted that the penalty of thirty thousand shillings was too low for a manufacturing industry and could only make an impact on small scale electricity consumers but not large power consumers such as heavy manufacturing industries.

The study established that KPLC had been empowered by the Electric Power Act, 1997 to discontinue supply of electricity to a customer whose use of electricity is detrimental to the electricity supply system/grid. This provision is stated in section 98 sub section (1) of the Act as follows:

> 'In any case where any consumer receiving a supply of electrical energy from a licensee, uses or permits be used such supply for any purpose or deals or permits it to be dealt with, in any manner so as to interfere unduly or improperly with the efficient supply of electrical energy by the licensee to any other consumer or endangers public safety, the licensee may, if he thinks fit, discontinue to supply electrical energy to such consumer so long as the electrical energy is so used or deal with.'

5.4.2. The Energy Act, 2006

The study established that the Energy Act 2006 was enacted by parliament to amend and consolidate the law relating to energy, to provide for the establishment, powers and functions of the Energy Regulatory Commission (ERC) and the Rural Electrification Authority, and for connected purposes (GoK, 2006b). The Act was arranged into seven (VII) parts as follows: Part I is Preliminary to the Act; Part II establishes the ERC and prescribes its powers, membership and activities; Part III are provisions for electrical energy such as licensing, supply, offenses and rural electrification; Parts IV are provisions of Petroleum and Natural Gas; Part V provides for Renewable Energy, Energy Efficiency and Conservation; Parts VI of the Act are provisions for The Energy Tribunal and; Part VII refers Miscellaneous provisions.

The study established that provisions of the Energy Act that addressed electricity conservation were contained in Part V of the Act under the title, "Renewable Energy, Energy Efficiency and Conservation". Section 104 empowers the minister for energy to develop energy conservation programmes and promotes their implementation through consultations, financial support, demonstration projects and research. Section 104 (2) of the Act empowered the Minister responsible for energy to perform such functions and exercise such powers as were necessary under the Act to enhance energy efficiency and conservation. The functions of Minister included but were not limited to: –

(i). making, in consultation with the Kenya Bureau of Standards, requirements for the particulars to be displayed on labels on equipment or on appliances;

(ii). taking all measures necessary to create awareness and for the dissemination of information for efficient use of energy and its conservation;

(iii). strengthening consultancy services in the field of energy conservation;

(iv). promoting research and development in the field of energy conservation;

(v). formulating and facilitating implementation of pilot projects and demonstration projects for promotion of efficient use of energy and its conservation;

(vi). giving financial assistance to institutions for promoting efficient use of energy and its conservation;

(vii). supporting the preparation of educational curriculum on efficient use of energy and its conservation for educational institutions, and coordinate with them for inclusion of such curriculum in their syllabus;

(viii). implementing international co-operation programmes relating to efficient use of energy and its conservation; and

(ix). giving financial incentives for any investment made to replace or install additional capital investments to improve energy efficiency;

(x). making it mandatory, in collaboration with Kenya Bureau of Standards, the importation of energy efficient but cost effective technologies (GoK, 2006a).

However, the study established that the Energy Act, 2006 did not provide for the Minister to consult or invite energy stakeholders particularly consumers to participate in formulating programmes for energy conservation. If the Act had the provision, all energy users would have been involved in the formulation of energy conservation programmes. This could have guaranteed that the energy conservation programmes formulated were acceptable and implementable by all energy users.

That Energy Act, 2006 also had specific provisions for conservation of energy within factories and buildings. This was provided for in Section 105 (1) to (4) of the Act highlighted as follows:

(i). The commission (ERC) shall, in consultation with the Minister (Minister for energy), designate factories or buildings and electrical appliances by types, quantities of energy use, or methods of energy utilization for purposes of energy efficiency and conservation.

(ii). In the event that there is a reasonable cause, the Commission may give instruction to the owner of any designated factory or building, to furnish factual information on energy utilization for the purpose of inspection and to assure that energy conservation measures are in accordance with the standard, criteria and procedures provided in regulations under this Act and the said owner of the designated factory or building shall comply within thirty days starting from the date of receipt of such instruction, and in default commits an offence and shall, on conviction, be liable to a fine not exceeding one million shillings, or to a maximum term of imprisonment of one year, or to both.

(iii). If the Commission determines that the owner of the building is not able to comply without financial or technical assistance and that the activities required to be in compliance may be eligible for assistance from an identified source, the commission may decide to give additional grace period to allow the owner to access assistance from the identified source.

(iv). The owner of the designated factory shall keep records of information required under regulations under this Act at the designated factory for a minimum of five years, and in default commits an offence and shall on conviction, be liable to a fine not exceeding one million shillings, or to a maximum term of imprisonment of one year, or to both.

From provisions of section 105 of the Act, electricity use within factories and building are regulated by ERC in consultation with the Minister responsible for energy. In enforcing the provisions, buildings or factories that did not adhere to the provisions of the section 105 were liable to a fine not exceeding one million shillings, or to a maximum term of imprisonment of one year, or to both of the fines and imprisonment.

The study established that Section 106 of the Energy Act, 2006 had specific provisions for energy conservation in buildings as stated in subsections (1) and (2) below:

(1) The owner of a building designated under section 105, shall conserve energy, audit and analyze energy consumption in his building in accordance with the standards, criteria, and procedures as prescribed by regulations.

(2) A person who fails to comply with this provision commits an offence and shall, on conviction, be liable to a fine not exceeding one million shillings, or to a maximum term of imprisonment of one year, or to both.

The study established that penalties prescribed by the Energy Act 2006 in sections 105 and 106 were high for light industries and low for heavy industries. Therefore, the penalties had significant effects on consumption of electricity by light industries but little or no effect on heavy industries. None of the manufacturing industries within Eldoret Municipality had been sued in a court of law for operating against the provisions of sections 105 and 106 of the Energy Act, 2006 (KAM Eldoret Chapter Chief Executive Officer Personal Communication, March 2010). This therefore indicates that the manufacturing industries within Eldoret Municipality had either complied with the provisions of the Act or the provisions of the Act were not enforced.

CHAPTER SIX

TECHNOLOGICAL/OPERATIONAL STRATEGIES FOR ELECTRICITY CONSERVATION USED BY SELECTED MANUFACTURING INDUSTRIES

6.0. Introduction

This chapter addresses objective three (3) of the study which intends to: establish the technological/operational strategies for electricity conservation by selected manufacturing industries within Eldoret Municipality. Eight (8) operational/technological strategies adopted for conservation of electricity by the selected manufacturing industries within Eldoret Municipality were established. Seven (7) of the operational/technological strategies namely; (i) switching off machines and light not in use, (ii) Regular servicing of machines, (iii) increased supervision of workers, (iv) use of roof skylight sheets, (v) use of automatic machines, (vi) proper calibration of meters and, (vii) use of energy saving bulbs were used by both light and heavy manufacturing industries as shown by Table 21. Table 22 shows that installation of capacitors was one (1) of the eight (8) strategies used by heavy manufacturing industries only.

Table 21: Operational/technological strategies used by both heavy and light industries for electricity conservation and percentage of respondents

No	Operational/technological electricity conservation strategy used	% respondents within each of the selected industries								Mean %
		Heavy industries					Light industries			
		Unga Ltd	Ken-Knit Ltd	New KCC Ltd	Arkay industries Ltd	HPM Ltd	Turbo Feeds Ltd	TTI Ltd	EFM Ltd	
1	Switch off machines & lights not in use	57.1	58.3	70.6	63.6	64.3	57.1	66.7	69.2	**63.4**
2	Regular servicing of machines	71.4	83.3	88.2	81.8	14.3	85.7	33.3	0	**57.3**
3	Increased supervision of workers	85.7	41.7	0	81.8	42.9	0	83.3	84.6	**52.5**
4	Use of roof skylights sheets	50.0	58.3	58.8	72.7	42.9	35.7	41.7	46.2	**50.8**
5	Use of automatic machines	0	50.0	94.1	0	78.6	64.3	0	76.9	**45.5**
6	Proper calibrations of meters	64.3	66.7	52.9	72.7	0	0	0	76.9	**41.7**
7	Use of energy saving bulbs	78.6	66.7	0	81.8	0	0	83.3	0	**38.8**

Key: EFM-Eldoret Farm Machinery HPM-Highlands Paper Mills TTI-Timber Treatment International

Source: Survey data, 2010

Table 22: Percentage responses on installation of capacitors as technological/operational strategies used by heavy industries only

No	Industry Name	% responses on installation of capacitors
1	Unga Ltd	78.6
2	Ken-Knit Ltd	66.7
3	New KCC Ltd	70.6
4	Arkay Industries Ltd	81.8
5	Highlands Paper Mills Ltd	57.1
Mean % responses		**71.0**

Source: Survey data, 2010

6.1. Technological/Operational strategies used in both heavy and light industries

6.1.1. Switching off machines and lights while not in use

Table 21 shows that the percentage of respondents in each of the industries who stated that switching off machines and lights not in use as technological/operational strategy for electricity conservation were: - 57.1% in Unga Ltd, 58.3% in Ken-Knit Ltd, 70.6% in New KCC Ltd, 63.6% in Arkay industries Ltd, 64.3% in Highlands Paper Mills Ltd, 57.1% in Turbo Feeds Ltd, 66.7% in Timber Treatment International Ltd, and 69.2% in Eldoret Farm Machinery Ltd. Thus, an average 63.4% of respondents in each of selected manufacturing industries stated the strategy. Given that the strategy was reported by majority of the respondents (63.4%), the study concluded that switching off machines and lights not in use was a major technological/operational strategy used for electricity conservation within the selected industries.

By switching off machines and lights not in use, the study established that electricity was used productively and only during times of necessity. For instance, the study established that during day time, all security lights in factory premises as well as lights within rooms lit by sunlight were switched off. This was because sunlight was used for lighting making electric light bulbs unnecessary. In addition, machines that did not have processing works were switched off until such a time when there was work to be done. Operational instructions were placed at strategic places within industries such as Ken-Knit Ltd, Highlands Paper Mills and New KCC Ltd, to guide and remind workers to switch off unneeded lights and machines.

6.1.2. Regular Servicing of Machines

Table 21 shows the percentage of respondents who stated that regular servicing of machines was an operational/technological strategy used for electricity conservation in each of the industries were: - 71.4% respondents from Unga Ltd, 83.3% respondents from Ken-Knit Ltd, 88.2% respondents from New KCC Ltd, 81.8% respondents from Arkay industries Ltd, 14.3% respondents from Highlands Paper Mills Ltd, 85.7% respondents from Turbo Feeds Ltd and 33.3% respondents from Timber Treatment International Ltd. None (0%) of the respondents from Eldoret Farm Machinery Ltd stated regular servicing of machines being a technological/operational strategy used conservation of electricity (Table 21). The results indicated that regular servicing of machines was operational/technological strategy that was used in seven of the eight selected manufacturing industries within Eldoret Municipality. The study established that the level of application of the strategy to conserve electricity was lowest at Highlands Paper Mills Ltd with 14.3% of its respondents stating the use of the strategy and Timber Treatment International Ltd had the second lowest respondents who reported the use of the strategy at 33.3%. Therefore, the study recommends that Eldoret Farm machinery Ltd starts to adopt the strategy while HPM Ltd and TTI Ltd increase the use of the strategy to the level applied by the other selected manufacturing industries selected.

The study established that servicing of machines by the selected manufacturing industries were divided into two categories namely; repairs and routine maintenance. Repairs involved either fixing faulty parts of machines with new ones or welding broken metallic parts of machines. For the repairs to be conducted, machine operators and electricians first assessed the nature of fault in a machine before deciding on the type of repair to undertake. Routine maintenance of machines, on the other hand, entailed performing recommended tasks such as lubrications, replacing bearings, cleaning, tightening loose bolts and nuts on machines after specified periods of time prescribed in the manufacturer's manuals or set by the industry management. The study established that each of the selected industries had developed schedules to guide routine maintenance for industry machines. The time intervals of the maintenances were adopted from the manufacturer's manual of each of industry machines.

Table 23 shows that there were six (6) time intervals between maintenance processes of named industry machines in the selected manufacturing industries within Eldoret Municipality. The shortest time interval for maintenance was 250 hours of operations of two (2) types of machines gearboxes and sumps at New KCC Ltd. while the longest time interval was one (1) year. Other time intervals for routine maintenance established were; 1 month, 3 months, 4 months and 6 month (Table 23)

Table 23: Maintenance schedule for machines in each selected manufacturing industry

		Time intervals between two maintenance activities					
Industry	**Machines types**	**250 hrs**	**1month**	**3months**	**4months**	**6months**	**1 year**
Unga Ltd	Air Compressors		√				
	Water pumps		√				
	Wheat mills			√			
	Maize mills			√			
	Motors			√			
	Driers					√	
	Weighing Scales						√
	Weighbridges						√
Ken-Knit Ltd	Dyeing machines		√				
	Air Compressors			√			
	Water pumps			√			
	Motors			√			
	Twisting machines				√		
	Flapping machines					√	
	Boilers					√	
	Sewing Machines						√
	Blanket Machine						√
	Circular machines						√
	Embroider machines						√
	Ring-frame machines						√
New KCC Ltd	Gearboxes	√					
	Sumps	√					
	Chillers		√				
	Pumps		√				
	Pasteurizers			√			
	Boilers			√			
	Motors			√			
	Separators			√			
	Air Compressors			√			
	Homogenizers			√			
	Ammonia compressors			√			
	Weighing machines					√	
	Packaging machines					√	
	Driers					√	
	Conveyer belts					√	
Arkay Industries Ltd	Motors			√			
	Pumps			√			
	Decalicator					√	
	Expeller					√	

Industry	Machines types	Time intervals between two maintenance activities					
		250 hrs	1month	3months	4months	6months	1 year
	Feed mills						√
	Weighing machines						√
Highlands Paper mills Ltd	Vacuum pumps		√				
	Hydro-pulper			√			
	Water pumps			√			
	Blending chest			√			
	Forming machine			√			
	Board machine					√	
	Beaters					√	
	Guillotine machine						√
	Fastening machine						√
Timber Treatment International Ltd	Driers			√			
	Water pumps			√			
	Boilers				√		
	Machining shop					√	
	Impregnation machine					√	
	Conveyers						√
Turbo Feeds Ltd	Starters		√				
	Molasses pumps		√				
	Feed mills					√	
	Weighing machines						√
	Hammer mills						√
Eldoret Farm Machinery Ltd	Milling machine			√			
	Lathe machine			√			
	Re-boarer					√	
	Welding machines					√	
	Drilling machines					√	
	Shapers						√
	Crankshaft re-grinder						√
Total counts of machines	67	2	8	22	2	17	16
% of the total	100	3.0	11.9	32.8	3.0	25.4	23.9

Key: √ - Cell in which machine and time interval of the maintenance corresponds
Source: Field Survey, 2010

The results in Table 23 shows that routine maintenance of 32.8 % of machines was done after every three months, 25.4% of the machines (every 6 months), 23.9% of the machines (annually), 11.9% of the machines (monthly), 3% of the machines (weekly), and 3% of the machines (after every four months). Therefore, most maintenance works within the selected industries occurred within three (3) months and six (6) months.

The study established that regular servicing of machines led to increased energy efficiency of the machines thus reducing energy consumption by each of the serviced machines as was explained by Itron (2008). KAM (2005) also indicated that regular servicing of industry machines led to up to 14 per cent saving in energy costs especially electricity bills. However, the study established that maintenance schedules were not adhered to in most industries as was established in Table 15 that 43.9% of the respondents reported that machines were serviced only during break down.

6.1.3. Increased supervision of workers

Table 21 shows that the percentage of respondents in each of the selected manufacturing industries who stated the use of increased supervision of workers strategy for conservation of electricity were: 85.7% in Unga Ltd, 41.7% in Ken-Knit Ltd, 81.8% in Arkay Industries Ltd, 42.9% in HPM Ltd, 83.3% in TTI Ltd and 84.6% in Eldoret Farm Machinery Ltd. Therefore, an average of 52.5% of respondents in each of the industries stated that increased supervision of workers was a technological/operational strategy used for conservation of electricity. Though the strategy applied to both heavy and light industries, none (0%) of the respondents in two industries namely New KCC Ltd and Turbo Feeds Ltd stated the use of the strategy. the results of the study indicated that increased supervision of workers strategy had not been adopted within the two industries. In addition, the level of application of the strategy in Ken-Knit Ltd and HPM Ltd was low because minority of respondents from the industries (i.e. 41.7% of respondents from Ken-Knit Ltd and 42.9% of respondents from HPM Ltd) reported the use of the increased supervision of workers' strategy. Hence, the study recommended for New KCC Ltd and Turbo Feeds Ltd to adopt the strategy while Ken-Knit Ltd and HPM Ltd increase the level of application of the strategy so as to ensure maximum electricity conservation.

The study established that duties for supervisors on electricity conservation were to: prescribe durations of machine operations, ensure that machines were switched off at the end of operations or when not in use, train other workers on how to implement existing electricity conservation policies and supervise servicing and maintenance of machines. The study established that there were two categories of supervisors within the selected manufacturing industries; the shift supervisors and section supervisors. Shift supervisors were leaders of various shifts of workers such as morning shifts, afternoon shifts and night shifts. Section supervisors were persons assigned to be in-charge of the activities of each section of the industry. Increased supervision ensured that workers perform their duties adequately thus preventing wastage of electricity which occurred due to inadequately servicing of machines, unnecessary running of machines and unnecessary lighting.

6.1.4. Use of Roof Skylights (Translucent roofing) sheets

Table 21 shows that the percentage of respondents in each of the selected manufacturing industries who stated the use roof skylights sheets for electricity conservation were: - 50% in Unga Ltd, 58.3% in Ken-Knit Ltd, 58.8% in New KCC Ltd, 72.7% in Arkay industries Ltd, 42.9% in Highlands Paper Mills Ltd, 35.7% in Turbo Feeds Ltd, 41.7% in Timber Treatment International Ltd, and 46.2% in Eldoret Farm Machinery Ltd. Therefore, an average of 50.8% of respondents in each of selected manufacturing industries stated that use of roof skylights sheets was technological/operational strategy used to conserve electricity. The results indicated that although use of roof skylights sheets were used, level of application of the strategy was low in industries such as HPM Ltd, Turbo Feeds Ltd, TTI Ltd and Eldoret Farm Machinery Ltd where minority of respondents stated the use of strategy.

Atap Teduh Lestari (2010) defined roof skylights as horizontal windows made of white translucent acrylic sheets placed at the roof of the building, often used for day lighting. The white translucent acrylic is a 'Lambertian Diffuser' meaning that the transmitted light is perfectly diffused and distributed evenly over affected areas. In addition, skylights admit more light per unit area than windows, and distribute it more evenly over a space. There are two types of skylight windows; fixed type skylight window and skylight window which can be opened and fresh light can be taken. The study established that the selected manufacturing industries within Eldoret Municipality used the fixed type skylight windows. For example, Plate 3 shows roof skylights system used by Highlands Paper Mills Ltd for day lighting.

Plate 3: Roof sky lighting system of Highlands Paper Mills Ltd
Source: Field survey, 2010

The study established that use of roof skylight sheets contributed to electricity conservation by allowing entry of enough sunlight into the premises during the day. When the rooms become well lit by sunlight, electric lights which could have been in use are switched off thus achieving electricity conservation in lighting. Atap Teduh Lestari (2010) supports the findings of the study and states that with proper skylights design, there could be significant energy savings in commercial and industrial applications of up to 80 percent. US Department of Energy (2010) also stated that many commercial buildings can reduce total energy costs by up to one-third through the optimal use of day lighting.

6.1.5. Use of Automatic Machines

Table 21 shows percentage of respondents in each of the selected industries who stated use of automatic machines were: 50% in Ken-Knit Ltd, 94.1% in New KCC Ltd, 78.6% in HPM Ltd, 64.3% in Turbo Feeds Ltd and 76.9% in Eldoret Farm machinery Ltd and 0% in each of the three industries namely Unga Ltd, Highlands paper Mills Ltd and TTI Ltd. The results indicated that use of automatic machines was a technological/operational strategy used in five (5) of the selected manufacturing industries; three (3) heavy industries and two (2) light industries. Therefore, the three industries who were not using the strategy had not adopted it but the strategy was applicable to the industries. The study recommended for adoption of the technological strategy by all the manufacturing industries to improve on electricity conservation.

The study established that automatic machines referred to as machines that went off automatically when not in use or remotely operated by computers. Examples of automatic machines included the computer-operated flapping machines (universal machines) of knitting section of Ken Knit Ltd, packing machines (Nichrome Filpack CMD and Tetra Classic), ammonia compressors and weighing machines of New KCC Ltd. Plate 4 shows Universal flapping machine at Ken-Knit Ltd as one example of computer operated automatic machine.

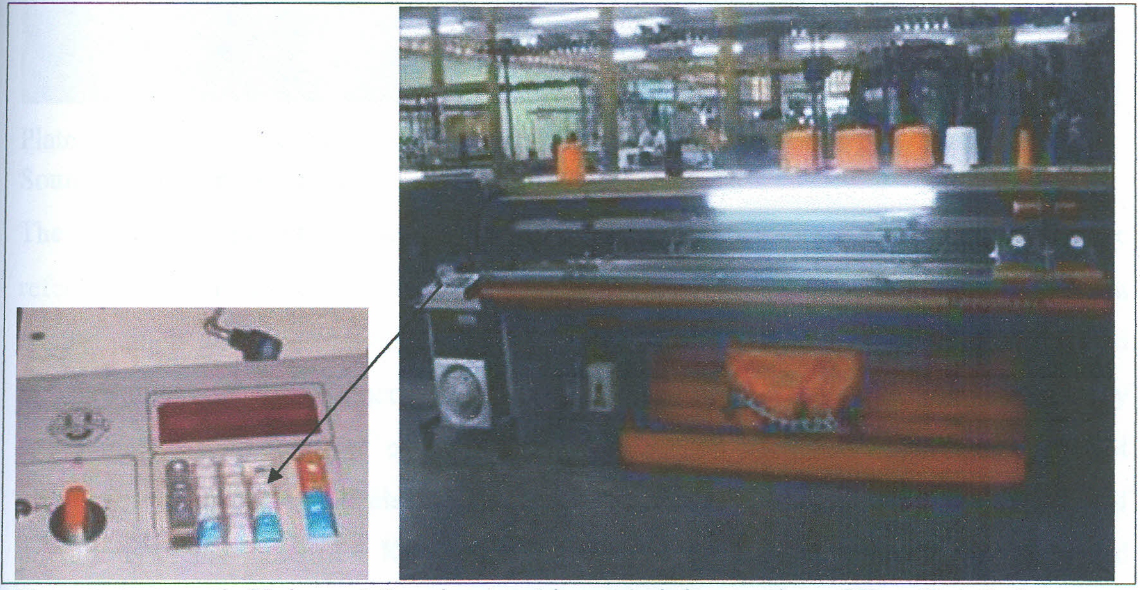


Plate 4: Automatic Universal flapping machine at knitting section of Ken-Knit Ltd
Source: Field survey, 2010

The automatic machines contributed to electricity conservation by switching off automatically when not in use hence preventing wastage of electricity. The findings of study are consistent with KAM (2005) which recommended that industrial plants should retrofit (replace) machines with modern or automatic and energy efficient machines to register more monetary savings in energy bills. However, the study established that most machines in the selected manufacturing industries within Eldoret Municipality were manually operated by machine operators. Each of the industries had a centralized power control panel for distributing and managing electricity to each of the machines in the industry. Plate 7 shows an example of centralized power control panel as used by Highlands Paper Mills Ltd.

Plate 5: Section control panel of electricity supply to machines of Highlands Paper Mills
Source: Field survey, 2010

The centralized power controls for Turbo Feeds and Eldoret Farm machinery were referred to by electricians of the industries as main switches. The study established that control panels were useful when electricity to all or some sections of the industries needed to be switched off during emergencies and at the end of operations of industry. The study established that the power control panels contributed towards reducing wastage of electricity by switching off electricity supplied to the entire industry plant at the end of operations of the industries. KPLC (2010) indicated that when electricity was switched from the main switch or centralized power controls, ensured that equipment did not use electricity unnecessarily. In addition, power loss from power cables within the wiring systems is also prevented thus conserving electricity.

The study revealed that the use of automatic machines and centralized power controls ensured that more electricity was conserved within the selected manufacturing industries within Eldoret Municipality. This was because automatic machines prevented unnecessary use of electricity by machines while centralized power controls prevented loss of electricity from power cables.

6.1.6. Proper calibrations of meters

Table 21 shows that the percentage of respondents who stated proper calibration of meters as the strategy from each of the selected manufacturing industries were: 64.3% from Unga Ltd, 66.7% from Ken-Knit Ltd, 52.9% from New KCC Ltd, 72.7% from Arkay industries Ltd, 76.9% respondents from Eldoret Farm machinery Ltd and 0% in each of three industries namely Highlands Paper Mills Ltd, Turbo Feeds Ltd and Timber Treatment International Ltd. The results of the study indicated that proper calibration of meters was an operational/technological strategy for electricity conservation used in five of the selected manufacturing industries; four heavy industries and one light industry. This demonstrated that, though proper calibration of meters was a strategy applicable to both heavy and light manufacturing industries, three selected industries had not adopted the strategy. Thus, the study recommended the adoption and use of proper calibration of meters by manufacturing industries for electricity conservation.

The study established that, proper calibration of meters worked to conserve electricity in three ways: ensured that electricity was not used to produce high and unnecessary heat in boilers and driers, promoted accurate weighing of materials to eliminate overloading or under loading of machines and; ensured production of goods and materials of required quality. Itron (2008) had indicated that 6% of electricity was lost in an industrial plant due to improper calibration of thermometers, occupancy sensors, and velocity meters of motors. Thus, the study inferred that proper calibration of meters led to electricity conservation of up to 6% within manufacturing industries.

6.1.7. Use of Energy Saving Lamps

Table 21 shows that the percentages of respondents in each of the four manufacturing industries, who stated the use of energy saving lamps was an operational/technological strategy used for conservation of electricity, were: 78.6% in Unga Ltd, 66.7% in Ken-Knit Ltd, 81.8% in Arkay industries Ltd, 83.3% in Timber Treatment International Ltd and 0% in four industries namely; New KCC Ltd, HPM Ltd, Turbo Feeds Ltd and Eldoret Farm Machinery Ltd. Therefore, use of energy saving lamps strategy for electricity conservation was reported in four of the selected manufacturing industries; three heavy industries and one light industry. The results of the study demonstrated that, though the use of energy saving lamps was an operational/technological strategy for electricity conservation applicable to both heavy and light manufacturing industries, some industries had not adopted the strategy. Thus, the study recommended adoption of the strategy by all manufacturing industries to conserve more electricity within Eldoret Municipality.

Energy saving lamps conserved electricity because they operated at low temperatures during conversion of electric energy to light. For example, Green Parks Partnerships (2001) stated that energy saving lamps such as CFLs operated at 100°C unlike incandescent lamps that operated at 700°C. Therefore, the study established that use of energy saving lamps such as incandescent lamps led to conservation of electricity of up to 70% lost due to heat. KPLC (2010) supports the findings and states use of energy saving lamps such as compact fluorescent lamps (CFL) enabled electricity consumers to save up to 80% electricity consumed in lighting.

The study established that selected manufacturing industries used four types of lighting lamps as shown by Figure 7. The lamps were: - fluorescent tubes reported by 42.1% of respondents, incandescent lamps reported by 21.5% of respondents, compact fluorescent lamps reported by 30.8% of respondents and halogen bulbs reported by 5.6% of respondents as shown in Figure 7.

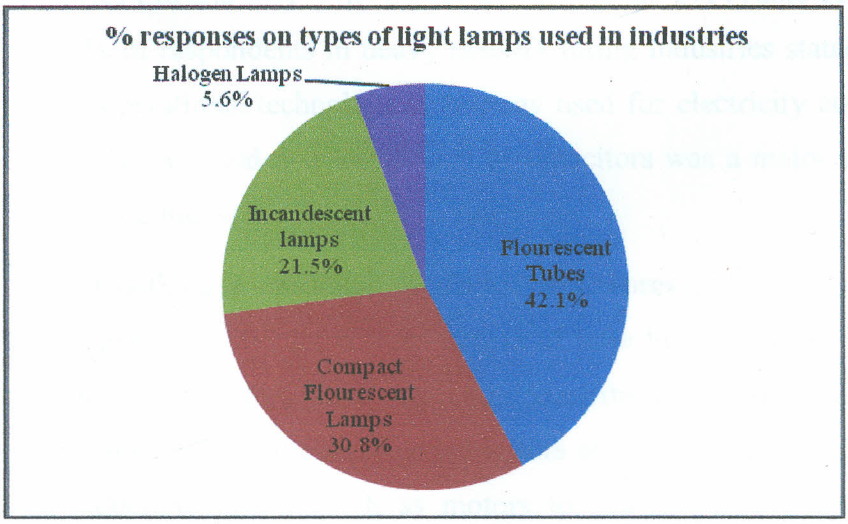


Figure 7: Responses on types of lighting lamps used in manufacturing industries
Source: Survey data, 2010

Daviot (2008) compared lighting efficiency of the four lamps as follows: fluorescent tubes produces 70 lumens of light per watt of electricity used, CFLs produce 55 lumens of light per watt, Halogen bulbs produce 35 lumens of light per watt and incandescent bulbs produce 15 lumens of light per watt of electricity used. Therefore, fluorescent tubes and CFLs were energy efficient than incandescent and halogen lamps. The study established that the sum of the percent respondents who stated use of the energy saving lamps was 72.9%, (42.1% on fluorescent tubes and 30.8% compact fluorescent lamps (CFLs)). The results of the study demonstrated that energy saving lamps were the most used within the selected manufacturing industries within Eldoret Municipality. Therefore electricity conservation was achieved through use of energy saving lamps.

6.2. Technological/operational strategies used by heavy industries only

6.2.1. Installations of Capacitors

The study established that respondents in heavy industries only reported use of capacitors for electricity conservation. The percentage of respondents who stated installation of capacitors as technological/operational strategy for electricity conservation in each heavy industry was: 78.6% in Unga Ltd, 66.7% in Ken-Knit Ltd, 70.6% in New KCC Ltd, 81.8% in Arkay industries Ltd and 57.1% in Highlands Paper Mills Ltd (Table 22). Therefore, an average of 71.0% of respondents in heavy manufacturing industries stated installation of capacitors as an operational/technological strategy used for electricity conservation. The results of the study indicated that installation of capacitors was a major strategy used by heavy manufacturing industries to conserve electricity.

Top Bits (2010) defined a capacitor as device that stores energy in an electric field between two charged "plates" for a short period of time before use or dissipation at an appropriate time. In explaining how capacitors contributed in electricity conservation, Electrotek Concepts (2002) indicated that capacitors are used to correct low power factor especially of inductive devices such as motors to nearly one (1) and thus reducing electricity wastage in the magnetic fields of inductive devices. Electrotek Concept also explained that power factor correction capacitors saves 10 to 25% on electricity bills by reducing the amount of power that passes through electric meters.

The study established that the each of the five heavy manufacturing industries had capacitors installed within sub-stations referred to as capacitor banks (KPLC large power administrator's personal communication, April 2010). A capacitor bank as defined by Top Bits (2010) refers to a sub-station in an electrical system containing capacitors connected in parallel and series and it has a display of readings of the power factor of the electrical system. Plate 6 shows capacitor bank that had been installed by New KCC Ltd and Plated 7 show capacitor bank of Highlands Paper Mills Ltd. The power factor readings of New KCC Ltd at the time of the study was 0.96 (Plate 6) and that of Highlands Paper Mills Ltd was 0.97 (Plate 7). The power readings of the other heavy industries were as follows: 0.94 for Unga Ltd, 0.92 for Ken-Knit Ltd and 0.94 for Arkay industries Ltd. The results of the study therefore demonstrated that the all heavy manufacturing industries complied with the KPLC regulation of keeping power factor of the industry at above 0.90.

Plate 6: Power control chambers of New KCC Ltd plant with a capacitor bank showing power factor readings of 0.96
Source: Field Survey, 2010

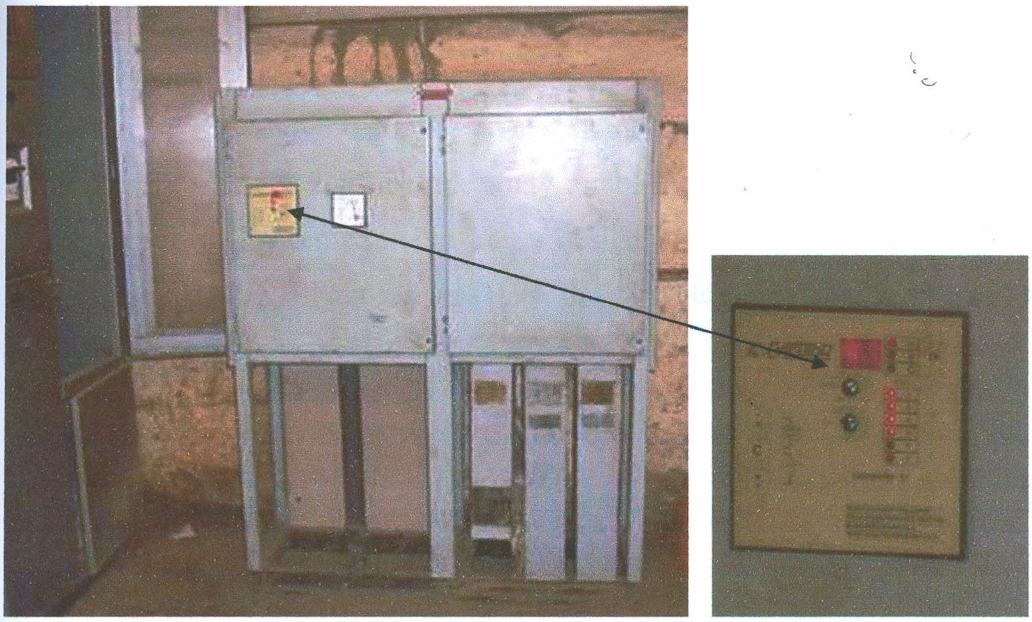


Plate 7: Capacitor Bank of Highlands Paper Mills showing power factor readings at 0.97
Source: Field Survey, 2010

The study also established that the capacitors installed at the substations (capacitor banks) depended on how the designed power factor of an installation was to be corrected to the desired power factor. Therefore, capacitors were rated using capacitor rating manuals in order to determine the correct capacitor to be installed into the electric system. A typical capacitor rating manual is provided by EPCOS (2005) shown by Table 24.

Table 24: Capacitor rating table for Power Factor Correction of inductive loads

Existing power factor (Cos φ_1)	**Desired power factor (Cos φ_2)**									
	1.0	**0.98**	**0.96**	**0.94**	**0.92**	**0.90**	**0.85**	**0.80**	**0.75**	**0.70**
0.40	2.29	2.09	2.00	1.93	1.86	1.81	1.67	1.54	1.41	1.27
0.45	1.99	1.79	1.70	1.63	1.56	1.51	1.37	1.24	1.11	0.97
0.50	1.73	1.53	1.44	1.37	1.30	1.25	1.11	0.98	0.85	0.71
0.55	1.52	1.32	1.23	1.16	1.09	1.04	0.90	0.77	0.64	0.50
0.60	1.33	1.13	1.04	0.97	0.90	0.85	0.71	0.58	0.45	0.31
0.65	1.17	0.97	0.88	0.81	0.74	0.69	0.55	0.42	0.29	0.15
0.70	1.02	0.82	0.73	0.66	0.59	**0.54**	0.40	0.27	0.14	–
0.75	0.88	0.68	0.59	0.52	0.45	0.40	0.26	0.13	–	–
0.80	0.75	0.55	0.46	0.39	0.32	0.27	0.13	–	–	–
0.85	0.62	0.42	0.33	0.26	0.19	0.14	–	–	–	–
0.90	0.48	0.28	0.19	0.12	0.05	–	–	–	–	–

Source: EPCOS, 2005

Table 24 indicated that, when the power factor of an installation was 0.70 and the desired power factor was above 0.90, the power factor correction capacitor rated at above 0.54 KVAR was used. For instance, the study established that 50 horse power motor used by blanket machine at Ken-Knit Ltd had a designed power factor of 0.7. Since the power factor readings of Ken-Knit Ltd was 0.94, the capacitor used for correcting power factor of the blanket machine was rated at 0.66 KVAR.

CHAPTER SEVEN

STAFF RESPONSIBILITIES IN ELECTRICITY CONSERVATION AT SELECTED MANUFACTURING INDUSTRIES WITHIN ELDORET MUNICIPALITY

7.0. Introduction

This chapter answers the specific objective four (4) of the study which seeks to assess the staff responsibilities in electricity conservation processes in selected manufacturing industries within Eldoret Municipality. The chapter contains results on (i) categories of industry staff, (ii) responsibilities of industry staff in electricity conservation and (iii) challenges faced by industry staff during electricity conservation.

7.1. Categories of industry staff

Table 25: Designation of respondents in the manufacturing industries

No	Staff designation in the industry	% within each industry								% of the Total
		Unga Ltd	Ken Knit Ltd	New KCC Ltd	Arkay industries Ltd.	HPM Ltd	Turbo Feeds Ltd	TTI Ltd	EFM Ltd	
1	Manager	7.1	8.3	5.9	18.2	7.1	14.3	16.7	7.7	**10.3**
2	Supervisor	21.4	25.0	23.5	27.3	28.6	7.1	16.7	38.5	**23.4**
3	Engineer	14.3	16.7	17.6	9.1	14.3	21.4	0	15.4	**14.0**
4	Electrician	21.4	25.0	29.4	18.2	14.3	14.3	25.0	7.7	**19.6**
5	Machine Operator	28.6	25.0	11.8	27.3	21.4	21.4	33.3	0	**20.6**
6	Clerk	0	0	5.9	0	0	7.1	0	23.1	**4.7**
7	Other workers	7.1	0	5.9	0	14.3	14.3	8.3	7.7	**7.5**
	Total									100.0

Source: Survey data, 2010

Table 19 indicated positions/designations of the selected respondents of the study within the selected manufacturing industries within Eldoret Municipality. The study established that the respondents fall into seven (7) categories as follows:- (i) Managers (10.3%), (ii) Supervisors (23.4%), (iii) Engineers (14.0%), (iv) Electricians (19.6%), (v) Machine operators (20.6%), (vi) Clerks/Accountants (4.7%) and (vii) other workers who included security guards, cleaners and drivers (7.5%). Each category of staff indicated that they had specific duties as spelt out as terms of services in letters of employment or appointments. However, all (100%) respondents indicated that their terms of service did not include electricity use or conservation. The findings were contrary to recommendation by ECC (2007) that all levels of employees working in an industrial factory should be collectively responsible for energy conservation.

7.2. Responsibilities of industry staff in electricity conservation

EECA (2009) indicated that the responsibilities of industry staff in electricity management could be divided into two main categories: electricity conservation policy formulation and policy implementations. The study therefore sought the position held by the staff assigned to oversee electricity usage in the industry. Figure 7 shows that 47.7% of respondents indicated that supervisors were designated to oversee electricity usage in the industries while 34.6% of respondents indicated that industry managers oversaw electricity usage. 10.3% of respondents indicated that all levels in the industry employee organizational structure had person(s) designated to oversee electricity usage and; 7.5% of respondents indicated that the persons who were overseeing electricity usage were ordinary workers such as security guards, caretakers, cleaners and office assistants.

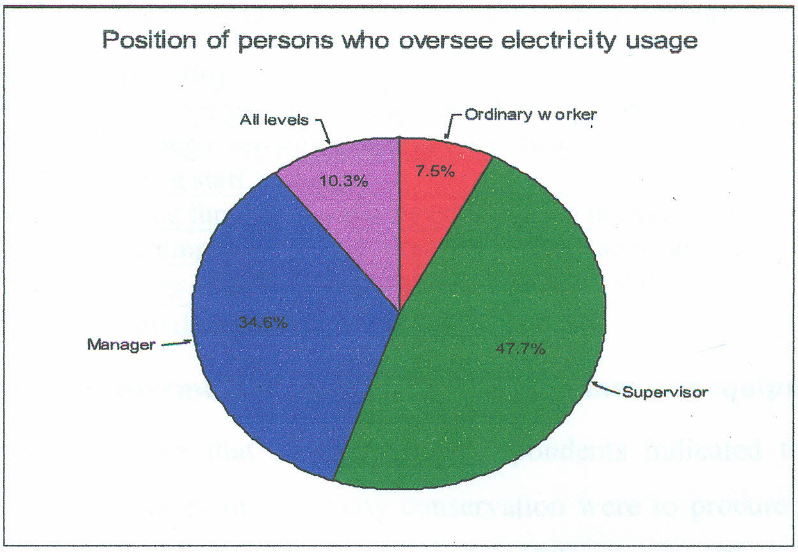


Figure 8: Responses on persons overseeing electricity use in the industries
Source: Survey data, 2010

7.2.1. Responsibilities of Industry Managers

The study established that there were three categories of managers in the selected manufacturing industries within Eldoret Municipality namely: - plant managers, technical/production managers and personnel/human resources managers. Interviews with the managers revealed that manager's core mandates in the industry were to set industry production targets and formulate policies and regulations expected to guide the processes to meet the targets. The finding is consistent with EECA (2009) since it stated that the responsibilities of industry managers and administrators are to identify electricity conservation policies and the set the main targets and goals of electricity conservations. The plant managers of all the selected manufacturing industries reported that they had developed electricity conservation regulations in consultations with the industry board of directors, legal officers, KAM Eldoret chapter, and the ministry of energy.

Table 26 indicates specific responsibilities of industry managers in electricity conservation as indicated by the respondents. The responsibilities were: - (i) procuring energy efficient machines and equipment, (ii) formulating electricity conservation regulations, (iii) organizing staff trainings, (iv) approving funds for electricity conservation projects, (v) representing industry in external meetings and seminars on energy use, and (vi) employing qualified personnel of electricity such as electricians and machine operators.

Table 26: Responses on responsibilities of industry managers in electricity conservation

No.	Responsibility	No. of respondents	Percent (%)
1.	Procuring energy efficient machines & equipment	59	55.1
2.	Formulating electricity conservation policies	55	51.4
3.	Organizing staff trainings	54	50.5
4.	Approving funds for electricity conservation projects	54	50.5
5.	Representing industry in external meetings & seminars	48	44.9
6.	Employing qualified personnel with electricity skills	45	42.1

Source: Survey data, 2010

(i). Procurement of energy efficient machines and equipment

Table 26 shows that 55.1% of the respondents indicated that the responsibilities of industry managers in electricity conservation were to procure energy efficient machines and equipment in the industry. Examples of the energy-efficiency machines that had been procured by management included: - computerized flapping machines at Ken Knit Ltd; Filling machine (Nichrome Filpack CMD) and Chillers at New KCC Ltd; and new motors for replacing faulty ones, compact fluorescent lamps to replace incandescent lamps in all the selected manufacturing industries. The machines prevented electricity wastage that was caused by use of machines with low energy efficiency thus conserving electricity.

(ii). Formulation of electricity conservation regulations

Table 26 shows that 51.4% of the respondents indicated that industry managers were responsible for formulating electricity conservation policies. The study established that the electricity conservation regulations that had been formulated in the heavy selected manufacturing industries were; ensuring the power factor of the industry was kept at 0.90;

regular servicing of industry machines in according to maintenance schedules and switching off machines not in use. The study also established that the small power consuming industries had developed electricity conservation regulations such as replacement of incandescent lamps with compact fluorescent lamps and switching off all office lights and equipment not in use at the end of day's operations.

(iii). Organization of staff trainings

Table 26 shows that 50.5% of the respondents reported that industry managers were responsible for organizing staff trainings on electricity conservation. The study established that the management of the selected industries had been organizing inductive trainings for newly recruited workers. The trainers of the industries reported that the inductive trainings covered the following:- overview of industry processes, health and safety of workers at place of work, first aid and existing policies and regulations of the industries. Some industries such as Arkay Industries Ltd and Ken Knit Ltd had sent some of the workers to energy conservation trainings that had been organized by KAM in November, 2009.

(iv). Approving funds for electricity conservation projects

Table 26 also show that 50.5%of the respondents indicated that the industry managers were responsible for approving of funds for electricity conservation projects. The study further established through interviews with industry managers that the funds that had been approved in 2009/2010 budget included money for procuring energy saving lighting lamps. The projects coincided with the KPLC's electricity conservation awareness campaign titled, 'Reduce Your Electricity Bill Now!!'. The campaign urged KPLC customers to use Compact Fluorescent Lamps (CFLs) to save 80% of electricity used in lighting and also save money in expenditures of electricity bulbs because CFLs lasted up to 10 times longer than ordinary bulbs (KPLC, 2010).

(v). Representing industry in meetings and seminars on energy

Table 26 indicates that 44.9% of respondents reported that managers represented the industry in energy conservation meetings and seminars organized by institutions such as MOE, ERC, KPLC and KAM. The study established that plant managers of manufacturing industries within Eldoret Municipality were obligated to attend monthly power system performance meetings organized by the KPLC North Rift and KAM Eldoret chapter. The report of such a meeting which was held on 27th January, 2010 indicated that issues discussed included conserving electricity within industry plant by ensuring power factor readings at capacitor banks are always kept above 0.9 (KPLC North Rift, 2010).

(vi). Employing qualified personnel with electricity skills

Table 26 shows that 42.1% of the total respondents indicated that managers, particularly personnel or human resources managers, were responsible for employment of qualified electricity personnel to enhance electricity management (usage and conservation). The qualified electricity personnel named were; electricians and machine operators with diplomas or graduate degrees in relevant fields such as electrical engineering, wiring and electronic engineering. In addition, the study established that 100% of the selected manufacturing industries regularly contracted registered energy auditors or environmental audit experts to conduct energy and environmental audits in the industries as required by government legislations. GoK (2003) concur with the findings as it stated that an environmental audit of a development (except for self-auditing), should be conducted by a qualified and authorized environmental auditor or environmental inspector who shall be an expert or a firm of experts registered by National Environment Management Authority.

7.2.2. Responsibilities of Supervisors

Table 27: Responses on Responsibilities of Supervisors in Electricity conservation

No.	Responsibility	No. of respondents	Percent (%)
1	Ensuring all workers adhere to industry regulations	69	64.4
2	Prescribing duration of machine operation	67	62.6
3	Supervise the servicing of machines	66	61.7
4	Switching off machines at the end of operations	64	59.8
5	Training workers on new electricity conservation strategies	58	54.2
6	Reporting areas of electricity misuse to management	52	48.6

Source: Survey data, 2010

The study established that industry supervisors had six (6) responsibilities in electricity conservation processes in the selected manufacturing industries within Eldoret Municipality (Table 27). These responsibilities were as follows:-

(i). Ensure adherence to industry regulation by all workers

The study established that the core responsibility of industry supervisors (as indicated by 64.4% respondents in Table 27) was to ensure that all workers adhered to regulations including electricity conservation regulations as set by industry management. The study established that the process of ensuring that all workers adhered to the set regulations were; monitoring workers performances, providing advice and guidance on the regulations, warning workers who disobey the regulations and report workers who persist to disobey industry rules and regulations to the managers in-charge of personnel. The finding concur with EECA (2009) which stated that the roles of middle level workers particularly supervisors in electricity conservation are to monitor, advise and assist lower level staff in implementing the electricity conservation strategies.

(ii). Prescribing durations of machine operation

Table 27 shows that 62.6% of the respondents indicated that the responsibilities in electricity use of supervisors were to prescribe the duration of machine operations in the industries. The study established that when the duration of operation is prescribed, machine operators are guided on the time of switching on and off the machines. The activity of prescribing durations of operation of machine reduced unnecessary consumption of electricity leading to conservation and savings in electricity bills.

(iii). Supervise servicing of machines

Table 27 shows that 61.7% of the respondents indicated that the responsibility of supervisors in electricity conservation was to supervise servicing activities of machines. The respondents also reported that the supervision processes entailed making observations to the servicing activities of machines as conducted machine operators and electricians as well as reporting, to the industry management, how the servicing process had been conducted. Therefore, the supervisors ensure that machines were adequately serviced and thus becoming energy-efficient and reducing electricity consumption.

(iv). Switching off machines at the end of operations

The percent respondents who indicated that supervisors switched off machines at the end of operations were 59.8%. For instance, the study established that the supervisors at the light industries such as Turbo Feeds Ltd and Eldoret Farm Machinery Ltd were responsible for switching off all the machines at the elapse of the 12 hours and 9 hours of machine operation respectively. Switching off of the machines ensured that machines did not consume electricity unnecessarily after the close of industry operations thus reducing electricity wastage.

(v). Training workers on new electricity conservation strategies

Table 27 shows that 54.2%of the respondent indicated that supervisors were responsible for training other workers on the new strategies of electricity conservation introduced to the industry. From the respondents, the study established that the supervisors facilitated in the inductive training for all the newly employed lower level workers in the industries. The respondents also reported that during these trainings, the supervisors introduce the workers to the existing regulations and strategies of electricity conservation and explain the targets of strategies of electricity conservation. This ensured that all workers were aware of the purposes and targets of existing regulations on electricity conservation in the industries.

(vi). Reporting areas of electricity misuse to management

Table 27 shows that 48.6% of the respondents indicated that the supervisors had the responsibility of reporting areas of electricity misuse to the management. For instance, the respondents indicated that supervisors had reported areas of unnecessary lighting especially the exterior security lights left on during the day and, machines running for long hours without loads. The industry management had taken measures such as issuing warnings, suspending or sacking the workers who were responsible for misused electricity. For example, Ken-Knit Ltd Trainer personal communication March, 2010 indicates that two machine operators were suspended in 2009 because of misuse of electricity. The measures (punishments as were referred to by respondents) that had been taken by management had discouraged other workers from misusing electricity in the industry hence achieving conservation through controlled electricity use.

7.2.3. Responsibilities of Machine Operators

Table 28: Responses on Responsibilities of machine operators in Electricity conservation

No.	Responsibility	No. of respondents	Percent (%)
1.	Switching off machines not in use	65	54.2
2.	Ensuring machines operates at recommended loads	61	50.8
3.	Servicing and repairing faulty machines	54	45.0
4.	Regular cleaning of machines	45	37.5

Source: Survey data, 2010

Table 28 indicates responsibilities of machine operators in electricity conservation and percentage respondents under each of the stated responsibility. The responsibilities were:-

(i). Switching off machines not in use

Table 28 shows that 54.2 per cent of respondents indicated that machine operators were responsible for switching off machines not in use. The responsibility occurred in industries or section of industries where the tasks of switching off machines at the end of operations had not been assigned to supervisors especially in small scale industries such as Eldoret Farm Machinery Ltd and Turbo Feeds Manufacturers Ltd or sections of large industries such as knitting and embroidery sections of Ken Knit Ltd and weighing section of New KCC Ltd.

(ii). Ensuring machines operates at recommended loads

Table 28 illustrates that 50.8% of the respondents indicated that the machines operators ensured that the raw materials did not exceed the recommended loads lest the machines would be ineffective and consume more power than expected. Machine operators were in-charge of in-putting raw materials to machines for processing as well as ensuring that the raw materials were of recommended quality. For instance, in Arkay Industries Ltd, Unga Ltd and Turbo feeds Ltd, machine operators were required to ensure that the grains were of the moisture contents (less than 6%) since machines were reported to consume more power to process grains with high moisture contents. The study also established that machines operators in milling sections of Unga Ltd and Arkay industries turned off the mills for sometimes to wait for raw materials to accumulate, then turn them on to operate at maximum loads. This ensured that the machines did not consume extra amounts of electricity for specific amounts of raw material processed.

(iii). Servicing and repairing faulty machines and systems

Table 28 shows that 45.0% indicated that machine operators participated in electricity conservation by servicing or repairing faulty machines in the industry. The servicing activity ensures that machines operate efficiently at all time thus reducing electricity wastage by the machines. From the respondents, the category of machines operators who were tasked to performing servicing or maintenance of machine were those with professional expertise on the machines such as mechanical, electrical and electronic engineers. The machine operators who had no professional expertise were to report faulty machines to the workers in-charge of repairs and maintenance particularly to engineers through the supervisors.

(iv). **Regular cleaning of machines**

Table 28 indicates that 37.5% of the respondents reported that the responsibility of machine operators was to clean machines regularly. Microsoft Encarta (2009) supports the findings and states that cleaning machines removes materials such as dust that increases friction of moving parts of pulleys therefore improves energy efficiency of the machines. The study established the machines that required regular cleaning included: hydro-pulper in Highlands Paper mills Ltd which was cleaned with clean water after every six (6) hours of operations and pulleys of conveyer belts at milk delivery section of New KCC Ltd plant which required cleaning after every 12 hours.

7.2.4. Responsibilities of Industry Electricians

Table 29: Responses on Responsibilities of Electricians in Electricity conservation

No.	Responsibility	No. of respondents	Percent
1.	Monitoring electricity supply cables and switches	60	56.1
2.	Regular servicing of electrical equipment	58	54.2
3.	Installation of energy saving lighting lamps	58	54.2
4.	Installation of power factor correction capacitors	43	40.2
5.	Monitoring electricity meters	41	38.3
6.	Training other workers to switch off unnecessary lights	40	37.3

Source: Survey data, 2010

Table 29 shows that the electricians within the selected manufacturing industries had six (6) responsibilities in electricity conservation. These responsibilities of electricians were as follows:

(i). **Monitoring electricity supply cables and switches**

Table 29 indicates that 56.1% of the respondents reported that electricians were responsible for monitoring the electricity supply cables and switches in the industry. By monitoring, electricians identified faulty switches that could not put off electricity. The actions prevented electricity wastage that occurred due to unnecessary lighting.

(ii). **Conduct regular service on electrical equipment**

Table 29 shows that 54.2% of the respondents indicated that electricians were responsible for conducting regular servicing of electrical equipments such as motors, meters (voltmeters and ammeters) in the industry. The findings are consistent with Green Energy Park Partnership (2001) recommendations that servicing and retrofit (replacement) activities can be handled through 'in-house' maintenance personnel, or an independent contractors or electricians. The study established that servicing activities of the equipment in the industries were guided by prescribed maintenance and servicing schedules that had been developed following manufacturers manuals. For instance, servicing of motors was conducted after every 6 months in all the industries.

(iii). Installation of energy saving lighting lamps

Table 29 illustrates that 54.2% of the respondents indicated that electricians were responsible for installation of energy saving lamps particularly CFLs and fluorescent tubes in the industries. The results are in agreement with Green Energy Parks Partnership (2001) which explained that an electrician must be involved in the replacement of old incandescent lamps with new energy saving CFL lamps. By installation of the energy saving lamps, electricians would have contributed to electricity conservation as explained by KPLC (2010) that, 80% of electricity is conserved in lighting by replacement of ordinary lamps (incandescent lamps) with CFL lamps.

(iv). Installation of power factor correction capacitors

Table 29 shows that 40.2% of the respondents reported that, electricians were responsible for installation of capacitors within the selected industries. The capacitors corrected power factor to above 0.9 thus reducing electricity wastage was one of responsibilities of electricians in electricity conservation in manufacturing industries. The study established that the first step taken by electricians before installing a capacitor was to identify the mean power factor of the industry in 24 hours. When the power factor was found to be below 0.9, capacitors with ratings that correct the power factor to above 0.9 were identified for installation. Electrotek Concepts (2002) explains that installation of power factor correction capacitors leads to a reduction in total consumption of electricity and electricity charges.

(v). Monitoring electricity meters

Table 29 indicates that 38.3% of the respondents reported that electricians were responsible for monitoring electricity meters in the industry. The study established that, in monitoring meters, electricians were able to identify and repair faulty meters at the earliest time. This process works towards electricity conservation since correct meter settings lead to the use of exact amount of electricity for the tasks thus preventing electricity wastage.

(vi). **Creation of awareness to other workers on switching off unnecessary lights**

Table 29 shows that 37.8% indicated that electrician were responsible in creating awareness to other workers to switch off unneeded lights in the industries. The strategy of switching off unneeded lights had been recommended by KPLC (2009b) and KAM (2005) to be adopted for electricity conservation by domestic, commercial and industrial electricity consumers. Therefore, the study established that the electricians were creating awareness in order to increase knowledge and adoption of the strategy by all workers in industries which would lead to increased electricity saving in lighting.

7.2.5. Responsibilities of ordinary workers

Table 30: Responses on Responsibilities of ordinary workers in Electricity conservation

No.	Responsibility	No. of respondents	Percent (%)
1	Switching off unnecessary lights	66	61.7
2	Reporting machines running without load to supervisors	61	57.0
3	Opening window curtains and widows in offices	57	53.3
4	Cleaning windows and roof skylight sheets	55	51.4

Source: Survey data, 2010

The study established that the workers who were categorized as ordinary workers included: workers who perform loading and unloading of materials, sweepers, cleaners, security guards, office assistants, packing and wrapping workers in all the selected industries. The study also established that the ordinary workers had four (4) responsibilities in electricity conservation as indicated by Table 30.

(i). **Switching off unnecessary lights**

Table 30 shows that 61.7% of the respondents indicated that industry workers were responsible for switching off unnecessary lights. KPLC (2009b) and Itron (2008) supports the findings and states that electricity is saved by switching off unnecessary lights, thus, workers participation in switching off lights ensures that electricity is saved in lighting within the industry. However, the study established that it was not entirely the responsibility of ordinary workers to switch off unnecessary lights but all the other industry workers were also expected to switch off lights when there was enough sunlight in the rooms or offices.

(ii). Reporting machines running without load to supervisors

Table 30 shows that 57.0% of the respondents indicated that ordinary workers of industries were responsible for reporting machines running without loads to supervisors. The supervisors then switch off the machines or instruct machines operators to switch of the machines immediately. This resulted in prevention of unnecessary consumption of electricity by the machines not in use and thus achieving electricity conservation.

(iii). Opening window curtains and widows in offices

Table 30 indicates that 53.3% of the respondents reported that ordinary workers particularly office assistants were responsible for opening window curtains or opening steel or wooden windows of the industry premises. The activity increase entry of sunlight into the processing rooms and offices reducing the use of electricity in lighting. Therefore, the responsibility was geared towards ensuring that electricity used for lighting rooms was conserved. However, the study established that most industry premises particularly processing rooms did not have windows thus roof skylights sheets were used to allow entry of sunlight into the rooms.

(iv). Cleaning windows and roof skylight sheets

The percentage of respondents who indicated that ordinary workers were responsible for cleaning glass windows and roof skylight sheets was 51.4% (Table 30). The cleaning was conducted weekly mainly at the milling sections of Unga Ltd, Arkay industries Ltd and Turbo Feeds Ltd. the respondents indicated that during processing, small particulate matter such as dust are emitted from the mills. The particles emitted would attach themselves to the glass windows and roofs of the industry premises thus inhibiting entry of sunlight from the glass windows and from the skylights sheets of the industry premises. Therefore, frequent cleaning removed the particles and allows entry of enough sunlight into rooms thus saving on electricity used for lighting during the day.

7.3. Challenges faced by industry workers in electricity conservation

7.3.1. Inadequate trainings on electricity conservation strategies

Figure 9 shows that majority of industry workers (64 per cent) reported that selected manufacturing industries, who were their employers, had not organised any training on electricity conservations.

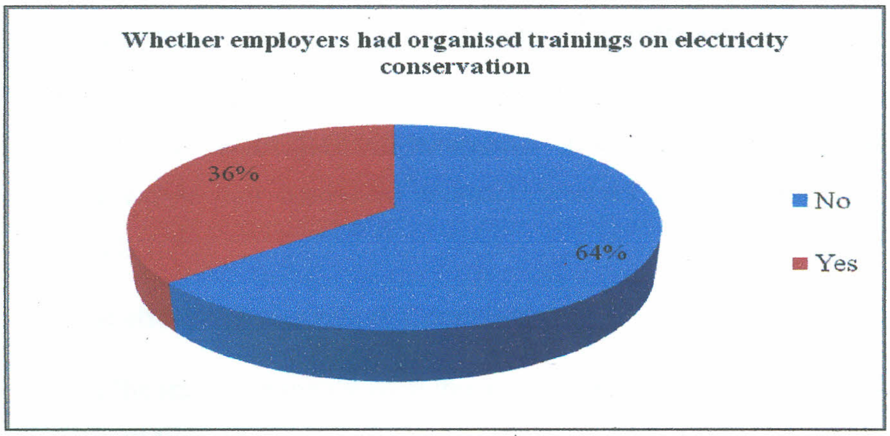


Figure 9: Staff responses on electricity conservation trainings
Source: Survey data, 2010

Table 24 indicates the durations to which the trainings on electricity conservation that had been organised took. 35.9% of the respondents stated that the trainings took between 2 to 4 days while the respondents who indicated that the trainings took 1 week were 20.5%, 1 day were 20.5%, less than 1 day were 18.0% and 1 month were 5.1%. The results therefore imply that 94.9% (35.9+20.5+20.5+18.0) of the respondents reported that the trainings that had been organised by the employers took durations up to 1week indicating that the trainings were short.

Table 31: Responses on duration taken by organized trainings on electricity conservation

No	How long did the organized training on electricity conservation strategies take?	% respondents
1	2-4 days	35.9
2	1 week	20.5
3	1 day	20.5
4	Less than 1 day	18.0
5	1 Month	5.1
	Total	100.0

Source: Survey data, 2010

Figure 9 and Table 31 therefore indicate that majority of industry workers had not been given adequate training on electricity conservation. This is because less than half (36%) of the respondents reported that trainings had been organised. According to ECC (2000) lack of adequate training on electricity conservation strategies make it difficult for industry workers to implement instructions and regulations as set by high-level managers. Inadequate trainings had led to lack of awareness and skills by workers to successfully implement the electricity conservation regulations. For instance, managers of all the selected industries reported that workers often did not switch off industry machines and lights not in use because of lack of awareness. Therefore, inadequate trainings on electricity conservation had hampered industry workers in implementing electricity conservation regulations.

7.3.2. Lack of effective Channels of Communication

Figure 10 shows the most commonly used modes of communication in the manufacturing industries within Eldoret Municipality were notice boards at 47.7% level use. However, 100% of respondents indicated that notice board were not effective modes of communication because; (i) workers rarely read notices put on the notice boards, (ii) it was difficult to know whether new information had been placed on the notice boards (iii) notices were often removed by unknown persons before being read by all workers and (iv) notice boards did not offer room for immediate feedback or further clarifications on the information they carry.

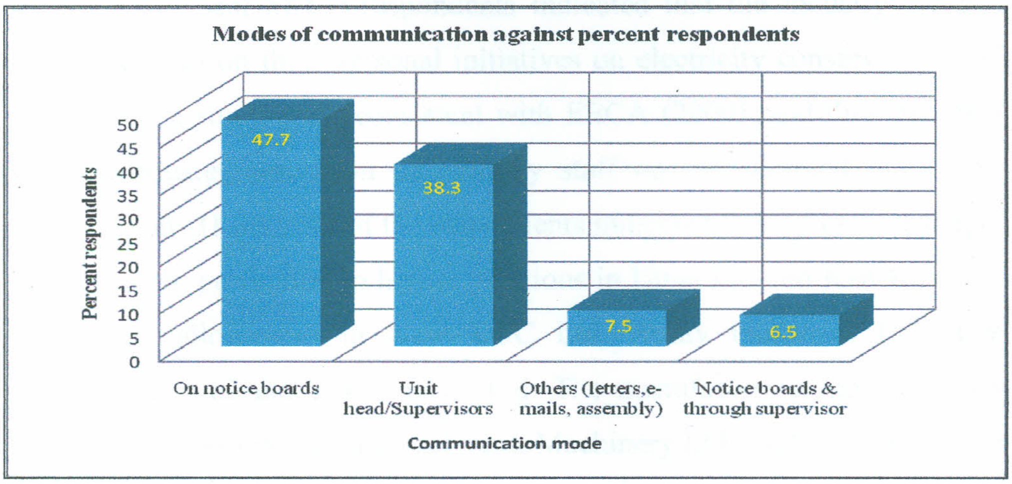


Figure 10: Responses on modes of communications used in the manufacturing industries
Source: Survey data, 2010

Although advanced modes of communications such as e-mails and telephones could be effective modes of communication; they were less preferred or used in the selected manufacturing industries within Eldoret Municipality with 7.5% level of use (Figure 10). The industry management stated that the main reason of not using e-mails or telephone was inadequate computers and lack of internet and telephone infrastructural services within the industries. The industry management also indicated that the existing infrastructure was accessible to less than 5% of industry workers particularly management staff. However, the respondents explained that the use of notices and communication through supervisors combined well and was very effective because supervisors would alert workers within the industry on any new notice placed at the notice board and also made clarification on unclear information. The supervisors also took feedbacks on the information communicated from the workers to industry management as soon as possible therefore promoting interactions between industry management and other staff. Despite the effectiveness of combined supervisors and notice boards, the study established that level of use was at 6.5% (Figure 10).

7.3.3. Inadequate motivation of staff

EECA (2009) recommended that company management should motivate their staff by developing incentives such as rewarding best performing staff in electricity conservation or staff who had innovated new ways of electricity conservation. However, during the study 69 per cent of the respondents indicated that the industry management had not rewarded them on their personal initiatives on electricity conservations (Figure 11). The results of the study are inconsistent with EECA (2009), and thus demonstrate that there was inadequate motivation of industry staff on the personal initiatives of electricity conservation. 31 per cent of the respondents indicated that industry management rewarded staff through; promotion to higher positions in Unga Ltd and Ken-Knit Ltd and increased salaries or allowances in New KCC Ltd, Arkay industries Ltd, Timber treatment international Ltd and Turbo feeds Ltd. The manufacturing industries where no reward system was reported were Eldoret Farm Machinery Ltd and Highlands paper mills Ltd.

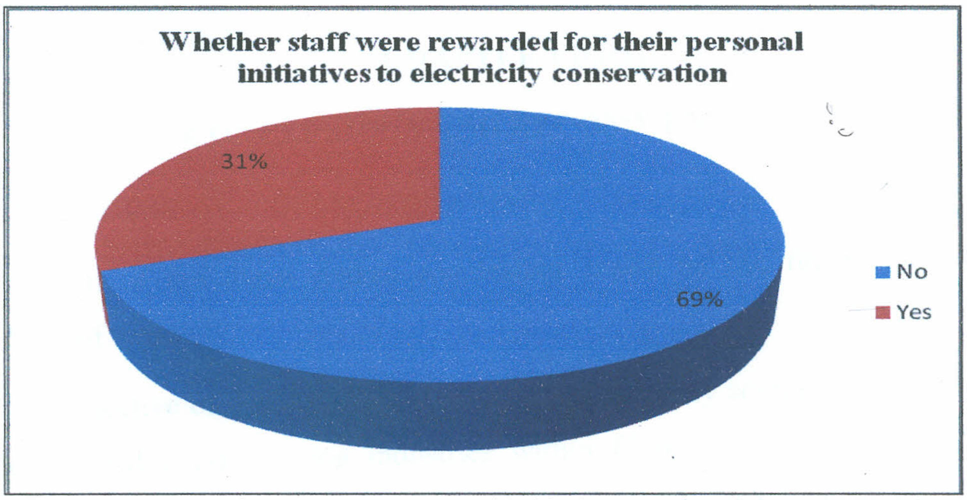


Figure 11: Rewarding staff on personal initiatives to electricity conservation
Source: Field Survey data, 2010

The management of industries such as Unga Ltd and Ken-Knit Ltd indicated that trainings were used to motivate industry staff to adhere to policies and regulations that had been set by industry management on electricity conservation. The management explained that trainings empowered industry staff with knowledge of electricity conservation strategies which enable them to implement strategies effectively under minimum supervisions.

CHAPTER EIGHT

CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

This section of the thesis makes conclusions based on the findings of the specific objectives of the study.

The first objective of the study which states that:- identify sources of electricity wastage in the selected manufacturing industries within Eldoret Municipality established that manufacturing industries are categorized as heavy or light industries according to electricity consumptions. Majority (70.1 per cent) of workers in the manufacturing industries had knowledge on electricity wastage caused by ten (10) sources of electricity wastage in the selected manufacturing industries within Eldoret Municipality. Of the ten sources of electricity wastage, six were applicable to both heavy and light industries namely: (i) inadequate servicing of industry machines, (ii) unnecessary running of machines and equipment, (iii) unnecessary lighting (iv) use of lighting lamps with low energy efficiency, (v) use blunt cutting blades of machines, and (vi) improper calibration of machines' meters. Three of the sources of electricity wastage namely (i) low power factor, (ii) leakage of compressed air and (iii) leakage of steam applied to heavy industries only while one (1), (i) hard start of motors, applied to light industries only.

The second objective of the study which states that:- identify and analyze policies for electricity conservation used by selected manufacturing industries within Eldoret Municipality, identified electricity conservation policy strategies within the selected manufacturing industries. The study concluded that 86 per cent of the respondents had knowledge of the existing electricity conservation policies. Further, the study concluded that selected manufacturing industries within Eldoret Municipality had adopted six (6) policies for electricity conservation. Four (4) of the policies namely (i) optimal use of electricity policy, (ii) energy saving lighting policy, (iii) regular maintenance of industry machines policy (iv) machines' retrofit policy were used by both heavy and light industries, while two (2) of the policies namely (i) power factor above 0.90 policy and (ii) surcharging policy were used by heavy industries only. The policies had been developed through the domestication of provisions of two Acts of parliament Electric Power Act, 1997 and Energy Act of 1997 by industry management. KPLC had been mandated to implement the provisions of Schedule of Tariffs 2008 on electricity conservation such as keeping power factor at above 0.9 at all times and surcharging customers whose power factor falls below 0.9.

The third objective of the study which states that: - to establish technological/operational strategies for electricity conservation by selected manufacturing industries within Eldoret Municipality, established that the selected manufacturing industries within Eldoret Municipality used eight (8) technological/operational strategies to conserve electricity. Seven (7) of the strategies, that is; (i) Switching-off machines and lights not in use, (ii) regular servicing of machines, (iii) increased supervision of the production processes, (iv) use of roof skylights sheets, (v) use of automatic machines, (vi) proper calibrations of meters and (vii) use of energy saving lamps, were used in both heavy and light industries, while, one (1) of the strategies, that is; installation of capacitors was used in heavy industries only.

The fourth objective of the study which states that; to assess the staff responsibilities in the electricity conservation processes in selected manufacturing industries within Eldoret Municipality established five categories of staff namely (i) Management, (ii) Supervisors, (iii) Electricians, (iv) Machine operators, and (vi) ordinary workers such as security guards, cleaners and drivers were responsible for electricity conservation within the selected manufacturing industries. The responsibilities of industry staff were divided into; policy formulation and implementation. The main roles of industry management were to formulate policies and regulations on electricity conservation. Implementations of the policies and regulations on electricity conservations were performed by other categories of staff such as electricians, operators of machines, supervisors and ordinary workers. However, the staff of the manufacturing industries were faced with challenges in conserving electricity such as inadequate training on electricity conservation strategies, poor communication networks within the industries that hampered free flow of information and; lack of adequate motivations such as rewarding personal initiatives of staff on electricity conservation.

8.2. Recommendations

Recommendations are based on the specific objectives of the study as well as the conclusions. On the first objective of sources of electricity wastage in selected manufacturing industries within Eldoret Municipality, the study recommends that individual manufacturing industries within Eldoret Municipality should monitor electricity consumptions by conducting electricity audits frequently. The electricity audits will facilitate documentation of consumption trends of electricity within industries, sources of electricity wastage and strategies adopted or to be adopted to reduce electricity wastage. Electricity audit documents would assist in future identifications of sources of wastage.

On the second objective of identifying and analyzing policies for electricity conservations, the study recommends that adequate awareness creation on the existing electricity conservation policies should be made to all staff of the selected manufacturing industries within Eldoret Municipality. Awareness creation would inform industry staff of their roles and responsibilities in electricity conservation as spelt out by the existing electricity conservation policies thus promoting full implementation of the policies.

On the third objective on operational/technological strategies for electricity conservation, the study recommends that the manufacturing industries should undertake an inventory of all machines and equipments used in the industries. The inventory would enable easy identification and replacement of machines having low electricity efficiency and; development of servicing schedules as per the machines manufacturers' manuals. The servicing schedules of machines developed should be adhered to strictly and implemented by qualified personnel such mechanical or electrical engineers.

On the fourth objective of assessing staff responsibilities in electricity conservations processes in the selected manufacturing industries within Eldoret Municipality, the study recommends that staff working in the manufacturing industries should be motivated to participate in the formulation and implementation of the electricity conservation strategies within the industries by: organizing frequent trainings on electricity conservation, rewarding best performing staff with monetary rewards or certificates, establishment of effective communication channels that facilitates easy exchange of information of electricity conservation amongst all industry staff.

Areas for further research

The study suggests the following three areas for further research:

(i). Assessment of electricity pricing in promoting electricity conservation in the manufacturing industries.

(ii). The influence of Kenya Association of Manufacturers (KAM) on electricity utilization and conservation policies in manufacturing industries.

(iii). Level of industry workers participation in the development of electricity management policies in selected manufacturing industries within Eldoret Municipality

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