UNIVERSITY OF NAIROBI

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

Comparative Study of Energy Consumption in Base Transceiver Stations

By

ONYANGO, CHARLES ODUOR - F52/70118/2011

B.Sc Elect. Eng. (UoN), Dip. Proj. Management (KIM)

A project submitted in partial fulfillment for the Post Graduate Diploma (PGD) in Energy Management in the Mechanical and Manufacturing Engineering Department in the University of Nairobi

22nd JUNE 2012

DECLARATION

Declaration:

This project is my original work and has not been presented for an award in any other University.

Sign: ________________________ Date: _______________

Charles Oduor Onyango

Approval:

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

Sign: ________________________ Date: _______________

Prof. Felix Makau Luti

DEDICATION

This research project is dedicated to my children Wayne, Wendy and Ian.

ACKNOWLEDGEMENT

I would like to acknowledge the efforts of the following people who contributed positively towards the success of this research project: My supervisor, Professor Felix Makau Luti who gave positive guidelines on the subject under study; Program Co-ordinator, Dr. Alex Aganda, my course lecturers who offered a strong foundation in the main area of study; my colleagues at work who helped me to refine and get relevant materials for the study; my colleagues in class who made some positive criticisms on certain parts of the research project.

ABSTRACT

The study was to carry out a comparative analysis of the energy consumption in the Base Transceiver Stations segment of telecommunications network. A case study was carried out at Safaricom Ltd which is the largest operator in Kenya by subscriber base and network infrastructure. It was guided by the following objectives; to compare energy consumption in the sites, identify energy conservation opportunities in base stations and get the average the average consumption for each energy consumption model.

A combination of case study and descriptive design was used. The BTS population was generally divided into three areas indoor grid site, outdoor renewable hybrid site and outdoor grid site. Purposive sampling technique was utilized to select the sites that were studied. Data was obtained through the use of data collection sheets, interviews, sample site measurements, empirical calculations and review of the existing reports to carry out the assessment. The data was analyzed with Microsoft Excel and presented using tables and figures.

The study found the elimination of air conditioning unit as presenting the single most energy saving. Outdoor sites were found to have low energy intensity. Average consumption per hour of the highest traffic for the three types of sites considered was found with outdoor renewable hybrid site, outdoor grid site and indoor grid site consuming 6.96MJ, 7.9MJ and 24.1 MJ respectively. An implementation strategy was developed with the recommendation to put up more outdoor sites as opposed to indoor. The findings of this study are intended to assist operators in the telecom industry including Safaricom Ltd where the case study was conducted in making decisions. Other researchers can use this study as a source secondary information.

TABLE OF CONTENTS

Page No.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

OPERATIONAL DEFINITION OF TERMS

BTS: The entire system of hardware and software that are contained in equipment that enable a communication between mobile stations to access the core of the mobile network

Cell: Basic service area covered by one BTS and has a unique a unique cell global identity

Dual Rate Traffic: A combination of half rate and full rate traffic carried by communication channels

Erlang: A dimensionless unit for measuring traffic being carried by a communication channel. It is a one-hour unit of continuous or intermittent phone traffic conversations, faxing or data connection on a channel. By multiplexing, a channel can carry multiple communications in compressed form which are then separated at the receiving end. One continuous call for one hour or three calls of 20min each are both equal to 1 erlang.

Battery Bank: A combination of batteries connected in series to achieve 48V. If each battery has a capacity of 170Ah at 12V then 1 battery bank would be 170Ah at 48V. To increase the backup duration the banks are connected in parallel 2 battery banks would have a capacity of 340Ah at 48V

LIST OF ABBREVIATIONS ACRONYMS

BSC	–	Base Station Controller
BSS	–	Base Station Subsystem
BTS	–	Base Transceiver Station (Base Station)
CGI	–	Cell Global Identity
CODEC	–	Compression/Decompression Technique
ETACS	–	Extended Total Access Communication System
GEF	–	Global Environment Facility
GMSC	–	Gateway Mobile Switching Centre
GSM	**-**	Global Systems for Mobile Communication
MS	–	Mobile Station
MSR	–	Mobile Switching Room
MSC	–	Mobile Switching Centre
NSS	–	Network Switching Subsystem
OSS	–	Operation Support Subsystem
PLC	–	Programmable Logic Control
RAN	–	Radio Access Network
SDR	–	Software Definable Radio
SLPK	–	Standards and Labelling Programme in Kenya
VRLA	–	Valve Regulated Lead Acid Batteries

UNITS OF MEASUREMENT USED

Unit Symbol		Unit Name (Quantity)
E	–	Erlang (Traffic)
lx	–	lux (Illuminance)

CHAPTER ONE

INTRODUCTION

1.1 Background

The mobile telecommunication industry has undergone tremendous development in the recent past. This has led to the growth in the number of subscribers, mobile stations, size of network infrastructure, and number of value added services being offered by the operators. Various projects in the industry include development of new products and services, installation of new and upgrade equipment and construction of shelters for equipment. All equipment being installed require power supply to function hence energy consuming. The energy being utilized can either be from renewable or non-renewable sources (Kothari and Nagrath, 2008).

Energy resources are being depleted at a very fast rate and with the ever growing demand for energy driven primarily by social and economic development, the cost continues to go up. The telecommunication sector has also seen new technologies being deployed in quick succession. With this comes the challenge of meeting energy demands of the sector through a combination of various methods such as utilizing energy conservation opportunities, deploying renewable energy and hybrid systems. Apart from lowering energy costs, the methods above also contribute to reducing the greenhouse gas emissions, mainly CO_2 and general environmental degradation.

The Government of Kenya through the Ministry of Planning and Vision 2030 developed the Vision 2030 as the main development plan for the country to achieve a middle developing country status by the year 2030. Three pillars identified in the vision are economic, social and political whose achievements are dependent on a number of enablers. One of the enablers is energy. The government realized the importance of energy in overall development of the country and created the Ministry of Energy to oversee and coordinate all matters related to energy sourcing, transmission, distribution and installation. The Ministry of Energy has developed an energy policy to reduce energy consumption by 20% by the year 2030 through implementation of energy efficiency and renewable energy resource utilization. The Ministry of Industrialization together with United Nations Development Programme (UNDP) and Global Environment Facility (GEF) have initiated the Standards and Labelling Programme in Kenya (SLPK) with the goal of reducing energy related CO_2 by improving the energy efficiency of selected appliances and equipment in both home, commercial and industrial sectors. The selected products include motors, refrigerators, air conditioners and Compact Fluorescent Lamps.

Telecom operators utilize network infrastructure, information technology infrastructure, operations and support services. The infrastructure consists of the Base Transceiver Stations (BTS), Base Station Controllers (BSC), Mobile Switching Centre (MSC) and Gateway Mobile Switching Centre (GMSC). Telecommunications companies also consume energy resources in the transport fleet and buildings for switch rooms, offices, retail shops and warehouses. Grid electricity, fossil fuel, fuel cells, solar and wind electricity in various combinations are used to power the base stations.

This study focused on comparing various energy consumption models in BTS that are currently popular in the sector, identification of the energy conservation opportunities in the BTS part of telecommunication infrastructure in Safaricom and estimating the average consumption for each of the sites.

It is important to note that most telecommunication equipment such as the radio and microwave units operate on DC power at -48V. This means the positive side of the supply is grounded or earthed. Equipment providing support services use alternating current and these include lighting, air-conditioning, pumps, cleaning and maintenance.

1.1.1 Profile of Safaricom Ltd

Safaricom, which started as a department of Kenya Posts & Telecommunications Corporation, the former monopoly operator, launched operations in 1993 based on an analogue extended total access communication system (ETACS) network and was upgraded to GSM in 1996 with a license being awarded in 1999

Safaricom Limited was incorporated in 1997 under the Companies Act as a private limited liability company. It was converted into a public company with limited liability on 16 May 2002. By virtue of the 60% shareholding held by the Government of Kenya (GoK), Safaricom was a state corporation within the meaning of the State Corporations Act (Chapter 446) Laws of Kenya, which defines a state corporation to include a company incorporated under the Companies Act which is owned or controlled by the Government or a state corporation. The GoK shares were held by Telkom Kenya Limited (“TKL”), which was a state corporation under the Act.

Following the offer and sale of 25% of the issued shares in Safaricom held by the GoK to the public in March 2008, the GoK ceased to have a controlling interest in Safaricom under the State Corporations Act and therefore the provisions of the State Corporations Act no longer apply to it. Vodafone currently holds the majority shares of the company.

Safaricom Limited is Kenya's current leading Mobile Telephone Operator and aims to become the best company in Africa.

The Head Office is located along Waiyaki Way adjacent to Westlands District Commissioner’s offices.

1.2 Statement of the Problem

Energy resources are becoming scarce by the day and the costs are going up. The increasing cost adds up to the capital (CAPEX) and operational (OPEX) expenditures of the telecom operators. The competition within the industry and reduction of mobile termination charges by CCK has led to drastic reduction in revenues for the operators. Of the four operators in the country, only Safaricom is making profits while the rest have not broken-even. In their half year financial report for the year 2011/12 and full year results, Safaricom Ltd, identified escalating energy costs as one of the factors negatively impacting on their operation. The company has therefore adopted continued cost reduction as one of the strategies to maintain profitability.

This study sought to identify and assess energy conservation opportunities, quantify the savings, recommend an implementation strategy and arrive at an energy benchmark which can be applied across the industry. The study was restricted only to the BTS part of the network. Currently, there are about 2900 BTS sites countrywide (Safaricom, 2012) and therefore overall savings can be significant.

Energy resources in off-grid areas are mainly fossil fuel, and with the steady expansion of network access in these areas, this is expected to dominate the energy mix within the industry. Where grid power exist, in most circumstances it is characterized by poor quality (under/over voltages, fluctuations, brown-outs, longer outages etc.), and this results to occasional running of the standby generators thereby increasing costs. Because of history of electricity in Kenya, most consumers still believe that grid power is only generated from hydro sources within the country. This is not correct because Independent Power Producers mostly use thermal plants and the cost of fuel used is passed on to consumers. It is subject to international crude oil prices.

1.3 Objectives of the Study

1.3.1 General Objective

The main objective of this study was to compare the energy consumption of Base Transceiver Stations which is the main access point in telecommunication network.

1.3.2 Specific Objectives

a) To compare energy consumption of Base Transceiver Stations

b) To identify energy conservation opportunities in the Base Transceiver Station.

c) To recommend average energy consumption in the Base Transceiver Stations.

1.4 Significance of the Study

1.4.1 Safaricom Ltd

The outcome of this project would help the management of Safaricom Limited understand the impact of the energy solutions currently used and the conservation opportunities available. They are able to know which types of energy solutions need enhancement or discontinued. It provides a benchmark for the sector in terms of energy consumption. It further provides for an implementation strategy.

1.4.2 Other Researchers

Other researchers can now gain an insight on the impact of various energy solutions in use, conservation opportunities available in this industry especially at the access part of the network. It has also provided an analysis of the various energy elements. This research therefore provides a starting point for further research work in this field by providing secondary data.

1.4.3 The Government

The results of this study can help the government to update her energy policies in line with new developments and technologies in the telecom industry. The government can also find a benchmark which has not been available previously hence it can assist when policy reviews are being carried out. The implementation strategy developed can be useful for existing and prospective telecom operators.

1.5 Limitations of the Study

1.5.1 Lack of Cooperation

Management and employees might have withheld information because of competition fears in the industry. This could be true in areas of sourcing power network elements such as solar panels, wind turbines, generator sets among others. With the rapport created of being a member of staff, an assurance was put forward that that this work was purely for academic purposes only. This assurance was further put in the officer's data collection sheets.

1.5.2 Geographical Location

The sites selected were those that met the requirements for study by the model of energy source powering the sites. Because of limited time and resources, the sites selected were those within or close to Nairobi. The conditions of operations in other parts of the country especially in Northern and Coastal areas could give different results. The result was for a carried out in the month of May which may be different if hotter or colder months were part of the study.

1.6 Scope of the Study

The focus was on analyzing the different types of BTS sites for energy solutions in use. The study was confined to three sites of different types namely indoor grid connected, outdoor hybrid site which uses a combined renewable and generator and outdoor site on grid power. The study was carried out during the months of April to May 2012. The actual measurements were done between 2^{nd} May and 15^{th} May of 2012 at the sites. Since peak traffic is recorded between 7.00PM and 8.00PM, the readings were taken at around such times.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

There has been growing demand for energy in the telecom industry due to increasing number of subscribers leading large network infrastructure and value added services. Various energy sources are currently being used to serve the BTS. However, the major problem has been how to conserve the scarce energy available to meet this need and also use it efficiently. The operators need solutions that are cost effective in order to remain competitive in the market where subscribers continue to demand lower service charges.

2.2 Review of Theoretical Literature

Energy conservation opportunities emanate from the operation, technology and maintenance of the various elements deployed in the network. Various energy solutions are being deployed in the sites. Mobile phone has become a necessity for every household and is no longer a luxury it was a few years ago. This section is dedicated to various literatures that explain the theoretical concept of the study as well as fundamental critical review carried out on various energy conservation opportunities. A brief description of a typical network infrastructure was carried out before narrowing down to the BTS.

2.2.1 Mobile Telecommunication System Architecture

The mobile station has two components namely the mobile equipment or handset itself and the subscriber identity module (SIM) card. The subscriber identity module contains user specific information. The mobile station (MS) communicates over the air interface with a BTS which contains radio transceivers. One or more BTSs are connected to a BSC whose functions are to radio resources, mobility, operation and maintenance for the radio network. The BTS and BSC are together known as base station subsystem (BSS). One or more BSCs are connected to an MSC which is the switch that controls call setup, routing, billing and other functions. Since subscribers are mobile, the MSC provides a number of mobile management (MM) functions in addition to interfaces to other networks (Clint and Daniel, 2007).

This network is illustrated in figure 2.1.

Source: GSM for Dummies (2011)

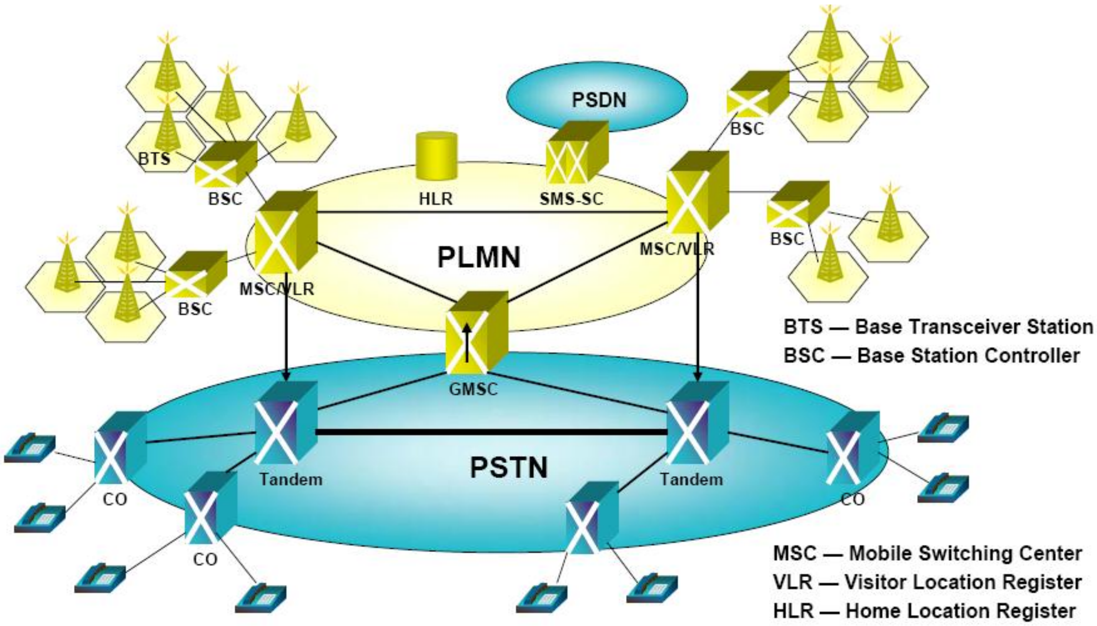


Fig. 2.1 Mobile Network Architecture

Mobile communication has grown over the years with different technologies being deployed. With varying technology, different generations have evolved from first (1G) to third (3G) and currently long term evolution sometimes referred to as fourth generation (4G). Below is a brief description of each.

<u>First Generation (1G) System</u>

This was a form of wireless communication that enabled frequency re-use, mobility of the subscriber and handover. It used analog system in the transportation of information content by not utilizing compression-decompression techniques (CODECs). This was the start of wireless revolution and was widely used for voice services. Increase in demand and limited capacity led to development of higher generations.

Second Generation (2G) System

In the second generation, digital radio technology is used to transport information content. It is popularly known as Global System for Mobile (GSM) communication. Other services delivered on top of voice included SMS, roaming, increased security among others. With reducing operating costs due to higher technology, users started to benefit from lower charges.

Evolution Generation (2.5G) System

This provided the bridge between 2G and 3G generation using platforms such as General Packet Radio Services (GPRS), Enhanced Data rates for GSM Evolution (EDGE) and CDMA2000. The enhancements over 2G primarily laid over use and delivery of packet data services with speeds exceeding 14.4kbps barrier.

Third Generation (3G) System

This wireless communication provides higher quality voice, value added services, high speed data services to one or several radio channels and flexibility for evolution to next generation systems. No single 3G infrastructure platform, technology or application exists. It is used in both mobile and stationary wireless applications involving high speed data by utilizing wideband techniques. It also supports universal roaming and Internet Protocol architecture.

Long Term Evolution (LTE) System (4G and 5G)

This is the application of high level convergence of data and circuit switched services, merging fixed, mobile phones and other mobile devices. With this evolution, live video streaming is possible allowing for tele-presence and video conference. Basically, it enables multiple functions to be performed on a single platform. Instead of radio access network technology (RAN), software definable radio (SDR) platform is to be deployed (Clint and Daniel, 2007).

With newer generations come more energy efficient devices. However, the improved and value added functionality has meant the overall energy consumption has remained high and continues to increase.

2.3 Base Transceiver Station (BTS)

They are commonly referred to as boosters. The primary elements are radio, microwave and antennae to facilitate access and transmission of signals.

It is generally seen as a tower on which antennae are mounted and a shelter all enclosed compound. An example is shown as figure 2.2.

Figure 2.2 Typical Indoor BTS

There are various types of BTS available to serve the network. Energy sources to these sites are varied.

Source: Safaricom Ltd (2011)

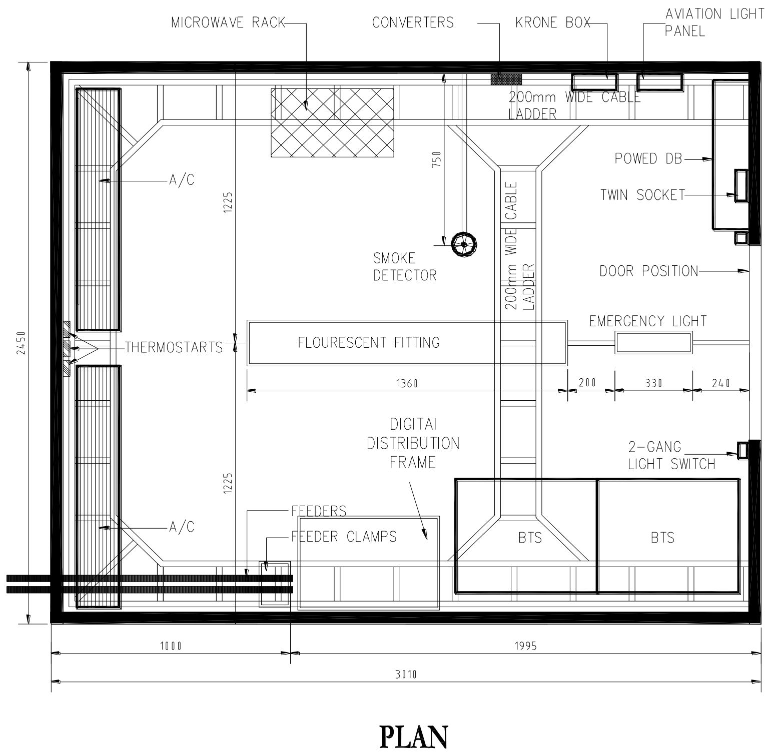


Figure 2.3 Typical Indoor Shelter Layout

2.3.1 Indoor Shelter BTS on Grid Power

This is a BTS where the energy powering the equipment is primarily drawn from mains commercial power supply from utility provider. In Kenya, the utility provider is Kenya Power and Lighting Ltd. These sites also have single standby generator set that automatically provide power whenever mains failure occurs. Main telecom equipment is housed in a shelter which is either prefabricated or masonry. Inside the shelter, the temperature has to be set at values that allow for the equipment and batteries to work optimally hence prolong their life. When power fails, the generators start automatically but take a few seconds before carrying the load. There is automatic transfer switch (ATS) or change over board which facilitates the transfer between mains and standby generator set power. During this short duration, the batteries in the shelter provide the DC power for the equipment to continue working. If the generator fails to provide power, the batteries shall continue to power equipment until they are drained upto allowed minimum. Because batteries provide DC power at 48V which is the standard for telecommunication equipment, only these would continue to operate. All services that rely on AC power therefore stop operating. For most BTS sites, the battery backup time is designed to be eight hours. However, equipment usually shut off earlier than battery backup duration due to high temperatures because the air conditioners do not operate on DC power hence the room temperature normally rises to critical levels leading to equipment shut down. Alarms are normally connected to various equipment and transmitted to a network management centre (NMC) from where they are monitored on a 24 hour basis. When a fault occurs, the NMC personnel alerts the responsible party to remedy the situation. The following are some of the alarms in a BTS:

- Main gate of site
- Electric fence
- External Wall Sensor
- Water in Shelter
- Smoke in Shelter
- Shelter Room Temperature
- Air conditioner failure
- Mains power failure
- Generator failure
- Generator service
- Site on Battery
- Fuel level in fuel tank

With these alarms active, it is not expected that the site will shut down but action is taken swiftly to correct problems and failures that occur that have resulted from the initiated alarm.

2.3.2 Outdoor BTS Site on Hybrid Power

This type of BTS is similar to outdoor site described below in all aspects except the model of powering the site. The source of power is from solar and/or wind with battery backup, generator backup and battery backup systems. The sites do not have mains (grid) power. The primary source of power is the renewable energy with the standby generator set which starts when the power from the renewable source falls below the required level.

If the generator fails or runs out of fuel, the battery backup unit provides DC power to the telecom equipment.

These sites are mainly in the rural areas where grid power is not available. Mobile telephone penetration has moved to mostly rural areas because most there are fewer potential subscribers in urban areas. The solar panels are rated to provide a total of 3.5kW while the wind turbines total 3.0kW. These charge the batteries and keep them fully charged for as much time as possible.

Figure 2.4 Typical Site on Hybrid Power (Combined Solar-Wind and Genset)

2.3.3 Outdoor BTS on Grid Power

These are sites where the equipment is installed in weather proof modular cabinets. One cabinet is dedicated for services (power) including the battery backup unit while the remainders are for telecom equipment such as radio and microwave. They have been mostly deployed on roof tops where existing slab is used as it is or reinforced. They are powered from grid with standby generator set. They eliminate the need for air conditioning the equipment and occupy less space. Instead, fans are used to circulate air in the compartments.

Figure 2.5: Typical Outdoor BTS Site on grid with generator

Figure 2.6: University of Nairobi ADD Outdoor Site

2.4 Energy Conservation Opportunities in BTS

This section was dedicated to the various opportunities for energy conservation in the BTS bearing in mind the three types described above.

a) Air Conditioning

The indoor shelters use two 3.5kW air conditioning units. In the telecommunication industry, the general standard is to use N+1 system where N is the service requirement but with at least one addition for redundancy. This means one air con is sufficient at a time while the remainder is redundant. In case one unit fails, the other continuously runs until the faulty one is repaired. There is also a provision to run both units if the temperature rises above the control point. A PLC is programmed to handle the operation mode.

b) Lighting

The shelter has few lights whose main purpose is to provide enough illumination for personnel operating the equipment and other services in the room. The lights must provide a minimum of 250 lux at 1m above floor level. Emergency lights are usually installed in the room to provide lighting whenever mains power fails. They are to provide minimum of 1 hour of lighting. The other function is to externally light the site for security around. The other form of light is the aviation warning light (AWL) at the top of the towers. AWL is useful in alerting pilots of the height of the mast or tower. The total electric power utilised by the lights in a site is 300 watts.

c) Efficiency of telecom equipment in BTS

Modern technologies have made it possible to have more efficient telecom equipment for use in the BTS. Currently, flexi and multi radio BTS offer some cost effective solutions and are widely deployed in various sites countrywide. Their energy consumption is about 400W less than those of legacy BTS.

d) Batteries

Batteries are not energy consuming devices when fully charged. The consumption is when they have been discharged and charging current helps to restore the energy storage. A higher capacity battery supports the equipment for longer periods and in case of hybrid sites, the generator set will take longer before starting. This would therefore reduce the period of generator run times leading to savings. Most indoor sites use 2 battery banks of 170Ah.

Lead acid batteries are the most commonly used in the telecom industry. It has advantages of low cost and high voltage output per cell. However, it is heavy, affected by temperatures variations and cannot stay in discharged state for long without being damaged. The alternative which has been mainly considered is nickel-cadmium batteries which have long life and not affected much by temperatures variations but they are expensive and have lower voltage output per cell (Crompton, 1995). The electromotive force of a battery is affected by both concentrations of sulphuric acid and temperature changes. Most batteries are made such that the electrolyte contains 29% by weight of the sulphuric acid at the start of discharge which reduces to 21% at the end of discharge (Crompton, 1995).

Heating effects in batteries can be classified as internal and external. External heating is due to increase in environmental temperatures surrounding the batteries. Internal heating is due to four effects:

a) Chemical heating due to reaction of lead and lead dioxide with sulphuric acid

$$PbO_2 + Pb + 2H_2SO_4 = 2PbSO_4 + 2H_2O + 89400 \text{ cal}$$

b) Chemical heating due to dissociation of water to hydrogen and oxygen towards end of discharge:

$$H_2 + {}^1/_2O_2 = H_2O + 57410 \text{ cal}$$

c) Ohmic heating due to operating current and electrical resistance of the battery

d) Localized heating due to tracking of current along low conductivity paths on the top of battery

The batteries used in the telecommunication sector fall under the category of stationary batteries where they are used as backup when the main power source is either absent or unstable (Theraja and Theraja, 2005).

In the VRLA batteries for telecommunications, energy density is less important than cycle efficiency. They mostly use gelled electrolyte and have flame arresters just under the protective cover (Vincent and Scrosati, 1997).

Most batteries used in the used come pre filled with electrolyte hence they have reduced life as they deteriorate during storage period. The recharges during storage also further affects service life since each battery has a number of cycles of discharge (Mantell, 1970). Useful service of dry charged batteries begins with addition of sulphuric acid which means such batteries would last longer.

The more shallow the discharge, the greater the number of cycles before battery failure. Failure is the oxidation of the positive grids such that most of the grid is converted to active material without strength leading to collapse.

Source: Vincent and Scrosati, (1997)

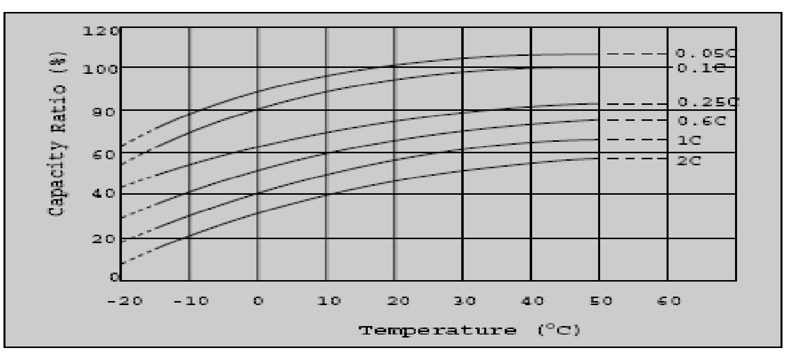


Figure 2.7: Effect of Cycle Depth on Cycling Life

e) Rectifiers

The purpose of a rectifier is to supply uninterruptible DC power to DC loads and therefore maintains a parallel connection to battery(s) so at to supply seamless DC power to the load. The rectifiers used in the shelters are usually modular in construction whereby the modules are added as the load increases. The maximum power capacity of a BTS rectifier 4.5kW. However, this power is not fully consumed.

Alarms for rectifier failure and rectifier module failure are basic requirements for any rectifier used. During normal power supply, the rectifier keeps the batteries fully charged through float charging. Without AC power, the battery powers the equipment and low voltage disconnect switch control in-built in the rectifier helps to ensure the batteries are not discharged beyond allowed depth for long life service.

Figure 2.8: Rectifier with 2 Battery Banks

f) Generator Set

Indoor shelters use 12kVA gensets while outdoor use 8kVA gensets to operate. Since indoor shelters have air-conditioning equipment, the generator has to be able to carry full compressor loads as necessary. Outdoor sites use fans which have negligible power consumption and they are generally compact. With such design, they generally consume less energy.

f) Electric Fence

Electric fence energizer equipment generates high voltage intermittent pulses of up to 10kV along the fence lines. The pulse consists of a short burst of intense electrical energy released onto through lead-out cables in a controlled way over a period of about 0.3ms. When an intruder touches a live wire, he/she receives a memorable but not lethal shock by completing the electric circuit back to the energizer via the ground earth system. The fence unit consumes 6W at 240V AC. but also on backup of 12V battery DC source. The energizer is monitored for the fence, mains and battery conditions.

CHAPTER THREE

RESEARCH DESIGN, METHODOLOGY AND MATERIALS

3.1 Introduction

According to Kothari (1990), research methodology is a way of systematically solving the research problem. It may be understood as a science of studying how research is done scientifically. The aim is to describe in details the methods to be applied in carrying out the research study. A research undertaking that is within the scope and purpose requires one to design a proper methodology which is vital towards the realization of desired results that may be used by policy makers to modify programmes or in the alternative, evaluate the relevance of a given programme in reference to the existing ones. This can be achieved by collecting information and subjecting it through an in-depth analysis for purposes of finding solutions to the existing status of the subject under investigation.

3.2 Study Design

The researcher used a combination of case study design in the project's area of study while descriptive design was used to get information and explain the important features pertaining to the energy conservation opportunities available.

A research design being an arrangement of conditions for collection and analysis of data, aims to combine relevance with the research purpose. It is the scheme that is used to generate answers to research problems (Kombo, 2006).

3.3 Target Population

Walliman (2005) argues that population is a collective term used to describe the total quantity of cases of the type which are the subject of the study. The total number of BTS currently stands at about 2900 which therefore forms the population. However, all these sites can be classified in three broad groups: indoor shelter site with mains power, indoor shelter site with renewable power and outdoor site with mains power. A population is a group of individuals, objects or items from which samples are taken for measurement. Capturing the variability in population allows for more reliability of the study.

3.4 Sampling Design

A purposive sampling technique was used to select the participant sites in the course of carrying out the research where the number of sites forming the population was divided into three relevant and significant strata based on whether it was indoor on grid (mains) energy, outdoor on hybrid energy or outdoor site on grid. According to Kombo (2006), the principle object of any sampling procedure is to secure a sample, which, subject to limitations of size, will reproduce the characteristics of the population, especially those of immediate interest as closely as possible. The studied sites were selected based upon falling in different categories, close proximity and ease of access.

3.5 Data Collection Methods and Instruments

Data was collected through access to various documents availed by the company from existing records. As observed by Rossman (1999), the techniques are critical procedures for collecting qualitative data. Data collection refers to gathering specific information aimed at refuting of proving some facts. The researcher developed a table from which experimental values from site measurements were recorded. From discussions with the field officers, more information was realized to explain some scenarios on the ground. A data recording schedule was prepared for recording raw data.

3.5.1 Reliability and Validity

To ensure reliability and validity of such instruments, the various documents from records that were used were only those of the past two years but mostly last year. Discussions with the field officers were mostly based on open-ended questions. This provided room for relevant explanations by providing freedom to the officers to express their feelings.

3.6 Equipment and Materials Used

Table 3.1 shows various equipment used during the study.

Table 3.1: List of Equipment Used

No.	Item Description	Model	Used For
1.	Clamp meter / Multi meter	Fluke 337	Measuring AC /DC Voltage and Current
2.	Lux meter	Radha LX-101	Measuring Light Levels
3.	Measuring Tape	Panyi Leader	Measuring room, distance between light source and floor level
4.	Digital Camera	Sony	Taking Images
5.	Scanner	Konica Minolta C652	Scanning hard/paper copies
6	Handheld Thermometer	Stulz BaseTech	Temperature measurements

3.6.1 Measurement Methodology and Procedure

The current radio access system in use records peak traffic every day for each site and stores in a database. From these records, it was found that the highest traffic is usually recorded between 7.00PM and 8.00PM. With such an assumption, measurements of energy consumed were taken at times that were as close as possible to this period. The following were recorded: current, voltage, temperature and illuminance. These were later analysed.

3.7 Data Analysis Methods and Procedures

Levine (2010) asserts that data analysis is a body of methods that help to describe facts, detect patterns, develop explanations and test hypothesis. It refers to examining what has been collected in a survey or experiment and making deductions and inferences (Kombo, 2006). The data collected were analyzed using Microsoft Excel.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter analyses the findings, interprets and presents data in line with the objectives of the study. The data obtained is presented in tabular form and in descriptive statistics especially line and bar graphs.

4.2 Presentation of Findings

4.2.1 Energy Consumption of the sites

The recorded consumption for the period of fourteen days commencing on 2nd May 2012 was as shown in tables 4.1, 4.2 and 4.3. The temperature readings were taken inside the shelter.

Table 4.1 Indoor Site – Baba Ndogo Kasabuni

SITE NAME: Baba Ndogo Kasabuni

DATE	TIME	AC VOLTAGE (V)	CURRENT (A)	INDOOR TEMP (°C)	ILLUMINANCE (lx)	POWER (kW)	ENERGY /MONTH (GJ)	ENERGY /HOUR (MJ)
2/5/2012	7.32PM	239	28.9	20	265	6.91	17.90	24.87
3/5/2012	7.15PM	240	28.4	20	265	6.82	17.67	24.54
4/5/2012	7.22PM	240	26.7	20	265	6.41	16.61	23.07
5/5/2012	7.50PM	240	26.9	20	264	6.46	16.73	23.24
6/5/2012	7.30PM	242	28.3	20	265	6.85	17.75	24.65
7/5/2012	7.30PM	240	28.3	20	265	6.79	17.60	24.45
8/5/2012	7.24PM	240	27.8	20	265	6.67	17.29	24.02
9/5/2012	7.31PM	239	28	21	263	6.69	17.35	24.09
10/5/2012	7.44PM	240	26.9	20	265	6.46	16.73	23.24
11/5/2012	8.00PM	238	29	20	265	6.90	17.89	24.85
12/5/2012	7.32PM	240	27.9	20	264	6.70	17.36	24.11
13/5/2012	7.32PM	239	29.1	20	264	6.95	18.03	25.04
14/5/2012	7.30PM	240	28.5	19	265	6.84	17.73	24.62
15/5/2012	7.30PM	240	28.2	20	265	6.77	17.54	24.36
Average		239.79	28.06	20.00	264.64	6.73	17.44	24.23

Table 4.2 Outdoor Site – University of Nairobi ADD

SITE NAME: UoN ADD

DATE	TIME	AC VOLTAGE (V)	CURRENT (A)	INDOOR TEMP (°C)	ILLUMINANCE (lx)	POWER (KW)	ENERGY /MONTH (GJ)	ENERGY /HOUR (MJ)
2/5/2012	7.30PM	240	11.3	N/A	N/A	2.71	7.03	9.76
3/5/2012	7.30PM	240	10	N/A	N/A	2.40	6.22	8.64
4/5/2012	7.30PM	240	9.1	N/A	N/A	2.18	5.66	7.86
5/5/2012	7.30PM	240	7.5	N/A	N/A	1.80	4.67	6.48
6/5/2012	7.30PM	241	7.1	N/A	N/A	1.71	4.44	6.16
7/5/2012	7.30PM	241	9.7	N/A	N/A	2.34	6.06	8.42
8/5/2012	7.30PM	238	9.8	N/A	N/A	2.33	6.05	8.40
9/5/2012	7.30PM	239	10	N/A	N/A	2.39	6.19	8.60
10/5/2012	7.30PM	240	10.1	N/A	N/A	2.42	6.28	8.73
11/5/2012	7.30PM	240	10.3	N/A	N/A	2.47	6.41	8.90
12/5/2012	7.30PM	240	7.3	N/A	N/A	1.75	4.54	6.31
13/5/2012	7.30PM	240	7.6	N/A	N/A	1.82	4.73	6.57
14/5/2012	7.30PM	240	9.2	N/A	N/A	2.21	5.72	7.95
15/5/2012	7.30PM	240	10	N/A	N/A	2.40	6.22	8.64
Average		239.93	9.21			2.21	5.73	7.96

This is an outdoor site powered from grid and generator backup.

The voltages and currents recorded in Table 4.1 and 4.2 are root mean square values (RMS) of the quantities. Power is supplied at 240V which is the rms value which represents voltage that is able to provide equal DC power. This is the value of interest in this study. However, peak voltage (V_p) and peak-peak voltage (V_{pp}) can be calculated as shown.

$$V_p = V_{rms} / 0.707 = 240/0.707 = 340V$$

$$V_{pp} = 2*V_p = 2*340 = 680V$$

Therefore to get the power a direct multiplication of voltage and corresponding current has been done.

Table 4.3 Renewable Hybrid Outdoor Site – Ololua

SITE NAME: Ololua

DATE	TIME	DC VOLTAGE (V)	CURRENT (A)	INDOOR TEMP (^oC)	ILLUMINANCE (lx)	POWER (kW)	ENERGY /MONTH (GJ)	ENERGY /HOUR (MJ)
2/5/2012	7.00PM	48	39.8	N/A	N/A	1.91	4.95	6.88
3/5/2012	7.00PM	48	40.4	N/A	N/A	1.94	5.03	6.98
4/5/2012	7.05PM	48.1	40.7	N/A	N/A	1.96	5.07	7.05
5/5/2012	7.00PM	48	40.6	N/A	N/A	1.95	5.05	7.02
6/5/2012	7.17PM	48	41	N/A	N/A	1.97	5.10	7.08
7/5/2012	7.20PM	48	40.5	N/A	N/A	1.94	5.04	7.00
8/5/2012	7.00PM	48	40.5	N/A	N/A	1.94	5.04	7.00
9/5/2012	7.00PM	48.1	40.4	N/A	N/A	1.94	5.04	7.00
10/5/2012	7.10PM	48	40.6	N/A	N/A	1.95	5.05	7.02
11/5/2012	7.30PM	47.9	41.2	N/A	N/A	1.97	5.12	7.10
12/5/2012	7.25PM	48.2	40.3	N/A	N/A	1.94	5.03	6.99
13/5/2012	7.30PM	48	40.7	N/A	N/A	1.95	5.06	7.03
14/5/2012	7.10PM	48	40.5	N/A	N/A	1.94	5.04	7.00
15/5/2012	7.00PM	48	40.7	N/A	N/A	1.95	5.06	7.03
Average		48.02	40.56			1.95	5.05	7.01

This is an outdoor site powered from combined wind-solar (renewable) and generator backup.

The readings in Tables 4.1, 4.2 and 4.3 were taken at the incoming terminals such that they represent what is consumed by the whole site.

Table 4.4 Comparison of the Sites Energy Consumption

DATE	BABANDOGO_KASABUNI	UON_ADD	OLOLUA
	ENERGY CONSUMED PER HOUR (MJ)	ENERGY CONSUMED PER HOUR (MJ)	ENERGY CONSUMED PER HOUR (MJ)
2/5/2012	24.87	9.76	6.88
3/5/2012	24.54	8.64	6.98
4/5/2012	23.07	7.86	7.05
5/5/2012	23.24	6.48	7.02
6/5/2012	24.65	6.16	7.08
7/5/2012	24.45	8.42	7.00
8/5/2012	24.02	8.40	7.00
9/5/2012	24.09	8.60	7.00
10/5/2012	23.24	8.73	7.02
11/5/2012	24.85	8.90	7.10
12/5/2012	24.11	6.31	6.99
13/5/2012	25.04	6.57	7.03
14/5/2012	24.62	7.95	7.00
15/5/2012	24.36	8.64	7.03
Average	**24.23**	**7.96**	**7.01**

Table 4.4 and Fig. 4.1 are results of information extracted from tables 4.1, 4.2 and 4.3. The aim was to help compare the three sites.

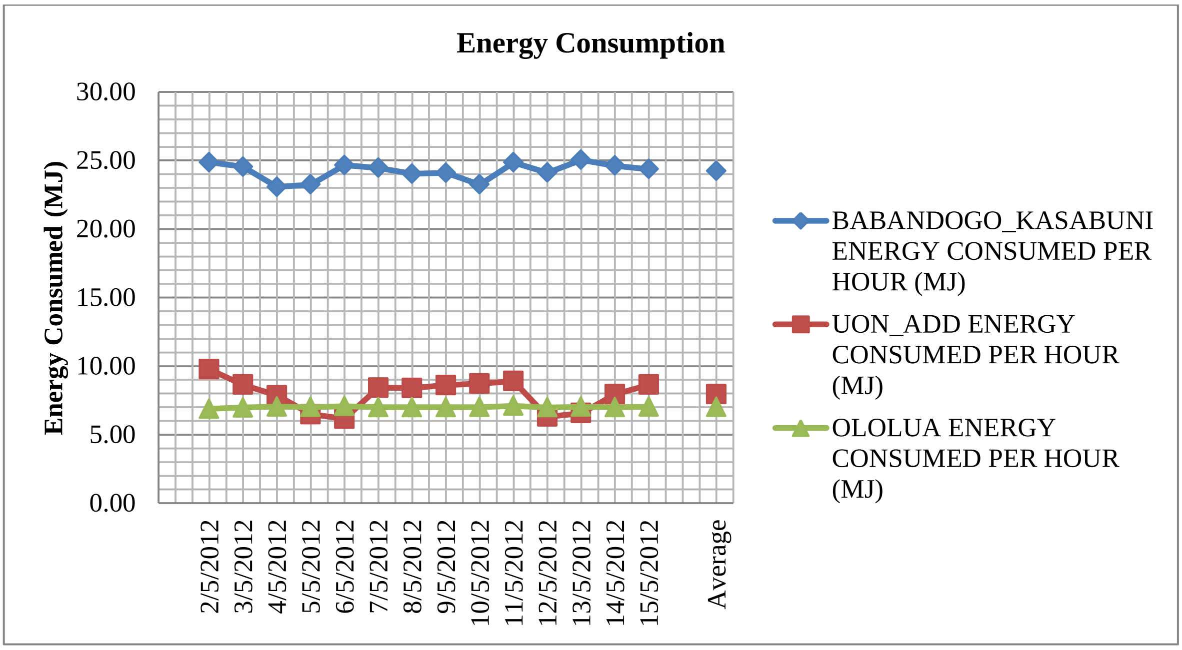


Figure 4.1 Comparison of the Sites Energy Consumption

4.2.2 Traffic Carried by the Sites

Table 4.5 Sample Traffic Log for Baba Ndogo_Kasabuni

BSC_NAME	CI	CI2	CellName	Date	Dual_Rate_Traffic (E)
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-02	24.176
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-02	13.418
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-02	19.542
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-02	39.16
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-02	36.3
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-02	32.915
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-03	25.001
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-03	14.047
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-03	9.465
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-03	42.318
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-03	38.406
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-03	31.638
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-04	27.057
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-04	15.308
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-04	10.65
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-04	51.835
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-04	47.494
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-04	29.994
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-05	27.157
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-05	15.644
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-05	9.215
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-05	48.533
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-05	47.183
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-05	27.863

Where:

BSC_ NAME is the number of the BSC controlling the study BTS.

CI is the cell sector identification number. There are six sectors in a cell.

C12 is the cell identification number for the BTS

CellName is the BTS name

Dual_Rate_Traffic is the traffic achieved under dual rate policy.

Table 4.5 shows part of traffic log that was extracted from the system for this study. The comprehensive traffic log for the whole test period is shown in the Appendix 4.

Table 4.6 Comparison of Peak Traffic for the Three Sites

Date	101-BABA_NDOGO_KASABUNI	564-Ololua	682-UoN_ADD
	Traffic (E)	Traffic (E)	Traffic (E)
2012-05-02	165.511	69.561	75.771
2012-05-03	160.875	72.15	69.63
2012-05-04	182.338	80.309	64.526
2012-05-05	175.595	70.563	50.333
2012-05-06	175.6	85.245	46.572
2012-05-07	196.404	75.829	67.301
2012-05-08	176.155	75.368	67.258
2012-05-09	178.847	75.173	68.257
2012-05-10	176.89	70.881	69.816
2012-05-11	181.077	70.695	69.955
2012-05-12	178.513	72.684	47.054
2012-05-13	185.368	77.404	51.687
2012-05-14	196.931	77.001	64.142
2012-05-15	185.496	77.701	69.445
AVERAGE	179.6857143	75.04028571	62.98192857

Table 4.6 and Fig. 4.2 are obtained from Appendix 5. It is a comparison of the three sites in terms of the traffic carried.

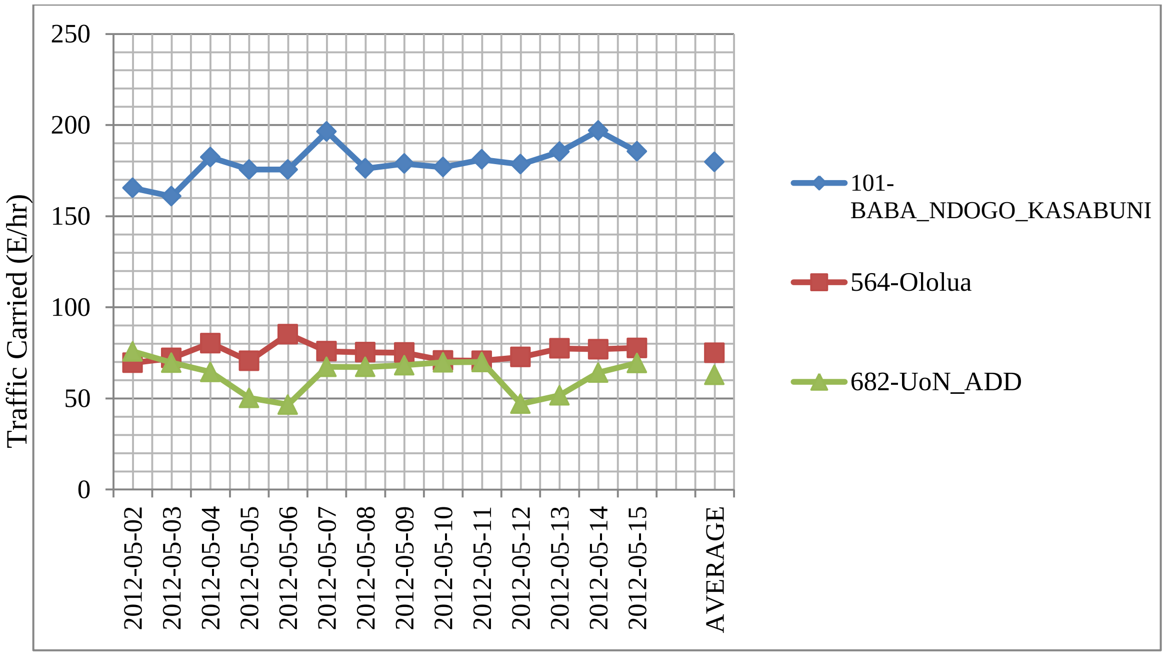


Figure 4.2 Traffic Comparison of the Sites

4.2.3 Comparison of Traffic Carried and Energy Consumed by the Sites

Table 4.7 Comparison of Traffic and Energy Consumption for Baba Ndogo

SITE NAME: Baba Ndogo Kasabuni

DATE	TRAFFIC (E)	ENERGY /HOUR (MJ)
2/5/2012	165.511	24.86556
3/5/2012	160.875	24.5376
4/5/2012	182.338	23.0688
5/5/2012	175.595	23.2416
6/5/2012	175.6	24.65496
7/5/2012	196.404	24.4512
8/5/2012	176.155	24.0192
9/5/2012	178.847	24.0912
10/5/2012	176.89	23.2416
11/5/2012	181.077	24.8472
12/5/2012	178.513	24.1056
13/5/2012	185.368	25.03764
14/5/2012	196.931	24.624
15/5/2012	185.496	24.3648

The content of table 4.7 has been extracted from the first two columns of tables 4.4 and 4.6. It compares the traffic carried by BabaNdogo Kasabuni site and energy consumed over the period. This is an indoor shelter site.

Table 4.8 Comparison of Traffic and Energy Consumption for UoN ADD

COMPARISON OF TRAFFIC AND ENERGY CONSUMPTION PER HOUR

SITE NAME: University of Nairobi ADD

DATE	TRAFFIC (E)	ENERGY /HOUR (MJ)
2/5/2012	75.771	9.7632
3/5/2012	69.63	8.64
4/5/2012	64.526	7.8624
5/5/2012	50.333	6.48
6/5/2012	46.572	6.15996
7/5/2012	67.301	8.41572
8/5/2012	67.258	8.39664
9/5/2012	68.257	8.604
10/5/2012	69.816	8.7264
11/5/2012	69.955	8.8992
12/5/2012	47.054	6.3072
13/5/2012	51.687	6.5664
14/5/2012	64.142	7.9488
15/5/2012	69.445	8.64

Similar to table 4.7, the content of table 4.8 is an extract from tables 4.4 and 4.6. It compares the traffic carried by University of Nairobi ADD site and energy consumed over the period. This is an outdoor site.

Table 4.9 Comparison of Traffic and Energy Consumption for Ololua

COMPARISON OF TRAFFIC AND ENERGY CONSUMPTION PER HOUR

SITE NAME: Ololua

DATE	TRAFFIC (E)	ENERGY /HOUR (MJ)
2/5/2012	69.561	6.87744
3/5/2012	72.15	6.98112
4/5/2012	80.309	7.047612
5/5/2012	70.563	7.01568
6/5/2012	85.245	7.0848
7/5/2012	75.829	6.9984
8/5/2012	75.368	6.9984
9/5/2012	75.173	6.995664
10/5/2012	70.881	7.01568
11/5/2012	70.695	7.104528
12/5/2012	72.684	6.992856
13/5/2012	77.404	7.03296
14/5/2012	77.001	6.9984
15/5/2012	77.701	7.03296

Table 4.9 follows the same analogy as tables 4.7 and 4.8

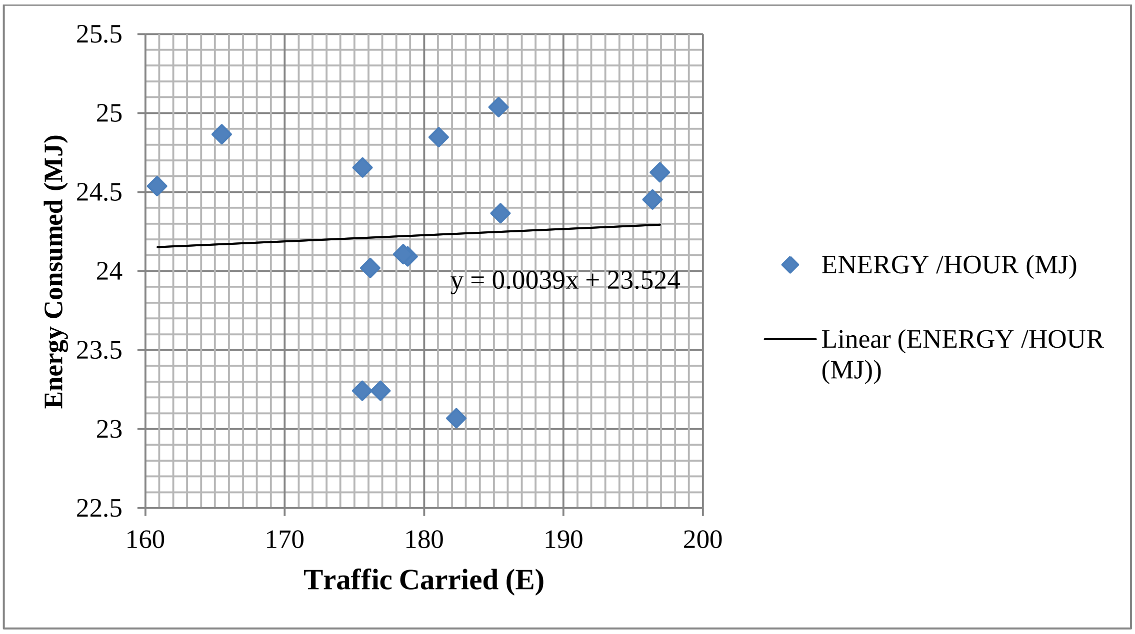


Figure 4.3 Relationship between energy and traffic in BabaNdogo Kasabuni

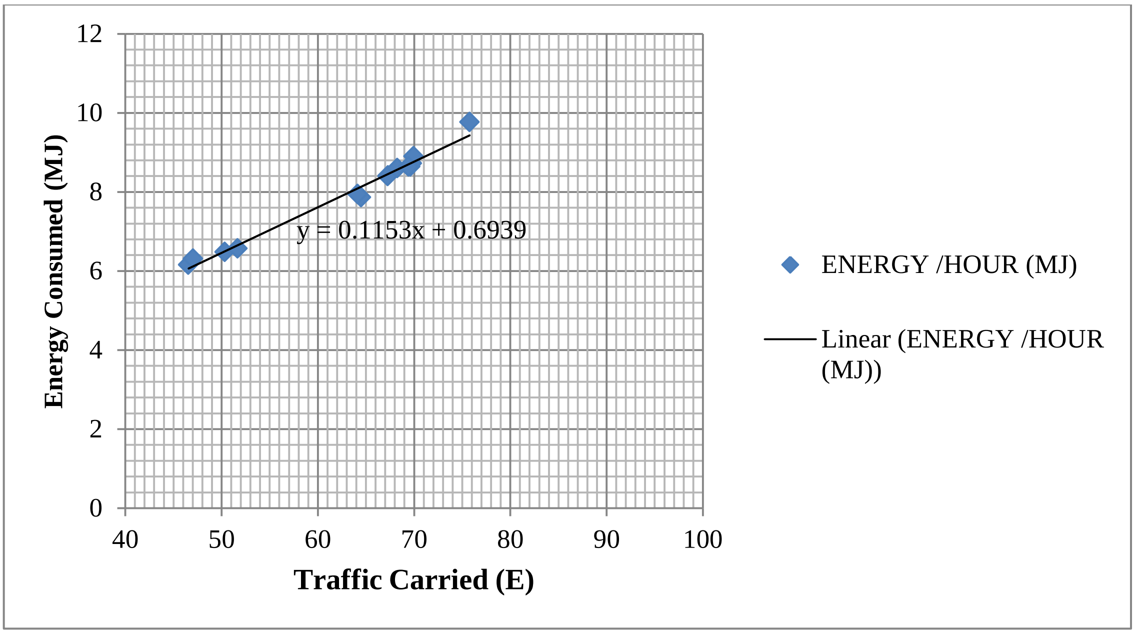


Figure 4.4 Relationship between energy and traffic in UoN ADD

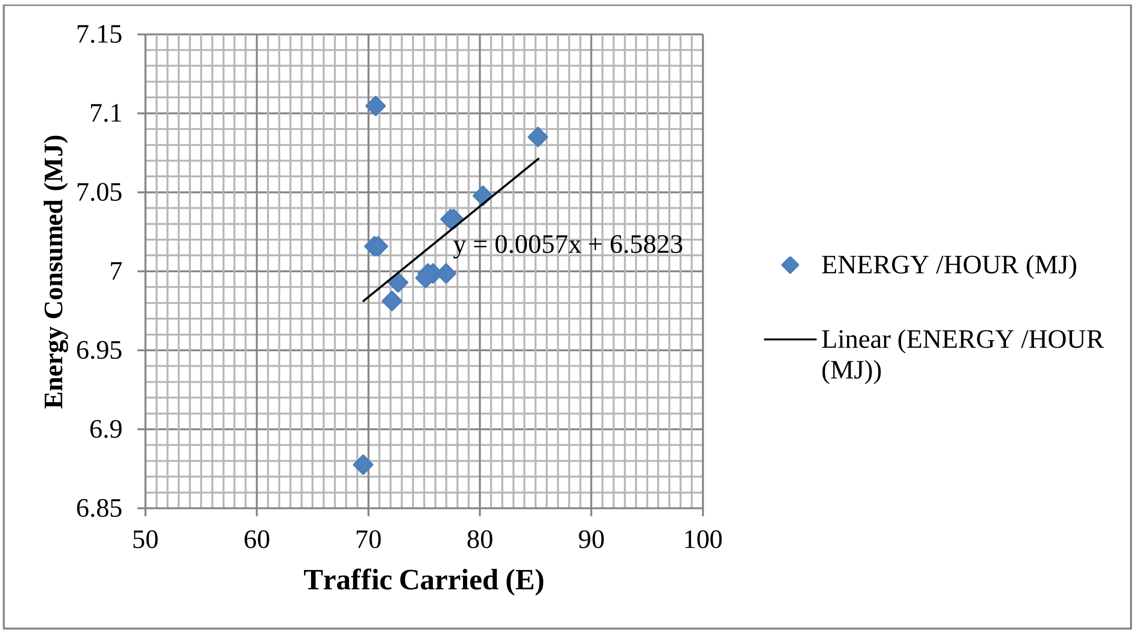


Figure 4.5 Relationship between energy and traffic in Ololua

Figures 4.3, 4.4 and 4.5 are graphical representations of tables 4.7, 4.8 and 4.8. By using this method, it easy to correlate energy consumed and traffic carried by each site and generate the line of best fit.

4.3 Analysis of Data Presented

4.3.1 General Information

The energy data was collected at times when the traffic is generally high. This time was identified at between 7.00PM and 8.00PM. Energy use was calculated in terms of joules.

Below is a sample calculation from raw data obtained from BabaNdogo_Kasabuni site on 2nd May.

2/5/2012	7.32PM	239V	28.9A	20°C	265lx	24.87MJ	17.90 GJ/month

$P = V_{rms} * I_{rms}$

Where:

P - Power (W)

V_{rms} - Voltage (V)

I_{rms} - Current (A)

If V = 239V, I = 28.9 then P = 239 *28.9 = 6907.1W = 6.907kW

In 1 hour, the energy consumed would be:

6.907kW * 1Hr = 6.907kWh = 24.87MJ …………………………… 4.1

Over a period of 24 hours and in one month of 30 days, the energy consumed would be:

6.907 * 24* 30 = 4973.1 kWh = 17.90GJ ………………………….. 4.2

This result compares well with Appendix 3 where the average monthly consumption over the period of six months was 17.74GJ.

Since traffic carried by a site is measured based on hourly unit, the energy consumed was averaged to find units consumed that match the period of traffic measurement.

From example above, the energy consumed during the an hour of peak traffic would be 24.7 MJ.

Traffic data extracted for the same site, day and period was 165.511 Erlangs.

2012-05-02	165.511 (E)

Other tables and charts presented attempt to compare, illustrate or relate energy consumed and traffic carried by the sites studied.

Table 4.1 illustrates energy units consumed at BabaNdogo Kasabuni site which is an indoor shelter site with grid power and generator backup. The site has presence of air conditioning units and non-compact telecom equipment which are less efficient. This can explain the huge energy it uses. Traffic per unit of energy consumed was:

$$^{179.686}/_{24.22} = 7.42 \text{ E/MJ} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.3$$

From Table 4.2, it was clear the site used about three times less energy. This site is an outdoor site on grid power and generator backup. However, it also carried less traffic. Its traffic per unit of energy consumed was:

$$^{62.982}/_{7.96} = 7.9 \text{ E/MJ} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.4$$

According to Table 4.3, Ololua which is outdoor site on renewable energy of wind-solar hybrid with a generator backup used the least energy. Because it also carried less traffic, its traffic per unit of energy consumed was:

$$^{75.040}/_{7.01} = 10.71 \text{ E/MJ} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 4.5$$

From equations, (1), (2) and (3), it is clear that outdoor site on renewable energy was found to be the most energy efficient while indoor shelter on grid power was the least energy efficient.

4.3.2 Energy Conservation Opportunities in the BTS

General energy conservation opportunities were found in various elements. The main one was in the 3.5kW air conditioning units which during peak hour consume about 8A at 240V giving 1.6kW consumption against its rated capacity of 3.5kW. Recent technologies have enabled production of equipment that can operate at higher temperatures of upto 50^{o}C. Given that outdoor atmospheric temperatures do not reach these levels in Kenya, the use of fans instead of air conditioning units may be encouraged. The batteries currently in use in the shelters are those that fail earlier than their rated life when operated at higher temperatures. The air conditioning units, to a large extent are basically cooling the batteries. Batteries such as Nickel Cadmium that can perform at high temperatures and therefore require no cooling, should be used as part of battery replacement or retrofits during maintenance. The use of more efficient telecom equipment should be encouraged. The government through CCK and Ministry of Industrialization can together rate the various equipment in terms of energy savings capability. Elimination or reduction of number of indoor sites would respectively eliminate or reduce areas of energy usage drastically.

4.3.3 Energy Consumption in the BTS

From Figures 4.3, 4.4 and 4.5, it was clear that indoor site had the highest degree of scatter while outdoor site on grid had lower scatter. A higher degree of scatter as seen in Figure 4.3 is a sign of poor level of control hence potential for energy savings. The figures provide a best fit line for each site in the form of:

$$Y = MX + C \quad \text{..... 4.6}$$

Where:

Y – Energy consumed for the period (MJ)

M – Variable energy consumed directly related to traffic (MJ/E)

X – Traffic carried over the period (E)

C – Fixed energy consumption (MJ)

Microsoft Excel's application's linear regression function determines a linear equation that best describes a data set. It uses the sum of least squares method to find the straight line of best fit.

For indoor shelter site on grid power:

$$Y = 0.003X + 23.52 \quad \text{..... 4.7}$$

For outdoor site on grid power:

$$Y = 0.115X + 0.693 \quad \text{..... 4.8}$$

For outdoor site on hybrid renewable energy:

$$Y = 0.005X + 6.582 \quad \text{..... 4.9}$$

Fixed energy consumption is highest for indoor shelter. This is mainly due to air conditioning and bulky telecom equipment which have lower energy efficiency. These are independent of traffic levels.

Energy savings are realized by first avoiding indoor shelter models. Hybrid outdoor sites would be appropriate only in areas where grid power is not present. Outdoor site on grid has the best control which is indicated by lower fixed costs and least scatter in Figure 4.4.

From equations (4.3), (4.4) and (4.5) in terms of energy intensity, indoor shelter site carries least traffic at 7.42 E/MJ therefore ranking lowest in energy use closely followed by outdoor site on grid. Outdoor site on hybrid energy has least energy intensity at 10.7 E/MJ.

4.3.4 Average Energy Consumption

To get the average consumption per hour, the average peak traffic for the three sites was substituted into equations 4.7, 4.8 and 4.9. The energy consumption resulting were as below.

<u>Average Energy Consumption for Indoor Shelter on Grid Power</u>

From equation (4.7),

$$Y = 0.003X + 23.52$$

When X is 179.686 E,

$$Y = (0.003 * 179.686) + 23.52$$
$$= 24.1\ MJ$$

<u>Average Energy Consumption for Outdoor Shelter on Grid Power</u>

From equation (4.8),

$$Y = 0.115X + 0.693$$

When X is 62.982 E,

$$Y = (0.115 * 62.982) + 0.693$$
$$= 7.9\ MJ$$

Average Energy Consumption for Outdoor Site on Renewable Hybrid Power

From equation (4.9),

$$Y = 0.005X + 6.582$$

When X is 75.040, then

$Y = (0.005 * 75.040) + 6.582$

$= 6.96\ MJ$

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

The purpose of this study was to carry out a comparative study of energy consumption in the telecommunication industry in Kenya. This chapter presents conclusions and recommendations based upon the findings.

5.2 Conclusions

5.2.1 Comparison of Energy Consumption

In view of the study findings it can be concluded that indoor shelter base stations is the least favourable in terms of energy consumption. They consume most energy while operators are keen on reducing the energy bills. Outdoor BTS consume less energy and may be encouraged.

5.2.2 Energy Conservation Opportunities

A number of energy conservation opportunities are available in the BTS. Use of energy efficient equipment in the base stations and service systems would help conserve some energy. By using outdoor sites, some energy consuming elements such as air conditioning are reduced or replaced by fans that consuming less energy. The energy consumption can also be minimized by use of LED lights in place of linear fluorescent lamps currently in use for indoor shelter but provide the same illumination level. Larger capacity batteries are also encouraged to increase the duration before which the generator starts to power the sites. This is especially better in hybrid outdoor sites where the generator is starts only after the batteries are drained to the minimum set. Savings would arise from less diesel usage.

Further benefits of renewable energy system for outdoor sites include reduced maintenance requirements, reduced environmental and safety liability, a sign of corporate social responsibility by reduction of pollution, noise and GHG emissions and reduced exposure to risks of rising fuel costs.

5.2.3 Average Energy Consumption

The average energy consumption of indoor shelter site on grid was found to be the highest, followed by outdoor site on grid and the outdoor site on hybrid system had the lowest average consumption. The higher the energy consumption of a site, the less it is favourable for business competitiveness.

5.3 Recommendation for Further Studies

This study was carried on three sites, one from each type of energy solution. Further research can be carried out in more sample sites in order to validate or otherwise of these findings. Another area of study would be the breakdown of contribution of solar PV array and wind turbines in the renewable energy solution to know which of two need enhancement. Solar trackers are used to maximize the energy derived from the PV modules. Since Kenya is on the Equator, this tracking may not make much difference on the effectiveness of the system. An investigation is therefore recommended on this aspect.

REFERENCES

Crompton T.R. (1995). **Battery Reference Book,** 2^{nd} Ed., Butterworth-Heinnemann, pp 2/18-19, 2/28-32.

Doty S & Turner, W (2006). **Energy Management Handbook**, 6^{th} Ed., The Fairmont Press, pp 23-33.

Grobler, L.J. (2006). **Certified Energy Manager Course. Seminar Handout**, Held 21-25/5/2007, Johannesburg, South Africa. **Unpublished**

GSM for Dummies from *http://www.gsmfordummies.com/architecture/arch.shtml Retrieved on 8/2/2012*

Hart C. (2009). **Doing Your Masters Dissertation**, Sage Publications Ltd. pp 354

Kombo, D. (2006). **Proposal and Thesis Writing**, Don Bosco Press, pp 70-99.

Kothari, M. (1990). **Research Methodology: Methods and Techniques**, 2^{nd} Ed., New Age International, pp 8-55.

Kothari, D.P. and Nagrath, I.J. (2008). **Power System Engineering**, 2^{nd} Ed., Tata McGraw Hill, pp 42.

Levine, D.M. (2010). **Statistics for Managers Using Microsoft Excel**, 6^{th} Ed., Pearson.

Mantell, C.L. (1970). **Batteries and Energy Systems**, McGraw-Hill Book Company pp 142-144.

Rossman G.B (2003). **Learning in the Field.** *An Introduction to Qualitative Research* 2^{nd} Ed., Sage.

Safaricom Ltd (2011). **Full Year Financial Results 2010/11 Announcement on 18th May 2011**

Safaricom Ltd (2011). **Half Year Financial Results 2011/12 Presentation on 9th November 2011**

Smith, P.E. and Collins, D. (2007). **3G Wireless Networks**, 2nd Ed., McGraw Hill, pp.2-5, 25-30.

Theraja, A.K and Theraja, B.L (2005). **A Text of Electrical Technology**, 24th Ed., S. Chand and Company Ltd, pp 349-373

Vincent, C.A and Scrosati, B. (1997). **Modern Batteries.** *An Introduction to Electrochemical Power Sources*, 2nd Ed., John Wiley & Sons Inc. pp 153-160.

Walliman N. (2005). **Your Research Project.** *A step by step guide for the first time researcher*, 2nd Ed., Sage

APPENDICES

APPENDIX 1

DATA COLLECTION SHEET

SITE NAME: ______________________________

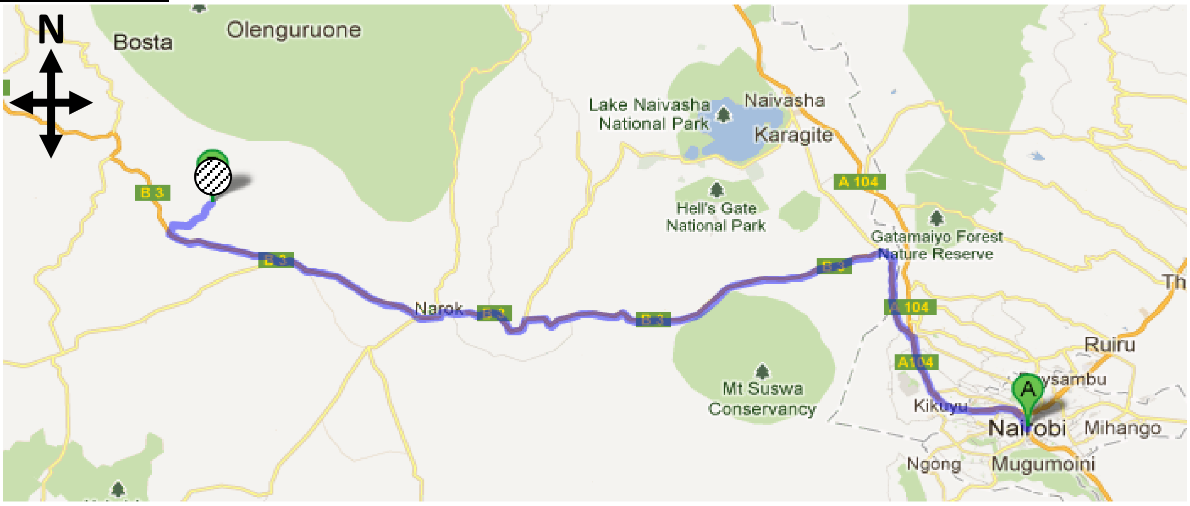
The researcher undertakes to utilize all the information obtained herein purely for purposes of this study and shall not in any way disclose any such confidential information pertaining to the officer without their express approval.

DATE	TIME	VOLTAGE (V)	CURRENT (A)	TEMP (^{O}C)	ILLUMINANCE(lx)

Thank You

APPENDIX 2 - SITES STUDIED

OLOLUA SITE



KEY: Approximate Site Location

UON ADD SITE

BABA NDOGO -KASABUNI

APPENDIX 3

EXTRACT FROM KPLC METER READINGS

SITEID	SITENAME	ACCOUNT NUMBER	SEP' 11 FO Readings	OCT' 11 FO Readings	NOV' 11 Readings	DEC' 11 Readings	JAN'12 Readings	FEB '12 Readings	March '12 Readings
101	101-BABA_NDOGO_KASABUNI	2809223-01	43025	47922	52912	57768	62769	67673	72593
682	682-UoN_ADD_HW	2964527-01	33820	35369	36878	38468	39985	41540	43142

Billing Month	**BabaNdogo Kasabuni**	**UoN ADD**	**BabaNdogo Kasabuni**	**UoN ADD**
	Energy Consumed (kWh)	Energy Consumed (kWh)	Energy Consumed (GJ)	Energy Consumed (GJ)
Oct-11	4897	1549	17.6292	5.5764
Nov-11	4990	1509	17.964	5.4324
Dec-11	4856	1590	17.4816	5.724
Jan-12	5001	1517	18.0036	5.4612
Feb-12	4904	1555	17.6544	5.598
Mar-12	4920	1602	17.712	5.7672
Average	**4928.00**	**1553.67**	**17.7408**	**5.5932**

APPENDIX 4

TYPICAL SITE TRAFFIC LOGGING FOR BABA NDOGO_KASABUNI

BSC_NAME	CI	CI2	CellName	Date	Dual_Rate_Traffic
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-02	24.176
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-02	13.418
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-02	19.542
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-02	39.16
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-02	36.3
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-02	32.915
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-03	25.001
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-03	14.047
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-03	9.465
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-03	42.318
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-03	38.406
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-03	31.638
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-04	27.057
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-04	15.308
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-04	10.65
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-04	51.835
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-04	47.494
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-04	29.994
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-05	27.157
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-05	15.644
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-05	9.215
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-05	48.533
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-05	47.183
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-05	27.863
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-06	22.24
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-06	46.819
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-06	49.113
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-06	9.963
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-06	17.74
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-06	29.725
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-07	34.342
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-07	49.364
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-07	57.533
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-07	10.411
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-07	16.947
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-07	27.807
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-08	29.185
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-08	49.472
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-08	48.076
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-08	9.079
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-08	14.803
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-08	25.54
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-09	28.832
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-09	48.975
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-09	51.429
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-09	9.543

BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-09	14.025
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-09	26.043
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-10	28.424
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-10	47.722
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-10	49.763
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-10	9.638
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-10	14.575
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-10	26.768
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-11	30.557
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-11	49.006
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-11	50.935
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-11	8.733
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-11	15.175
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-11	26.671
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-12	25.332
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-12	52.91
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-12	49.358
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-12	9.603
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-12	15.306
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-12	26.004
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-13	24.076
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-13	52.872
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-13	53.914
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-13	9.41
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-13	16.275
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-13	28.821
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-14	33.022
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-14	53.065
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-14	57.632
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-14	10.147
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-14	16.225
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-14	26.84
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-	2012-05-15	30.733
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-	2012-05-15	50.924
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-	2012-05-15	51.822
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-	2012-05-15	10.219
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-	2012-05-15	15.574
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-	2012-05-15	26.224

APPENDIX 5

TRAFFIC IN ERLANGS PER SECTOR PER SITE

BSC_NAME	CI	CI2	CellName	Date	Dual_Rate_Traffic (E)
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-02	24.176
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-02	13.418
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-02	19.542
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-02	39.16
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-02	36.3
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-02	32.915
BSC-1703	5640	564	564-Ololua-0	2012-05-02	11.947
BSC-1703	5641	564	564-Ololua-1	2012-05-02	7.153
BSC-1703	5642	564	564-Ololua-2	2012-05-02	6.522
BSC-1703	5644	564	564-Ololua-4	2012-05-02	14.458
BSC-1703	5645	564	564-Ololua-5	2012-05-02	8.775
BSC-1703	5646	564	564-Ololua-6	2012-05-02	20.706
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-02	2.761
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-02	6.908
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-02	4.057
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-02	20.924
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-02	13.467
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-02	27.654
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-03	25.001
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-03	14.047
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-03	9.465
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-03	42.318
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-03	38.406
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-03	31.638
BSC-1703	5640	564	564-Ololua-0	2012-05-03	12.185
BSC-1703	5641	564	564-Ololua-1	2012-05-03	7.378
BSC-1703	5642	564	564-Ololua-2	2012-05-03	7.339
BSC-1703	5644	564	564-Ololua-4	2012-05-03	14.842
BSC-1703	5645	564	564-Ololua-5	2012-05-03	9.856
BSC-1703	5646	564	564-Ololua-6	2012-05-03	20.55
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-03	3.103
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-03	6.428
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-03	3.821
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-03	18.489
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-03	16.006
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-03	21.783
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-04	27.057
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-04	15.308
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-04	10.65
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-04	51.835
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-04	47.494
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-04	29.994
BSC-1703	5640	564	564-Ololua-0	2012-05-04	14.364

BSC-1703	5641	564	564-Ololua-1	2012-05-04	16.59
BSC-1703	5642	564	564-Ololua-2	2012-05-04	6.914
BSC-1703	5644	564	564-Ololua-4	2012-05-04	11.521
BSC-1703	5645	564	564-Ololua-5	2012-05-04	10.044
BSC-1703	5646	564	564-Ololua-6	2012-05-04	20.876
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-04	2.565
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-04	5.976
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-04	2.703
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-04	19.453
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-04	12.692
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-04	21.137
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-05	27.157
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-05	15.644
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-05	9.215
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-05	48.533
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-05	47.183
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-05	27.863
BSC-1703	5640	564	564-Ololua-0	2012-05-05	12.606
BSC-1703	5641	564	564-Ololua-1	2012-05-05	8.118
BSC-1703	5642	564	564-Ololua-2	2012-05-05	6.486
BSC-1703	5644	564	564-Ololua-4	2012-05-05	13.276
BSC-1703	5645	564	564-Ololua-5	2012-05-05	9.813
BSC-1703	5646	564	564-Ololua-6	2012-05-05	20.264
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-05	1.651
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-05	5.397
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-05	3.231
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-05	13.528
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-05	8.711
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-05	17.815
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-06	29.725
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-06	17.74
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-06	9.963
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-06	49.113
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-06	46.819
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-06	22.24
BSC-1703	5640	564	564-Ololua-0	2012-05-06	14.947
BSC-1703	5641	564	564-Ololua-1	2012-05-06	9.735
BSC-1703	5642	564	564-Ololua-2	2012-05-06	8.186
BSC-1703	5644	564	564-Ololua-4	2012-05-06	15.918
BSC-1703	5645	564	564-Ololua-5	2012-05-06	12.617
BSC-1703	5646	564	564-Ololua-6	2012-05-06	23.842
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-06	0.922
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-06	6.672
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-06	2.675
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-06	7.221
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-06	11.181
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-06	17.901

BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-07	27.807
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-07	16.947
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-07	10.411
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-07	57.533
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-07	49.364
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-07	34.342
BSC-1703	5640	564	564-Ololua-0	2012-05-07	13.129
BSC-1703	5641	564	564-Ololua-1	2012-05-07	8.11
BSC-1703	5642	564	564-Ololua-2	2012-05-07	6.382
BSC-1703	5644	564	564-Ololua-4	2012-05-07	14.254
BSC-1703	5645	564	564-Ololua-5	2012-05-07	10.172
BSC-1703	5646	564	564-Ololua-6	2012-05-07	23.782
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-07	2.854
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-07	4.928
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-07	1.907
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-07	18.482
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-07	13.081
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-07	26.049
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-08	25.54
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-08	14.803
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-08	9.079
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-08	48.076
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-08	49.472
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-08	29.185
BSC-1703	5640	564	564-Ololua-0	2012-05-08	13.09
BSC-1703	5641	564	564-Ololua-1	2012-05-08	7.179
BSC-1703	5642	564	564-Ololua-2	2012-05-08	7.022
BSC-1703	5644	564	564-Ololua-4	2012-05-08	13.817
BSC-1703	5645	564	564-Ololua-5	2012-05-08	10.067
BSC-1703	5646	564	564-Ololua-6	2012-05-08	24.193
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-08	2.283
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-08	5.917
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-08	2.55
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-08	19.415
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-08	13.417
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-08	23.676
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-09	26.043
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-09	14.025
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-09	9.543
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-09	51.429
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-09	48.975
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-09	28.832
BSC-1703	5640	564	564-Ololua-0	2012-05-09	13.326
BSC-1703	5641	564	564-Ololua-1	2012-05-09	8.757
BSC-1703	5642	564	564-Ololua-2	2012-05-09	8.325
BSC-1703	5644	564	564-Ololua-4	2012-05-09	12.399
BSC-1703	5645	564	564-Ololua-5	2012-05-09	10.124

BSC-1703	5646	564	564-Ololua-6	2012-05-09	22.242
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-09	2.478
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-09	6.779
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-09	2.239
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-09	21.249
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-09	14.568
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-09	20.944
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-10	26.768
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-10	14.575
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-10	9.638
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-10	49.763
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-10	47.722
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-10	28.424
BSC-1703	5640	564	564-Ololua-0	2012-05-10	10.96
BSC-1703	5641	564	564-Ololua-1	2012-05-10	7.885
BSC-1703	5642	564	564-Ololua-2	2012-05-10	5.921
BSC-1703	5644	564	564-Ololua-4	2012-05-10	12.489
BSC-1703	5645	564	564-Ololua-5	2012-05-10	11.415
BSC-1703	5646	564	564-Ololua-6	2012-05-10	22.211
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-10	2.313
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-10	5.567
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-10	2.182
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-10	20.168
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-10	14.442
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-10	25.144
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-11	26.671
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-11	15.175
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-11	8.733
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-11	50.935
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-11	49.006
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-11	30.557
BSC-1703	5640	564	564-Ololua-0	2012-05-11	13.867
BSC-1703	5641	564	564-Ololua-1	2012-05-11	7.296
BSC-1703	5642	564	564-Ololua-2	2012-05-11	6.606
BSC-1703	5644	564	564-Ololua-4	2012-05-11	12.076
BSC-1703	5645	564	564-Ololua-5	2012-05-11	9.226
BSC-1703	5646	564	564-Ololua-6	2012-05-11	21.624
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-11	2.844
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-11	4.514
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-11	2.658
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-11	23.425
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-11	12.401
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-11	24.113
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-12	26.004
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-12	15.306
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-12	9.603
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-12	49.358

BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-12	52.91
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-12	25.332
BSC-1703	5640	564	564-Ololua-0	2012-05-12	11.915
BSC-1703	5641	564	564-Ololua-1	2012-05-12	7.715
BSC-1703	5642	564	564-Ololua-2	2012-05-12	5.797
BSC-1703	5644	564	564-Ololua-4	2012-05-12	13.161
BSC-1703	5645	564	564-Ololua-5	2012-05-12	10.999
BSC-1703	5646	564	564-Ololua-6	2012-05-12	23.097
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-12	1.671
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-12	3.636
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-12	1.767
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-12	12.283
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-12	10.964
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-12	16.733
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-13	28.821
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-13	16.275
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-13	9.41
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-13	53.914
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-13	52.872
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-13	24.076
BSC-1703	5640	564	564-Ololua-0	2012-05-13	13.211
BSC-1703	5641	564	564-Ololua-1	2012-05-13	7.883
BSC-1703	5642	564	564-Ololua-2	2012-05-13	6.885
BSC-1703	5644	564	564-Ololua-4	2012-05-13	14.639
BSC-1703	5645	564	564-Ololua-5	2012-05-13	10.861
BSC-1703	5646	564	564-Ololua-6	2012-05-13	23.925
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-13	0.713
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-13	5.139
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-13	2.235
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-13	8.797
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-13	12.179
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-13	22.624
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-14	26.84
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-14	16.225
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-14	10.147
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-14	57.632
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-14	53.065
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-14	33.022
BSC-1703	5640	564	564-Ololua-0	2012-05-14	14.624
BSC-1703	5641	564	564-Ololua-1	2012-05-14	8.379
BSC-1703	5642	564	564-Ololua-2	2012-05-14	6.151
BSC-1703	5644	564	564-Ololua-4	2012-05-14	13.019
BSC-1703	5645	564	564-Ololua-5	2012-05-14	11.463
BSC-1703	5646	564	564-Ololua-6	2012-05-14	23.365
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-14	2.422
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-14	5.803
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-14	1.776

BSC-1806	6824	682	682-UoN_ADD-4	2012-05-14	18.896
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-14	13.653
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-14	21.592
BSC-1102	1010	101	101-BABA_NDOGO_KASABUNI-0	2012-05-15	26.224
BSC-1102	1011	101	101-BABA_NDOGO_KASABUNI-1	2012-05-15	15.574
BSC-1102	1012	101	101-BABA_NDOGO_KASABUNI-2	2012-05-15	10.219
BSC-1102	1014	101	101-BABA_NDOGO_KASABUNI-4	2012-05-15	51.822
BSC-1102	1015	101	101-BABA_NDOGO_KASABUNI-5	2012-05-15	50.924
BSC-1102	1016	101	101-BABA_NDOGO_KASABUNI-6	2012-05-15	30.733
BSC-1703	5640	564	564-Ololua-0	2012-05-15	13.253
BSC-1703	5641	564	564-Ololua-1	2012-05-15	8.125
BSC-1703	5642	564	564-Ololua-2	2012-05-15	7.063
BSC-1703	5644	564	564-Ololua-4	2012-05-15	13.001
BSC-1703	5645	564	564-Ololua-5	2012-05-15	10.703
BSC-1703	5646	564	564-Ololua-6	2012-05-15	25.556
BSC-1806	6820	682	682-UoN_ADD-0	2012-05-15	2.449
BSC-1806	6821	682	682-UoN_ADD-1	2012-05-15	5.325
BSC-1806	6822	682	682-UoN_ADD-2	2012-05-15	2.275
BSC-1806	6824	682	682-UoN_ADD-4	2012-05-15	19.392
BSC-1806	6825	682	682-UoN_ADD-5	2012-05-15	14.393
BSC-1806	6826	682	682-UoN_ADD-6	2012-05-15	25.611