ENERGY AUDIT OF LIGHTING IN EAST AFRICAN BREWERIES LTD (EABL)

BREWING DEPARTMENT

BY

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DECLARATION

STUDENTS DECLEARATION

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SUPERVISORS DECLARATION

I confirm that the above student carried out this research under our supervision as university supervisor.

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ACKNOWLEDGEMENT

The almighty lord has guided me through the course and given me the wisdom and strength plus ability to carry out this research to completion. I wish to acknowledge each person who helped me in his or her special way to make this project a success. I would like to sincerely thank my supervisor Prof. F M Luti for providing me with guidance throughout the project.

DEDICATION

I dedicate this project to my dear son and wife, Trevor and Mary thanks for your undying support and to my dear brothers and sister.

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ABBREVATIONS AND ACRONYMS

EABL	East African Breweries ltd
EAC	Energy accountable centre
EMS	Energy Management System
EUI	Energy use indices
ESO	Energy saving opportunities
HSP	High sodium pressure
IEA	International Energy Agency
IES	Illuminating engineering society
ILER	Installed load efficiency ratio
KPLC	Kenya power and lighting
Ksh	Kenya shillings
KVA	Kilo volt amperes
KVAHr	Kilo volt ampere hours
KW	Kilo watts
LPG	Liquid petroleum gas

MT	Monitoring and targeting
RI	Room index
SADC	South African Development Corporation
SPB	Simple payback period
UDV	United Distillers Ventures
VSD	Variable speed drives
BAT	Best available techniques

APPENDICES

ABSTRACT

Currently EABL energy policy does not define the roles of each employee in implementing it; this is a big drawback since many people do not take the energy saving initiatives with the seriousness they deserve. A lot of energy is wasted in the brewing department through lights, which are left on when not in use. Systems and not people should be the driving factor of saving energy in the brewing department this is due to the fact that automated system are more effective when it comes to switching on and off lights rather than reliance on people to remember to switch off lights. This is going to be achieved through installation of occupancy sensors and photo sensors respectively and removing light fixtures where there is excess light.

Energy consumption measurement meters should also be installed within the department for various types of consumption instead of the current system of one meter for the whole operation of the department. This will enable an itemized audit and ease of monitoring and reporting changes for further evaluation. All the fluorescent light fixtures currently being used should be replaced with energy efficient fluorescent fixtures utilizing electronic ballast to save energy.

There are a lot of burnt out fixtures which are consuming power without giving out any output and these should be replaced or removed in areas with excess light this is a no cost measure which is going to save the company over ksh 300,000 annually by removing of the fixtures which are not required in some areas

The incandescent lamps should all be replaced with the compact fluorescent lamps, which consume less energy, and they are more efficient and they have a longer lifespan, this will bring down the cost of power consumption and the cost of replacing the bulbs since they have longer lifespan

All the employees should be given training on the importance and ways of saving energy and the benefits, which can be brought by such initiatives

CHAPTER ONE

INTRODUCTION

1.1 Background

East African Breweries Limited (EABL) spends a sum of Ksh500 million on average per annum, on electricity.

A small percentage reduction in the energy consumption and thus the cost reduction will allow for significant reduction in the cost of production per unit volume of the factory, this will translate to more competitive pricing and increased profit for the company. EABL as a manufacturing establishment utilizes several inputs which determine its productivity and the competitiveness and profitability in the market those inputs include:

- Capital investment –this refers to the further capital input into the establishment inform of profit ploughed back to buy new machinery and equipment.
- Raw material – these refers to the process input which are processed through a pre-determined set of factory operation to produce the finished products.
- Energy cost – energy expenses take a big share of the company`s total expenditure.
- Human resource- this refers to the skilled and semi skilled labor input into the production. Process and the supporting staff, the labor costs include wages and salaries.
- Overhead costs –these refers to the operating expenses incurred by the company to facilitate its operation, these include: maintenance costs stationary, insurance and other bills.

Energy is one of the major inputs for the economic development of any country. For the developing countries the energy sector takes a critical contribution view of the ever increasing energy needs requiring huge investment to meet them.

In the developed countries there are various motivations to improve the energy efficiency. Reducing energy use will directly reduce the energy cost of a company which results in financial savings and better pricing of goods to consumers. Reducing energy use is also a key to reducing the green house gas emissions according to Tuner and Steve, energy management handbook 6^{th} edition, 2007.

According to the (IEA) International Energy Agency, (2009), improved energy efficiency in industrial processes buildings and transportation has the potential of reducing the world energy needs by one third by the year 2050; this will help to control the global emissions of greenhouse gases. Towards this effort energy efficiency and renewable energy are the twin pillars of sustainable energy policy.

According to Sant R., (1991), economic growth is directly proportional to per capita energy consumption. The energy capacity in most of the developing countries is below the demand thus the slow economic growth pace.

Reduction in the level of energy importation and the depletion of the domestic energy resources can be realized by the use of energy efficient systems.

The Kenyan government through the ministry of energy and (KPLC) Kenya power and lighting company has introduced pilot project to supply energy saving bulbs for domestic users in an effort to save energy.

Energy is consumed in all the sectors of the economy namely the manufacturing, commercial, transport and residential. The manufacturing sector is the largest consumer of electrical energy followed by the commercial sector.

1.2 Statement of the problem

For the enhanced productivity and profitability of EABL as a manufacturing company, competitiveness of the company`s products in the market is fundamental as a driver of its growth. For enhanced market performance of the company in view of the competition promotion effort and good pricing are necessary. All these are achieved with low cost of production i.e. controlled factory overheads of which energy costs take a big share. This can be reduced considerably because unlike other inputs in manufacturing energy is a manageable expense.

The nature of operating environment and the competition in business requires clear strategies for managing the operating expenses which are incurred on daily basis including energy cost. Not only is energy manageable but organizations can set up measures to asses energy use and identify energy savings opportunities.

EABL operates in 24 hours for seven days a week 365 a year at all this time light is required thus lighting accounts for a major expense of energy consumption.

The Brewing Department is engaged in production of beer from the raw materials which is barley and malt converting them to worth then through fermentation and filtration before being passed to packaging.

The Department occupies a large area with 850 fluorescent light fixtures using magnetic ballast, 100 incandescent lamps, 30 High Sodium Pressure Lamps (HSP), 40 High Bay Incandescent fixtures. Electrical energy is used to energize all the lights within the department.

Energy audit of the lights in the department will be conducted to establish energy saving opportunities which can be realized by carrying out no cost measures and low cost measures implementation. This will be done by looking at the times of use of the lights, the benefits and savings of replacing the lights with better more efficient alternatives, the number of the fixtures with a view of establishing if they can be reduced and still maintain enough light level.

EABL has been working towards increased productivity at a reduced cost and higher profitability but a major drawback to this goal is the escalating cost of energy and the inefficient utilization of the factors of production thus the need for professional energy audit and management. Energy management entails pursuing practical means of energy saving with a clear focus of reaching the target energy use levels. The achievement of this will depend on getting commitment from the top management down all levels of the organization and this will include the establishment of functional energy management systems (EMS).

Light is not a direct factor of production unlike things like pumps, motors and compressors thus is always ignored when it comes to implementation of energy saving measures but it consumes a considerable sum of energy and it can be controlled by introduction of simple measures

1.2.1 Company description

East African breweries ltd (EABL) is a beverage producing company with beer, spirits, and non alcoholic drinks as its main products. The company does brewing, distilling, packaging marketing and distribution in eastern Africa countries, south Sudan, great lakes region and also export to Europe and America.

The company produces brands like Tusker, Pilsner, Guinness, White Cap, Senator, Balozi, Bell lager, Smirnoff Red, Smirnoff Black, Tusker Lite, White Cap Lite and also non alcoholic drinks like Malta Guinness and Alvaro. In addition EABL distills and produces a range of spirits brands for both local and export market such as Smirnoff vodka, Popov vodka, Richot Brandy, Three Barrels, Kenya Kane, Kane Extra, Kenya Gold, and also imports a lot of premium brands from the mother company Diageo plc for both domestic and duty free market.

The company was incorporated in 1922 as Kenya breweries ltd and later in 1936 it changed its name to east African breweries. EABL is headquartered in Nairobi Ruaraka area and it is a subsidiary of Diageo International Company of United Kingdom. EABL Kenya is organized into four major departments namely:

1. Brewing Department

This is the start of the production process where raw materials which include: Malt, Barley, Sugar, Hops, Adjuncts and water are converted into beer.

2. Packaging Department

This is where the finished product from the brewing is passed on for bottling and labeling. This done by Use of highly automated machines observing all the food safety and quality procedures to deliver the Best quality product to the customer.

3. Utilities

Utilities form the heart of the entire plant, it is charged with constantly providing, regulating, and Maintaining utility resources such as electricity, steam, carbon dioxide, water, and compressed air also operating the cooling plant.

4. United Distillers Ventures (UDV)

This is the distillery section which specializes in production of wines and spirits.

1.3 Objectives

- To identify energy saving opportunities (ESOs) for the department through the lights
- To identify the number of lighting fixtures in the Brewing Department and the number required for sufficient lighting.

- Collect data of lighting fixtures in the department and consider better more energy efficient alternatives

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

East African Breweries limited spends a sum of 1.10 billion Kenya shilling on average every year on its major energy resources alone this sum comprises of 500 million on electricity and 600 million on fuel oil. Minor energy sources utilized by the company include the liquefied petroleum gas (LPG) and diesel.

A small percentage reduction in the energy consumption, and thus the cost will allow for significant reduction in the cost of production of the company. This will in turn lead to a more competitive pricing of the company products. The earned savings can be ploughed back to benefit the business in terms of acquisition of new energy efficient equipments and marketing of its products.

EABL has a policy on energy, waste management and environment conservation. Towards implementation of the policy the company has put up a waste management system which is both aerobic and anaerobic to manage the waste from the production process. The organization is committed in promoting energy efficiency use, reduction of waste disposal to the environment and prevention of environmental degradation by its activities. In line with these the company has installed Carbon dioxide recovery systems in the fermentation tanks and has also invested in tree planting activities in various forests including Karura forest through the corporate sector department.

A number of energy saving systems has been established in the company to conserve energy and ensure efficient energy use, these include:

- Changing from hard start to soft start or variable speed drives (VSD) for most of the motors.

- Installation of automatic temperature monitoring systems which vary the speed of the controlled machine according to the load demand mostly in beer cooling systems.
- The company has been installed with a supply of 66KV supplementing the existing 11KV this will Present energy savings resulting from corona effects, harmonics effects, control and usage of Low current resulting to low heat losses and also saving from having a stable power supply.
- The facility has installed capacitor banks to ensure a high power factor thus mitigating the power factor surcharges; the plant has a mean power factor of 0.97.
- For two or more units performing the same functions the design is that one runs while the other one is in standby mode since running on higher loads enhances the plant efficiency.
- Boiler efficiency tests and flue gas analysis are frequently performed on running boilers
- Constant measuring and recording of energy consumption of the main consumers in the facility with a view of establishing a certain trend of consumption.
- Most high consuming areas and machineries are metered, to establish the saving opportunities
- The high bay security lights have been connected to photo sensors which puts them on at evening and off at daybreak
- Energy saving education to all the personnel within the facility is planned especially on no cost measures like switching off lights when there is enough natural light.

All the above measures shows the company commitment to energy management but is very important to take an energy audit and have a clear understanding of what can be saved and where energy is being lost thus the need for an energy audit. However EABL has not undertaken a proper energy audit of its facility before except for an electricity evaluation conducted in 2008 among other energy evaluation exercises. Thus as part of energy management and conservation initiative, a proper energy audit of the lighting in brewing department of the facility was deemed necessary.

The audit was aimed at thoroughly assessing and inspecting all the functional areas to ascertain their light use patterns and the type of light fittings in use. This will establish energy saving opportunities (ESO) and undertake simple energy savings including no cost and low cost measures.

According to the “energy star”, Light can account for over 35% of energy consumption in an industry depending on the type of activity carried out in them. Light control is one of the easiest ways to make substantial energy savings for very little investment and its one of the most common energy saving measures.

Light systems for commercial, industrial and even domestic are governed by standards regulation and building codes in Kenya it is known as the local government act cap 256. Light not only needs to be functional but must also meet occupational health and safety standards and be fit for purpose

In many cases office and industrial light is excessive and there is a considerable scope for making passive energy savings these can be achieved by replacing inefficient luminaries, by replacing obsolete lights with high performance low consumption alternatives and replacing magnetic ballast with electronic ones. This kind of approach will work well in the brewing department since light is on for a long period of time and reliance on manually switching off the light is not effective.

Energy management is a judicious exercise and effective use of energy to cut down on cost and maximize profits. This can be done by evaluating the current types of lights in use, their rated consumption compared to the area required light amount, this can be adjusted to reduce costs thus enhancing chances of competitive pricing of the company products. Effective management of energy consuming systems can lead to significant savings in energy and cost of energy and also extended equipment life.

2.2 ENERGY MANAGEMENT PROCESS

Energy management is a process that involves energy auditing as well as a number of other key elements. These elements include:

- Overall assessment of the system, processes or building to identify areas of energy wastages and in efficiency.
- Periodic recording of electricity consumption by use of meters
- A listing of appropriate energy conservation measures based on the assessment carried out within the site over a duration
- Regular review of actual energy and cost savings

Once initiated energy management becomes an ongoing process that is fully integrated with routine plant operations or building maintenance, occupancy or mechanical equipment.

This process approach has a number of advantages:

- The best and the most cost effective measures for a particular process or facility are selected and implemented in proper order
- Monitoring energy conservation results provide feedback for improving the energy consumption and check on project progress
- The useful service life of light fixtures and operation is extended
- The long term result is a facility that operates at optimum energy efficiency and lower total operating costs and giving maximum satisfaction to the users.

Like any other management process, energy management requires careful planning. Time is required to analyze, plan and co-ordinate implementation of the energy saving measures.

There are four steps involved in effective energy management process those are:

2.2.1 Energy Data Analysis

The energy data analysis involves reviewing electricity energy bills on a monthly and annual basis and comparing them to a previous reference year. In addition, Energy Use Indices (EUI) can be calculated from the collected data such as energy intensity per unit production.

2.2.2 Light Energy Consumption Audit

A detailed energy audit is a complete assessment of the manufacturing facility and its energy use patterns by looking at the type of lights installed, their consumption, determining how many are working and how many are not working. The physical characteristics of the facility including the state of the paint to determine if it reflects light or absorbs. Utility bills are reviewed to determine actual energy use. The energy audit provides the necessary information for designing an energy savings implementation program. Energy saving measures with individual payback periods is developed from the energy audit. The list is usually divided into no-cost measures, low cost measures and upgrading and retrofit projects involving considerable capital expenditure. Basing on the nature of the savings measure, cost implications and payback periods, a simple implementation plan is developed. The no cost and the low cost measures are usually undertaken first as they provide rapid payback and savings generated can be used to finance other more costly measures.

2.2.3 Implementation

In addition to the recommended savings measures identified in the energy audit report many practical concerns are considered when developing the implementation plan these include:

- Existing maintenance program for the facility's mechanical and electrical systems and the building envelope
- Existing repair and upgrading program for the envelope both mechanical and electrical systems
- Projected plans for major repair or renovations
- Available funds

When complete the implementation plan will integrate these concerns with energy management measures the result will be practical and cost-effective program tailored to the specific operation.

2.2.4 Monitoring and Targeting

Monitoring and target (M&T) is the activity which uses information on energy consumption downwards. It essentially combines the principle of thermodynamics and statistics. It involves setting certain targets to be achieved and monitoring the progress to determine if the plan is on course or it has deviated from the set target. The two activities of monitoring and targeting are distinct.

Monitoring is the regular collection of information on energy use; its purpose is to establish a basis for management to control and determine when, where and why energy is deviating from an established pattern, and as a basis for taking management action where necessary.

Target setting is the identification of levels of energy consumption which is desirable as a management objective to work towards. The two activities have elements in common and they share much of the same information but as a general rule monitoring comes before targeting.

2.2.5 Benefits of Monitoring and Targeting

Monitoring and targeting is a proven strategy for management. In addition to the cost savings the other key benefits include:

- Improved product costing
- Improved budgeting
- Enhanced preventive maintenance
- Material waste avoidance

2.2.6 Main Elements of Monitoring and Targeting

The essential elements of a monitoring and targeting system would apply to a plant, cost centre, process or other logical division of the facility.

- Measuring energy consumption over time
- Relating energy consumption to a measure of output production
- Setting targets for reduced energy consumption without reducing plants output
- Frequent comparison of consumption to target
- Reporting the variance
- Taking corrective action to rectify the variance

The logical division of the organization that does monitoring and targeting is termed as Energy Accountable Centre (EAC).Monitoring an energy management program is important in order to measure results and steer the program with progressive feedback. The simplest monitoring technique involves daily review of energy use data against the production patterns and to take corrective actions where necessary. Review of monthly energy bills and annual review will provide a base reference and historical picture of energy use patterns.

2.3 ELECTRICAL METERING AND TARRIFFS

Electricity is a commodity that cannot be stored and it has to be made immediately available by the generating utility upon demand by customer.

Electricity tariffs are used to measure electricity consumption as it is actually being used thus accurate meter data is essential for energy management. Supply authorities measure power by kilowatts (kW) and active energy consumption in kilowatt-hours (kWh) i.e. the product of power and time. Total power is measured in kilovolt amperes (kVA), reactive or magnetizing power is measured in kilovolt amperes or kilovars (kVAr) and consequently reactive energy is measured in reactive volt-amperes-hours (kVAhr).

2.3.1 Cost of Electricity

Electricity tariffs set out the rates used by the supplier authority to calculate the cost of electricity supplied to their customers. The tariffs also define the terms and conditions under which an electrical service is provided to the consumers.

2.3.2 Rate Structure

Tariff rate structure set out the prices charged for electricity according to the class or scale of service provided. The common classes of service are domestic, commercial industrial, agricultural and mining.

2.3.3 Rate Elements

Basically those comprise of:

1. A fixed charge which establishes a minimum billing

2. A power demand charge (kVA), or kW with power factor penalties) which is included to enable the utility to recover the capital cost of providing the generating capacity, distribution and transmission equipments of sufficient rating necessary to meet each and every consumer load requirements throughout the year.

3. An energy consumption charge (kWh), which covers and is related to the utility fuel cost.

Table 2.1 the current customer categories in Kenya

Tariff	Type of Customer	Supply voltage	Consumption Range kWh/month	Fixed charges KES/month	Demand charges KES/kVA/month
DC	Domestic Consumer	240 or 415	0-50	120	-
			51-1500	120	-
			Over 1,500	120	
SC	Small commercial	240 or 415	Up to 15,000	120	
C11	Commercial industrial	415- 3 phase	Over 15,000	800	600.00
C12		11,000	No limit	2500	400.00
C13		33,000/40,000	No limit	2,900	200.00
C14		66,000	No limit	4,200	170
C15		132,000	No limit	11,000	170
IT	Interruptible	240 or 415	Up to 15,000	120	

2.3.4 Simple Payback Period

Simple payback period refers to the length of time required for running total of net savings before depreciation to equal   the capital cost of the project. The basic idea is that the shorter the pay time the more attractive the investment.

The features of this method are:

- The method is simple to apply and favor project with short payback time, which reduces the uncertainty of calculating savings for periods along time in future. The effects of change in technology and market demands are reduced.
- By nature the method does not consider the savings made after the payback period therefore does not asses the overall value of the project.
- The payback method does not indicate a rate of return on the money invested.

$$\text{Simple payback period}=\frac{\text{capital invested}}{\text{annual savings}} \qquad [2.1]$$

2.4 LIGHTING SYSTEMS

The cost of lighting in the brewing department is high this is due to the large number of fittings involved and the long duration which they operate. Good effective lighting depends not only on providing the right level of lighting for the task but also on selecting the best suited light source and this will depend on where the light is being used. Optimizing the lighting controls and utilizing the day light will save a lot of energy which is normally wasted.

2.4.1 Effective use of day-light

To make good use of natural light however, requires more than just simple addition of more windows. Light pouring in through the windows can create glare and cause other space to appear very dark by comparison. The challenges of successful day-light are to admit only as much light as needed, distribute it evenly, and avoid glare. The effective use of day-light can be greatly enhanced by the overall architectural design of a building. Day light controls dim or switch lights when there is sufficient daylight, and can save 30%-40% of energy use for lighting during the day.

2.5 IES RECOMMENDED LIGHTING LEVELS

The Oregon Office of energy has developed a list of lighting level recommendations for the common tasks performed in buildings according to Oregon department of energy (www.oregon.gov) accessed on 10th march 2013. Lighting levels for the various function areas have been identified. These lighting levels have been selected based on criteria established by the IES as per the table2.2.

The recommended lighting levels stated in table 2.2 are the maintained levels. This represents lighting levels after the lamps have depreciated and the fixtures become dirty thus retrofit or new fixtures will have light levels approximately 25 percent higher than those listed. This assumes existing fixtures are cleaned when retrofitted.

Table 2.2 lighting levels recommended for various tasks

Function area	Light levels (lux)	Lighting power density (watts/m^2)
Private task office lighting	538	12.89
Standard classrooms	538	12.89
High desk drafting	807	16.12
Science labs	538-807	16.12
Computer works	322	7.52
Reading area	538	12.89
Open task lighting	376	8.60
Restrooms,hallways, eating area	215	7.52
Industrial area	538-807	12.89-16.12
Conference rooms	376	8.60
Hallways	215	7.52
Matches/Exhibition	538	15.04
Food preparation	807	16.12
Private task lighting	538	12.89

Source: Oregon Office of Energy (2010)

2.6 ASSESSING LIGHTING SYSTEM

The procedure for assessing lighting system is as follows

2.6.1 Determining minimum number of measurement points

Calculate the room index (RI) using equation 2.2

$$\text{Room index} = \frac{\text{length of room}\times\text{width of room interior}}{\text{mounting height (length of interior+width of interior)}} \qquad [2.2]$$

The minimum number measurement of points is then established based on table 2.3

Table 2.3 Determination of number of measurement points

Room index	Minimum measurement points
Below 1	9
1 and 2	16
2 and 3	25
3 and above	36

Source: Bureau of Energy Efficiency (2006)

2.6.2 Determination of installed load efficacy and installed load efficacy ratios

i. Calculate area of interior in m^2

ii. Measure total power consumption of light fixture in watts

iii. Evaluate watts per square meter (W/m^2) by dividing (ii) by (i)

iv. Ascertain maintained luminance (mean lux levels recorded at all points)

v. Divide (iv) by (iii) to get Lux per W/m^2 this gives the installed load Efficacy (ILE)

vi. Obtain target Lux per W/m^2 for type of interior applications using table 2.2

vii. Obtain Installed load Efficacy Ratio (ILER) by dividing (v) by (vi)

After obtaining the ILER then table 2.4 can be used to determine if to add or reduce the light level

Table 2.4 indicators of performance

ILER	ASSESSMENT
0.75 and above	satisfactory to good
0.51 to 0.74	Review suggested
0.5 and less	Urgent action required

Source: Bureau of Energy Efficiency 2006

2.6.3 Basic units of light

Candela-this is the intensity of light

Candela (cd) = Intensity

Lumens-this is the amount of light falling on a surface

Lumens (lm)= Amount of light(Φ)

Lux- this is the density of light

Lux = Illuminance (E)

Lux = lumens/Area (m^2)

Lx= I (cd)/distance (m^2)

$E (lx) = \Phi (lm)/A (m^2)$

2.7 LIGHT SOURCES

The sun is an abundant source of radiant energy. On a sunny day the illuminance on earth's surface may exceed 100000 lux. On cloudy day the illuminance drops to 10000 lux. Comparing those with the recommended levels of illumination which range from 150 lux for public assembly up to 650 lux for drafting offices it is obvious that there is much scope for utilizing natural lighting in energy management programs

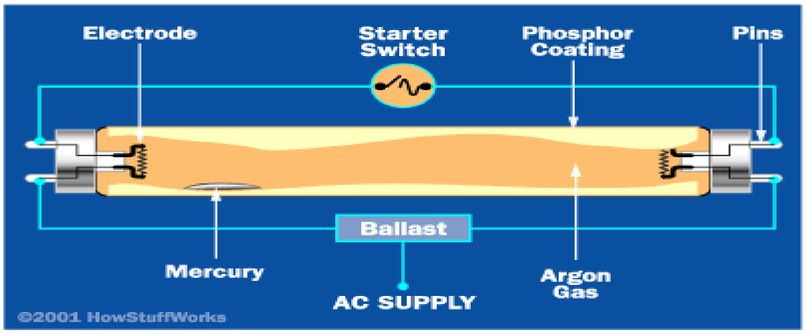
The electric light sources convert electrical energy into light energy thus it is important that when fitting the fixtures consideration should be given to the amount of light required depending on the use.

2.7.1 Incandescent lamps

In the incandescent lamps, light is produced by passing an electric current through a tungsten filament containing an evacuated glass filled with inert gas. The current heats the filament. Only 3% to 6% of input energy results in light production, the rest is dissipated as heat. The incandescent lamp is not an efficient light source, but its compact size and variety of type, low cost and the fact that the heat loss from the lamp makes the rooms warm makes it popular. In this case the incandescent lamps should be replaced with compact fluorescent lamps which are more efficient and use only one quarter the energy used by incandescent lamps with the same brightness and lasts 6 to 12 times longer this also means less time and effort is spend buying and replacing the light bulbs (Eastop and Craft, 1998).

2.7.2 Fluorescent Fixtures

Fig 2.1 connection of fluorescent lamp



Source: How stuff works, www.howstuffworks.com(2001)

This consists of a starter and ballast, when the lamp is turned on the current passes through the least resistance path through the starter to the electrodes on both ends of the tube which are filaments. when heated they generate electrons sending them into the gas tube and ionizing the gas creating an electrically conductive medium the voltage supply to the tubes is then maintained by the ballast.

2.7.3 High Sodium Pressure Lamps

A compact arc tube contains a mixture of xenon, sodium and mercury. The xenon gas which is easily ionized facilitates striking the arc when voltage is applied across the electrodes. The heat generated by the arc then vaporizes the mercury and sodium, the mercury vapor raises the gas pressure and voltage and the sodium vapor produces the light when the pressure within the tube is sufficient. High pressure sodium lamps are the most efficient artificial white light source with about 29% of the energy used by the lamp producing light. These lamps require ballast to regulate the arc current flow and deliver the proper voltage to the arc, they do not contain any starting electrodes instead an electronic starting circuit within the ballast generates a high voltage pulse to the operating electrodes. The use of these lights is basically security, and industrial lighting applications and also street lighting.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

A preliminary survey of the brewing department was conducted. This exercise was aimed at studying how the lights in the department are distributed and data collection about their power consumption, their time of operation; how they are switched on and off and to determine the number of installed non working light fixtures.

3.2 Data collection method

The brewing department is installed with only one meter for measurement of the electrical energy consumption , this means there is no separate meter for lighting thus for the purpose of this audit data was obtained from the light fixtures by recording their rated consumption capacity and measuring the actual consumption by use of a clamp meter to measure the current. A survey of the number of hours of use of the lights was also conducted this is due to the fact that some areas require light even during daytime.

Physical count was also employed as a means of obtaining data by establishing the number of working fixtures and the non working fixtures given that burnt- out fluorescent light fixtures consumes at least 15% of the rated power according to a study on industrial energy management carried out by south African Development Community (SADC), together with Canadian International Development Agency on 2007.

The data was obtained by performing a one week survey of the site both for the interior and exterior lights. In the interior survey the factors considered includes:

1. The size of the room

2. The colour of the room since some colours absorb light and others reflect light.

3. The activity which the room is used for since different activities needs different light levels.

4. The way the lights are switched on and off, this is due to the fact that most people just leave the light on even when they are not required.

5. The kind of existing ventilation in the room, this includes the number and size of the windows and possible means of modification to enable enough daylight in the room during daytime to avoid using light.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter the results of the audit are presented, analyzed and discussed. This is done with a view of making modification which can bring about energy saving and thus reducing the cost of production. The analysis is also looking to establish the suitability of the fixtures for the purposes they are installed and consider an alternative better suited for the purpose.

4.2 BURNT-OUT FLUORESCENT LIGHT FIXTURES

Burnt-out fluorescent light fixtures will still consume some energy. In practice, a fused fixture will consume 15% of its rated power according to SADC industrial energy management project. The survey conducted for whole brewing department shows the light installation was done without consideration of the required light levels for the area.

Some of the light fixtures are not working but still the light level was measured and found to be enough thus they can be removed without any effect on the required light levels. This can be shown by the analysis of one office in the beer filtration area.

The room dimensions are 5m width by 6m length

Office area= 5×6= 30m^2

The office is fitted with three fixtures each having two tubes of 58 watts

One of the fixtures is fused thus only four tubes are operational which gives an output of

4 × 56 =232 watts

The required light level of the office given that it is used for computer work as per the table 2.2

$30 \times 7.52 = 225.6$ watts

This shows that the two burnt out tubes are not necessary in the office since only four tubes of 58 watts are required to provide enough lighting for the office.

The energy consumption of the fixture was done using the formula

$$E_Q = (Q \times P \times H \times LF)/1000 \quad [4.1]$$

$$E_F = (F \times P \times H \times LF)/1000 \quad [4.2]$$

Where:

E_Q = total consumption of functioning fixtures (kWh)

E_F = total consumption of fused fixtures

Q = quantity of fixtures functioning

F= quantity of fixtures fused

P = power rating of each fixture

H = utility factor (no of utility hours)

LF = load factor

Electric unit cost = 13.55 ksh/kWh

Case analysis: Tank farm

Q = 180

F = 90

P= 58W

Total utility factor = (7×12×52) weeks = 4368 hrs

E_Q = (180×58×4368×0.96)/1000=43,777.84kWh

Cost 1= 43,777.84×13.55 = ksh.593,190

E_F = (90×58×4368×0.15)/1000 = 3,420.144 kWh

Cost 2 = 3,420.144×13.55 = ksh.46,343

Savings = cost 2 = ksh.46,343

Similar analysis was performed in all areas within the department and the findings are as per table 4.1

Table 4.1 Analysis for savings from fluorescent lamps

Area	**Fused Fixtures**	**Functioning fixtures**	**Hours per year**	**Energy consumption KWh**		**Total consumption kWh**	**Operating cost Ksh**	**Annual Savings Ksh**
				Fused	**Functional**			
Tank farm	**90**	**180**	**4368**	**3420.14**	**43777.84**	**47,197.98**	**639,533**	**46,343**

Malt silos area	45	185	8736	3420.14	89,987.79	93,407.93	1,265,677	46,343
Filter room offices	16	28	4368	608.03	1,945.68	2553.71	34,603	8,239
Filter room area	33	72	8736	2508.11	35,022.27	37530.38	508,537	33,985
Brew house area	44	186	8736	3344.14	90,474.21	93,818.35	1,271,238	45,313
Fermentation area	70	105	8736	5320.22	51,074.15	56,394.37	764,144	72,089
Brew house offices	3	21	4368	114.00	5,107.42	5,221.42	70,750	1,545
Effluent plant	6	27	4368	228.01	6,566.68	6,794.69	92,068	3,090
Asset care offices	0	27	4368	0	6,566.68	6,566.68	88,978	0
Bright beer area	43	127	8736	3268.14	61,775.40	65,043.54	881,340	44,283
Total	350	938		22230.93	348520.28	414529.05	5,616,868	301,230

The operation of the brew house is 24 hours but as per the table it is seen that some areas needs light for 24 hours but others only require light at night this is due to fact that they utilize daylight for operation and only require light at night. There is no implementation cost for removing the burnt out tubes thus the payback period will be zero years.

Implementation cost = 0 years

SPB = implementation cost/savings =$\frac{0}{301230} = 0$ years. [4.3]

4.3 HALOGEN SECURITY LIGHT SYSTEM

Note: a sum of 40, 250 W halogen lamps located over the tank farm and filter room are left on during the day when they are not required this was observed for 3 per week.

E = $\frac{Q \times P \times H \times LF}{1000}$ [4.4]

Where:

E = total consumption (kWh)

Q = quantity of fixtures (40)

P = power rating of each fixture (250W)

H = utility factor (0.96)

Electricity unit cost = 13.55ksh/kWh

Total utility factor = {(3×24) + (4×12)} × 52 = 6240 hrs

Total consumption = $\frac{40 \times 250 \times 6240 \times 0.96}{1000}$=59,904kWh

Operating cost = 59,904 × 13.55 = ksh 811,699

Non utilized utility factor = (3× 12) × 52 = 1872

Non utilized consumption $= \frac{40\times250\times1872\times0.96}{1000}$=17,971.20

Savings =17,971.20×1355 = ksh 243,509.76

Implementation cost (installing photo controls around the site) = ksh 50,000

$SPB = \frac{50,000}{243,509.76} = 0.205 years$

4.4 REFLECTORS INSTALLATION

Most of the light fittings do not have reflectors resulting to high energy losses since light is not directed to the specific area of utilization and it's just spread and lost. All the lights should be fitted with reflectors so that light can be directed to where it is needed. These reflectors intensify useful light resulting in less lights being used and saving energy without any compromise on lighting quality. New high performance reflectors offer a spectral efficiency of over 90% (kreith and yogi 2008), this means that two lights can be replaced by a single light, with a potential savings of around 50% in terms of energy cost.

4.5 ENERGY MANAGEMENT MATRIX

Energy management matrix shows an overall energy appreciation in an organization starting with the policy adopted by the top management, the implementation, training and the follow up on the implementation measures. Table 4.2 shows the general energy management matrix with the shaded regions shows the current position of EABL energy management commitment. This represents the achievement and areas where improvement is required.

Table 4.2 Energy management matrix

Level	Policy	Organization	Training	Performance measurement	Communication	Investment
4	Energy policy has commitment of top management	Clear accountability of energy consumption	Appropriate staff training conducted	Performance measured against targets	Extensive communication of energy issues	Energy efficiency support given resources
3	policy without active commitment from top management	Clear line management and accountability for improvement	Energy training done as per identified needs	Weekly performance measured for each unit	Regular performance reporting and staff briefing	Some appraisal means used
2	Policy available but not adopted	Unclear line management on energy	Ad hoc internal training	Monthly monitoring done	Limited communication	Low or medium cost measures considered
1	Un written set of guidelines	Informal mostly focused on energy supply	Training for technical staff only	Checking of monthly utility bills only	No serious energy efficiency promotion	Only low or no cost measures taken

Source: Carbon trust (2011)

CHAPTER FIVE

CONCLUSSION AND RECOMMEDATION

5.1 CONCLUSIONS

Most of the light in the department utilize energy which is not put into effective utilization resulting into high energy losses. Lights are just left on when daylight is enough to supply the required luminance thus all the lights not being used should be put off.

Most of the areas are installed with excess lighting fixtures which are not required of which some are burnt out and consumes energy without giving any output inform of light these should be replace and the extra fixtures should be removed to maintain the required light levels .

Most people just don’t take the responsibility of switching off lights when they leave their offices a lot of energy is utilized with no productive use and the average lamp life is easily attained leading to high rate of replacement of the fixtures, thus occupancy sensors should be installed in offices and employees should be sensitized on the importance of switching off light when leaving offices.

The company has an energy policy but its implementation is not effective, most of the employees are not aware of the existence of the energy policy and its contents. This is due lack of structures to implement energy saving measures and energy management practices in the organization thus measures should be put in place to implement the energy policy.

There is no direct costing of the energy consumed in the various cost centers like the way the other materials and services of production are posted in their respective cost centre thus taking control of the cost and since energy is a very high expense it should be directly allocated to the respective cost centers as per the usage.

The electrical metering system does not have separate metering for lighting and combines with other uses of energy thus no means of establishing the actual energy consumption by light alone.

In some areas security lights are left on even in the daytime consuming a lot of energy when not required this due to lack of automatic controls for the security lighting system.

Incandescent lamps are still being used in the brewing material store and in the washrooms despite the fact that they are very poor in energy saving.

The design of the buildings in future should factor in proper and adequate ventilation to make use of natural light during the day and save on light being on all the time.

5.2 RECOMMENDATIONS

Manually turn off the lights when exterior daylight is enough, this does not include any significant investment. All the employees needs sensitization training on the effects of leaving the lights on when they are not required especially the amount carbon being generated and its effect to the climate.

Install occupancy sensors and photo electric sensors, this is a more reliable method to manage the lights since there is no operator involvement thus the factor of human error is taken care of. From the research done on the installation of the above technology an occupy sensor will cost between Ksh 15,000 to Ksh 24,000 depending on type, sensitivity and radius of coverage. Thus the technology can be taken as a low cost measure. Photo electric sensors cost between Ksh 8,000 and ksh 16,000.

Reduce the light levels where appropriate according to the recommended level, this can be achieved by reducing the number of fixtures in those areas and also replacing the 58Wrapid start fixtures with T8, 32W instant start fixtures.

Replace incandescent lamps with compact fluorescent lamps and also replace the electromagnetic ballast fluorescent lamps with T8 fluorescent lamps with high frequency electronic ballast. This can be attained since the fluorescent lamps of today are very rugged and versatile thus can operate under extreme conditions up to temperature of $0^{o}F$ and provide flicker free operation and harmonic distortion of less than 5% and power factor of above 90 thus reducing energy consumption by 50% (Bird. J.2003).

Replace high bay incandescent fixtures with high pressure sodium (HPS) lamps especially in areas where light rendering is not important this is estimated to increase efficiency by 80 percent.

There is a requirement to establish the energy management section with a full time dedicated energy manager who shall coordinate and organize training of all the employees on matters related to energy saving and proper utilization of energy resources.

The energy policy framework should be reviewed and a way formulated to engrave the culture of energy saving to every employee. This can be better achieved by first making it part of induction for all the new employees to the company and organizing workshops for the existing workforce. The company magazine can dedicate a page for energy saving related education which should be posted by an authority in the field with the input of employees.

REFERENCES

- Bureau of Energy Efficiency (2006) "Determining number of measurement points",(www.bee-india.nic.in) accessed on 1st march 2013
- Bureau of Energy Efficiency, "Energy Performance Assessment of Lighting Systems", (http://emt-india.com) Accessed on 3rd April 2013
- Canadian International Development Agency, "South African Development Community Industrial Energy management project", 2007
- Carbon trust, (2011), "Energy management", (www.carbontrust.co.uk) Accessed on 1st march 2013
- Eastop T D, & Croft D R, "Energy Efficient for Engineers & Technologist, Gulf Publishing Company 1998
- Energy star, (2006), "buildings and plants", (www.energystar.gov) Accessed on 6th April 2013
- Grahams S, "Energy Research in Developing countries", international Development Research Centre, Ottawa, Canada 1994
- How stuff works, circuit connection of fluorescent fixture http:/www.howstuffworks.com accessed on 3rd April 2013
- International Energy Agency, (2009), "Efficient energy use", (www.en.wikipedia.org) Accessed on 5th April 2013
- Kenya Power and Lighting Company, "Energy Minister Launches Energy Saving Bulbs Project" http:/www.kplc.co.ke, Accessed on 2nd march 2013
- Kreith F, Yogi G D, "Energy Management and conservation Handbook", CRC Press, USA, 2008
- Oregon energy department, "developing clean energy resources", (www.oregon.gov/energy)accessed on 10th March 2013.

- Sant R, journal of the American Planning Association, Electric Utility Least-Cost Planning Making it work within a Multi attribute Decision- Making framework, Volume 57, issue 1, 1991
- Tuner W C, Steve D, “Energy management hand book 6th edition”, The Fairmount press USA 2007

APPENDIX A Lamp types and their features

Table A, Lamp types and their features

Type of lamp	Lumens per watts		Colour Rendering index	Typical application	Typical life hours
	Range	Ave			
Incandescent	8-18	14	Excellent	Homes, restaurants, general lighting	1000
Fluorescent	46-60	50	Good w.r.t coating	Offices, shops, hospitals, homes	5000
Compact fluorescent	40-70	60	Very good	Hotels, shops, homes, offices	8000-10000
High pressure mercury	44-57	50	Fair	General lighting in factories, garages, parking	5000
Halogen lamps	18-24	20	Excellent	Display, flood lighting, stadiums, exhibitions, construction area	2000-4000
High pressure sodium	67-121	90	Fair	General lighting in factories, warehouses, street lighting	6000-12000
Low pressure sodium	101-175	150	Poor	Warehouses, stores	4000-8000

Source: Bureau of Energy Efficiency (2006)

APPENDIX B site data for 58W fluorescent light fixture

Table B, site data for 58W fluorescent light fixture

Area	Fused fixture	Functioning fixture	Total fixtures	Percentage fused (%)
Tank farm	90	180	270	33
Filter room	16	28	44	36
Malt silo	45	185	130	34
Brew house	44	186	230	19
Effluent plant	6	27	33	18
Asset care offices	0	27	27	0
Bright beer area	43	127	170	250

APPENDIX C Daily electrical consumption at EABL

Table C, Daily electrical consumption at EABL

Area	**Daily consumption (KWh)**	**Percentage consumption (%)**
Main incomer (KPLC)	120340	100
Brewing Department	20320	16.885
Packaging Department	40310	33.497
United Distillers ventures (UDV)	4050	3.365
Air Compressors	25750	21.396
Boilers	5230	4.346
Refrigeration Plant	21660	17.999
Distribution (warehouse)	1500	1.246
Main offices (Tusker house)	1000	0.831
Auxiliaries, controls and losses	520	0.432