ELECTRICAL ENERGY EFFICIENCY IMPROVEMENT IN COMMERCIAL BUILDINGS: A CASE STUDY OF SELECTED BANK BUILDINGS IN ZARIA

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SEPTEMBER, 2012

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DECLARATION

I declare that the work in this thesis entitled "Electrical Energy Efficiency Improvement in Commercial Buildings: A Case Study of Selected Bank Buildings In Zaria" has been performed by me in the Department of Building under the supervision of Dr.A.A.Mati, Prof. I.Mbamali and Prof. Kabir Bala.

The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for the award of degree or diploma in Ahmadu Bello University, Zaria with similar dispensation, as well as in any other institution of higher learning. However, any error or omission is solely my responsibility.

_____ _____

AUDU ALI **DATE**

CERTIFICATION

This thesis entitled **"ELECTIRCAL ENERGY EFFICIENCY IMPROVEMENT IN COMMERCIAL BUILDINGS: A CASE STUDY OF SELECTED BANK BUILDINGS IN ZARIA**" by Audu Ali meet the requirements and regulations governing the award of M.Sc. Degree in Building Services in Building Department of Ahmadu Bello University, Zaria and hereby approved for its contribution to knowledge and literary presentation.

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DEDICATION

This Thesis is dedicated to my wife and my six children/ as well as the entire lecturers and five of my post graduate course mates of M.Sc. Degree in Building Services of year 2004/2005 for their encouragement given to me .

ACKNOWLEDGEMENT

In the name of Allah the Beneficent, the Merciful without whose mercy and grace the beginning and successful completion of this research work would have been impossible.

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ABSTRACT

The study used energy audit to determine where, when, why and how electrical energy is being used in selected bank buildings in Zaria. The information was used to identify opportunities to improve efficiency, decrease energy cost and reduce greenhouse gas emissions that contribute to climate change. The study employed both primary and secondary sources of data. Questionnaires were the instruments of the primary data collection while information from manufacturers' manuals, catalogues and maintenance records of the banks constituted the secondary data. The findings indicated that the average electrical energy consumption and cost for the four (4) bank buildings are 7,412.26 kWh/month and ₦63,004.14/month before retrofitting. The actual energy consumed (estimated wattage Rating on nameplate of appliances/equipment) was also calculated and compared to the consumed energy using One-way ANOVA. It was concluded that energy usage in the bank buildings involved much wastage especially in the area of lighting, cooling and plug loads. An energy efficiency programme which covers lighting, cooling and the plug loads was recommended.

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ABBREVIATIONS

AfriBank	African Bank Plc
AGO	Automotive Gas Oil
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
ATM	Automated Teller Machine
CFL	Compact Fluorescent Lamp
EC	Energy Conservation
ECO	Energy Conservation Opportunity
EMO	Energy Management Opportunity
EMS	Energy Management System
EUI	Energy Utilization Index
FinBank	First Inland Bank Plc
FirstBank	First Bank Plc
GHG	Greenhouse Gases
HVAC	Heating, Ventilation and Air Conditioning
PHCN	Power Holding Company of Nigeria
₦.K	Nigerian Naira and Kobo
kV	Kilovolt
KVA	Kilovolt Ampere
kWh	Kilowatt hour
LMS	Lighting Management System
LPG	Liquefied Petroleum Gas
MVA	Megavolt Ampere
MWh	Megavolt hour
M&E	Mechanical and Electrical Engineering Services
ECN	Energy Commission of Nigeria
PI	Power Inverter
PV	Photovoltaic
UBA	United Bank Of Africa Plc
R.E.S	Renewable Energy Resources
SPBP	Simple Payback Period
SWH	Solar Water Heater
W	Watt

CHAPTER ONE

Introduction

1.1 Background of the Study

Energy conservation is a process by which the energy required to provide services within residential, institutional and commercial buildings is reduced to a minimum, while achieving the required standard of service delivery. The architectural features of two buildings can be the same but their power/energy usage can never be the same (Thumann, 2006). This is the case with all building types including commercial building. Commercial buildings in Nigeria include shops, banks, restaurants, hotels, office buildings etc. (DOE, 2010). The commercial buildings may be of bungalow, low, medium or high-rise design. Energy is used in commercial buildings for space conditioning, lighting, equipment operation (computers, photocopying machines, Internet Browsing, fax machines etc.), operation of lift/escalators, water heating, cooking, etc. The energy used in this building sub-sector is mostly electricity with small amount of petroleum products such as LPG and kerosene, which are used for cooking in hotels and restaurants. Some quantities of petrol and diesel however, are also used for electricity generation in the Sub- sector due to persistent failures of public utilities power supply in Nigeria.

In developed countries, especially in the United States, thousands of existing public and private buildings have been retrofitted or otherwise modified to produce energy savings of up to fifty (50%) percentage (Thumann,2006). According to the London Economist (2006) the annual electricity bills for commercial buildings in the United Kingdom are about £8 billion (about ₦2 trillion) a year. It estimated that approximately twenty percent (20%) of this expenditure could be saved through the application of cost-effective energy efficiency measures.

According to Sayigh, (2006), the amount of energy consumed in a building depends upon the nature of its human systems, non-energized systems, and energized systems, and the interrelationships between them. To improve the energy efficiency, therefore, it is important to examine each of the three systems to establish the shortcomings and the options available to overcome them. Energy efficiency improvements in buildings, therefore, require a detailed electrical energy audit in order to have a clear picture of the structure of energy consumption. This picture includes both the quantities of energy consumed by type and the activities or output for which the energy is used. An electrical energy audit is a study to determine the quantity and cost of each form of energy input to a building (CIBSE-Good Practice Guide 311). This help in identifying where energy is being wasted,

together with appropriate energy efficiency measures that can be considered in order to reduce energy consumption.

Energy audit consists of several tasks, which can be carried out depending on the type of audit and the function of audited facility. It starts with review of the historical data of energy consumption, which can be compiled from the electricity bills. Then followed by the analysis of energy utilization such as running hours of air-conditioning, lighting, computers/equipment, locations of unnecessary air-conditioning and lighting due to unoccupied areas and efficiencies of equipment and machine and the areas of high energy consumption and the possibility to reduce consumption, PEA (2010).

This is concerned with the electrical energy efficiency improvement in commercial banks buildings.

1.2 Statement of the Problem

There is little or no thoughtfulness with regards to energy use efficiency in buildings in this country, even with large commercial buildings. The result doubtless is energy waste with its attendant cost implications (Sambo 2001). Building system and appliance were listed by world's energy council among the seven areas of potentials energy efficiency opportunities (ECN 2007).This study conducts an energy audit of selected commercial banks in Zaria with a view to identifying areas of improvement.

Improving energy efficiency and conservation are essential to achieving environmental sustainability. They are the simplest ways to reduce greenhouse gas emissions and other forms of air pollution such as acid rain and smog.

1.3 Justification of the Study

Most commercial operations outfit have over the years complained of high cost of energy while conventional electricity supplies are dwindling and previously secured electricity sources are becoming questionable. Wastage and inappropriate usage of electrical energy have been identified as one of the major problems of physical facility management in commercial offices in Nigeria (ECN, 2007).

Over the years, energy requirements in buildings for increasing number of services have increased thus making power supply distribution to undergo rapid development (DOE, 2010). Public interest in energy efficiency has increased as everyone has become more aware of the need to reduce global environmental pollution and promote sustainable development. Building energy experts have a professional responsibility and an economic incentive to inform themselves of these issues so that they are ready for business opportunities, which come their way and can, tell clients about cost effective ways of improving their building's energy efficiency. Saving energy also reduces emission of carbon dioxide (CO2), the principal contributor to climate change, and other gases causing acid rain and air pollution.

According to EPA (2010), lighting accounts for more than 40% of commercial sector electricity consumption in the United States. Lighting programs to date have achieved tremendous savings through lamp and ballast replacements. Largely through the success of these efforts, energy-efficient T8 lamps and electronic ballasts, compact fluorescent lamps (CFLs), and light-emitting diode (LED) exist signs have become standard practice in some regions for fluorescent lighting in new buildings and most lighting retrofits (Philips,2011).

1.4 Aim and Objectives

1.4.1 Aim

The aim is to study the energy consumption pattern and propose electrical energy efficiency programme for commercial bank buildings, with a view to decreasing electrical energy costs and reducing greenhouse gas emissions that contribute to climate change.

1.4.2 Objectives

The objectives are:

i. Articulate energy efficiency concepts especially in commercial buildings.

ii. Evaluate energy consumption patterns and occupants behaviour in commercial bank buildings.

iii. Develop an energy efficiency programme for the commercial bank buildings.

1.5 Statement of Research Hypothesis/ Questions

1.5.1 Hypothesis

The study Hypothesizes that energy consumption patterns and practice are the same for all the bank buildings in Zaria.

1.5.2 Research Questions

1. Are there discrepancies between the measured energy consumption and that specified by manufacturers?
2. What is the advantage of using modern appliance over an old one in terms of energy consumption?

1.6 Scope and Limitations

1.6.1 Scope of the project

The scope of this work is to study and identify how electrical energy is being used in some commercial buildings (Banks) within Zaria metropolis, carry out overall energy audit on building systems equipment and propose energy efficiency and cost saving measures.

1.6.2 Limitations

This study was carried out among some selected banks in Zaria Local Government Area. This is as a result of restricted access to most of the bank buildings more so, the energy audit process applied was a desk-based process, which used historical data such as meter readings and utility bills as well as computation of physical electricity end use data. This is due to limited resources and lack of sophisticated measuring and monitoring equipment.

1.7 Thesis Outline

This thesis contains five chapters, each of which is complimentary to the other. The chapters are briefly summarized below.

Chapter one contains of the introduction or the overview of this project, the problem statement of this project, the objectives of the project, the scopes of the project and the outline of this thesis for every chapter.

Chapter Two contains all the literatures review. This chapter explains the information about the article that related to the project design and the research on energy efficiency that is done by other researchers. The chapter also describes the journals and others important information regarding this project.

Chapter three is the chapter which describes the methodology of the project. This chapter explains in detail all the procedures and process that were carried out to arrive at the results.

Chapter four discusses the result and the analysis for this project. This chapter explains on the results and analysis of the project. The analysis includes the existing system and the improved on proposed system. Both values are compared to justify the theory.

Chapter five gives the Summary, and the conclusion of the project. It also includes the recommendation of the project.

CHAPTER TWO:

Literature Review

2.1 Introduction

Buildings are supposed to be equipped with some services towards meeting regulatory requirement. These services includes electricity, water, safety and security system, waste disposal, lifts, cabling of computers and telephone, lighting, heating, air conditioning and refrigeration. This regulatory requirement leads to the development of "Building Services Engineering "or M& EServices to address the demand in the building industry. It aims to promote and improve understanding and co-operation between the user, designers, contractors, operative and maintenance staff and other professional advisers concerned with building structure, site and services (DOE, 2010).

However, a system that gives efficient use of energy in the design and management of buildings, certain procedures should be agreed between the client, his professional advisers and, where feasible, the user. The energy requirement of existing buildings should be established using an energy audit.

2.2 Concept of Energy Consumption and Efficiency in Commercial and Institutional Buildings

Appraising the potential for energy efficiency improvements requires a clear picture of the structure of energy consumption. This picture must include both the quantities of the energy consumed by type and activities or output for which the energy is used. In this section, an analysis of energy consumption in commercial and institutional buildings in Nigeria is presented.

Commercial buildings include retail and wholesale buildings, banks restaurants, hotels and office buildings. The institutional buildings consist of hospitals and health centers, schools, prisons, universities, and government offices. Both building categories are normally classified as 'commercial' in the presentation of energy data by PHCN. The buildings themselves may be bungalow, low, medium or high-rise design. Electricity consumption in this building sub-sector is shown in table 1. The consumption reached about 27.2% of the total electricity consumption in 1993 with an average of 25.7% for the 6-year period, 1991-1996.

Energy is used in commercial and institutional buildings for space conditioning, lighting, equipment operation (computers, typewriters, fax machines, heaters, pumps, trolleys, etc.) operation of lifts/escalators, water heating, cooking, etc. The energy used in this sub-sector is mostly electricity with small amounts of petroleum products such as LPG and kerosene, which are used for cooking in

hotels and restaurants. Some quantities of petrol and diesel are also used for electricity generation in the sub-sector.

Typical electric consumption distribution in commercial buildings as follows:

Air-conditioning/ Mechanical Ventilation	60-65%
Lighting	20-25%
Equipment	10-15%
Lifts/escalators	5-15%

The largest share of electricity consumption is thus in the air-conditioning and lighting services, where it is used to achieve thermal comfort and high productivity. Hence, energy efficiency and conservation measures should be focused on reducing the heat gain and artificial lighting needs in buildings. Reduction of heat gain will result in lower cooling loads and hence smaller consumption for air-conditioning.

2.3 Measures of achieving energy efficiency

The following measures have proved to be particularly effective in the developed countries for achieving energy efficiency.

2.3.1 Commercial buildings

i. The improved operation of heating, ventilation and air-conditioning (HVAC) systems

ii. The electronic control of electrical demand

iii. The retrofit and replacement of existing incandescent lighting systems with more efficient fluorescent tubes or lamps

iv. The recovery of exhaust air cooling (for heating) capacity through the use of air-to-air heat exchangers.

2.3.2 Institutional buildings

i. Implementation of employee energy awareness and incentive programme

ii. Use of energy conserving water taps and shower heads

iii. Insulation of heat recovery devices

iv. Insulation of hot water pipes and reduced hot water temperatures

v. Insulation of micro-processors and demand controllers to limit electrical costs

vi. Enhanced diesel efficiency through waste heat recovery systems.

Studies have proved that about 20%-30% of the energy consumed is wasted due to low maintenance and inefficient processes. Therefore, it is obvious that energy efficiency improvement in commercial and institutional buildings can be a major contributor to energy saving on the national level.

2.3.3 Space Conditioning

Space conditioning is a common activity in commercial and institutional buildings, which provides thermal comfort for employees and thereby enhances productivity. The overall energy efficiency of air-cooling systems, from primary fuel to the cold produced, has been estimated to be barely 5%. The figure does not take account of avoidable losses through cooling unoccupied rooms.

Ventilation and cooling needs can be reduced. For instance, external heat gains can be minimized by shade trees, awnings that provide indirect light but shield direct sunlight, exterior or interior shades, reflective or tinted window coatings, insulated, windows, light coloured roofs, roof spays, wall and roof insulation ,ventilation by natural convection, use of the ground for cooling and use of traditional heat shielding materials such as thatch. Internal heat gains can be kept low by used, as can direct and indirect evaporative coolers, air-to-air heat exchangers, gas-fired absorption chillers, engine driven chillers and adjustable speed powered systems. These illustrate some of the technical means currently in use.

The methods available for increasing the energy efficiency of heating are analogous to those for improving cooling efficiently: better insulation of buildings, use of free heat gain from appliances, more efficient heating systems, use of passive solar energy, use of heat pumps and co-generation systems where

appropriate, development of a building's heat storage capacity, draught proofing, use of individual metering devices and thermostats, etc.

2.3.4 Lighting

Modern electric lighting plays a very important social role in all aspects of life. As the conversion of primary energy into final electricity has an efficiency of about 30%, the overall efficiency for lighting is currently about 3% (and for lights) if used with care. Unnecessary use reduces overall energy efficiency below 1%. The demand for lighting has continued to increase and the trend is expected to be maintained. Lighting is therefore a fruitful area for improved efficiency, where many analyst believe gains of 60% to 70% are readily achievable with best currently available technology.

Much of the lighting in commercial and institutional buildings continues to be provided by incandescent bulbs. These bulbs have an efficiency of about 4% in converting electricity to visible radiant energy. Much more efficient and cost-effective lighting techniques are available; in particular, compact fluorescent lights have efficiencies of up to 35% (typically of around 20%). Constraints to be the more rapid penetration of such technologies includes lack of awareness, low availability, high first cost, high replacement cost of breakages, and high retrofitting costs.

Further options to reduce electricity requirements include better lighting control (such as varying the light levels according to function), more efficient reflectors and ballasts for fluorescent tubes and behavioral changes such as turning off lights when they are not needed. However, people ascribe a high convenience or security value to keeping lights on.

2.3.5 Cooking

Cooking is one of the basic commercial services entailing energy use. Use of microwave ovens and electric stoves would provide better energy efficiency. Microwaves represent an efficiency gain over the average electric oven of the order of 7 to 10 fold. Most institutional cooking is done with kerosene, LPG or firewood. The use of more efficient stoves and adoption of better cooking habits can substantially reduce energy use.

2.4 Concept of Electrical Loads in Commercial Buildings

A commercial building is defined to mean a building being used for office or commercial purposes such as hotels, shopping plaza, banks, etc. other types such as residential or industrial buildings are not considered although most of the services in a commercial building may also be relevant for the other types of buildings. We need to consider first the types of electrical loads in a commercial building.

2.4.1 Air conditioning load

In a tropical climate such as obtains in Nigeria, most commercial buildings are air-conditioned. The load of the air conditioning system is usually a major portion of the total load. The load in an office complex is roughly 80% of the total load. Therefore, energy conservation measures concerning air conditioning load would have significant impact on the whole, if these leads to substantial savings. Architecture of the building plays a major role in deciding on the most suitable air conditioning system. A modern office building will usually be of the open floor plan system. Here, most office space partitions are not up to ceiling, and the spaces to be air-conditioned can be twenty to thirty meters deep. The usual system adopted is the central air conditioning system covering large spaces such as a whole floor or the entire building. Room units are employed for floor plans where all conditioned by one or a couple of room units which can be easily positioned effectively.

Large open office spaces require considerable time for the system to be effective. In some cases, the time required is two to three hours before the office opens for business. In the typical energy graph, the effective period when the system is supposed to be effective is between 7am and 7pm to allow for staff who report early and those who close late. The system is them effectively shut off for 10 hours

of the day whilst it required two hours to ensure comfortable working environment from 7am when the office is open to staff.

Room units, window or split systems require less time to create comfortable working environment from the time they are switched on. However, for a commercial building, the sheer numbers required make the system unacceptable in a very large building. Water condensation would have to be collected and drained away in several locations that major architectural efforts would have to be put in, to ensure an acceptable system. In addition, the problem of finding space on external walls is a serious limitation apart from the impact these units have on the architecture.

In the central air conditioning system, the chillers or condensing units are usually concentrated in one location such as the roof or on the floor to be air conditioned. In some cases, these loads are supplied at 400v. Thus, the current drawn may be over 100A requiring cables of substantial cross-sections with long lengths. In order to conserve energy, power is supplied at 11kv and then stepped down close to the chillers. For high-rise building uses chillers. For high-rise buildings, these chillers installations are usually located on the roof.

On the other hand, each room unit of a decentralized system is a major load when considered for the building, they form distributed loads with major investments in

cables and control switchgears. Thus, the distribution systems can be quite varied and energy conservation measures must be appropriate for the particular building.

2.4.2 Lighting Load

Lighting load in a commercial building is usually between 5% to 10%. However, lighting loads are usually constant for most of the day and night. Major strides have been taken in the technology of lamps to reduce the load whilst increasing the lighting output. In order to provide light evenly in the building, lighting fittings are distributed thus necessitating cabling all over the building.

2.4.3 Other Electrical Loads

In a commercial building, there are fixed appliances, which require special distribution systems to supply the power required. Others however, are conveniently supplied through convenience outlets. These loads put together can be heavy depending on the facilities installed such as kitchen equipment, heaters, etc.

2.4.4 Data loads

Several services in a commercial building require stable and reliable power supply such as power supply to communication equipment and computers. However, these loads may be between 1% to 5% of the total load of the building. This may in fact

be the tools used in energy conservation for the building. Power supply to this equipment is usually through UPS systems.

2.4.5 Automated Teller Machine (ATM) load

An ATM is a computer terminal activated by a magnetically encoded debit card that allows you to make deposits to and withdrawal from your account, pay bills, and transfer money between your accounts at anytime. ATMs are operated by most commercial banks only and many banks have several ATM conveniently located.

Automated teller machines come in two distinct forms: full function and cash dispenser units. The full function units usually reside at banks, dispense cash, and accept deposits, whereas cash dispensers are found at a variety of locations(convenience stores are the most prevalent) where they only dispense cash. A-10presents ATM energy consumption values from Meyer and Schaltegger (1999) andU.S. ATM manufacturers.

Because of the conventional Cash Dispensing Machine (CDM) system, ATM machines require a lot of power to dispense cash. The system also requires air conditioning, as it consists of a processor and operating system that consume a lot of energy. Generally, a conventional ATM requires around 2,500 watts of power per day (i.e., about 700 watts for the ATM and another 1,800 watts for the air conditioners).

2.4.6 Power Inverter

A power inverter is a type of backup power system. It is a device that is used to convert direct current to alternating current. It works by converting 12 Volt D.C. power into 220 or 240 volts A.C. It is typical application is to convert a battery voltage into conventional household A.C voltage allowing users to use electronic devices when an A.C voltage is not readily available. (PowerStream 2006)

In other instances, a backup power system may need a few minutes to activate, or it may be activated manually as needed. In addition to being used to provide power in an outage, such systems can also be used to save money on energy; for example, people or business activities (Such as banking among others) can use backup power during peak periods, and recharge the backup system during off-peak periods, for lower electrical bills. It is a good idea to research power needs well before they become critical. Some reasons to invest in backup power include: being a business which wants to stay open during outages; using electronic medical devices; working on computers, Powering ATM and wanting to avoid data loss; or simply wanting to enjoy the convenience of electrical power even when the grid is down.

2.5 Energy Conservation in Commercial Buildings

The cost of supplying power to commercial building is high and a lot has gone into various installations to reduce these costs. Many buildings have building

automation systems installed to optimize the supply of electrical power to the building. We shall consider the basic systems that are commonly used.

2.5.1 On-off system

The most basic principle is to switch on any load only when it is required and switch it off when it is not required. All systems for energy conservation employ this principle. Taking lighting load for instance, some or all-artificial lighting can be switched off during daylight accordance to a programme based on set criteria. This can be done manually, especially in the tropical climate when daylight is very much in abundance during the day. However, daylight is also controlled to prevent excessive heat load that can be associated with direct sunlight. On the one hand, direct sunlight is kept out by using window blinds and special glass to reduce heat load. These controls can be carried out manually or automatically.

2.5.2 Reduction of Current Value for the Supply of Energy

Most loads are inductive, especially when electric motors are used and the reactive component of the currents increases the resistive losses in the cables. When the power factor of the load is corrected then a measure of energy conservation is achieved. This is widely used in fluorescent fittings where capacitors are used to improve the low power factor of an ordinary lighting fitting. In commercial building, the number of lighting fitting can be counted in the thousands, although

the reduction of resistive energy loss in the cables is low. It is however a savings, when considered on long-term basis.

Other electrical loads such as compressors usually incorporate power factor correction devices with similar reduction in resistive loses. However, the loads are much larger and the reduction more significant. Many installations also include power factor correction equipment to the power supply in order to reduce the maximum demand from the power supply authorities. This device also conserve energy using solid state digital logic to measure power factor and give instructions for its automatic correction in a rapid and logical step-by-step manner.

2.5.3 Using of Infrared Remote Control for Lighting, Heating and Air-conditioning etc.

The most significant benefit of energy management equipment is the achievement of highly viable energy-saving schemes. Other benefits in the financial areas are in flexibility in office areas, low installation costs and vandal proofing. More benefits that are social are those of security, use by handicapped users and décor control.

A variety of equipment may be switched off on a local or pre-programmed basis using existing wiring. Lighting energy savings can typically be 50% (about 70% was saved in a trial made by the British Department of the Environment), and considerable flexible can be achieved.

When attempting to converse energy, one has to aim to use energy only when and where it is really needed. In the case of lighting, this means ideally the lights should be switched on when each individual needs more light at the particular time and place the person happens to be and that, as he/she moves around, the lighting pattern should immediately respond to the changed circumstances.

A highly flexible and responsive system of control is needed; it should respond to genuine need and yet is easily accepted by the user in his/her daily routine.

Similar control con be extended to other systems such as heating, air conditioning, etc. in these cases, sensors are used to assess the environment and depending on the set levels necessary equipment are switched on or off.

2.5.4 Building Automation

Computerization of the building control systems has made building automation system quite common. Banks, Oil Companies and Multinational corporations have made extensive use of computers in their daily operations. Extensive studies of the routine processes have yielded data that are used to carry out necessary controls of the management of building systems.

2.6 Role of lighting in Energy Consumption and Conservation.

2.6.1 Types of lighting

According to Fördergemeinschaft Gutes Licht (2009), Lighting illuminates rooms and sets the scene for room use; the different types of lighting available provide the tools for doing this. Aside from meeting the requirements of technical and functional regulations, standards and guidelines, good lighting also creates an aesthetically pleasing environment, generates positive moods and promotes a sense of well-being.

The modern working world with its mobile teamwork, recreation zones and flat screen monitors permits and requires new lighting solutions. Designing a lighting system for optimum functionality and aesthetic appeal calls for knowledge of the different types of modern lighting available and the kind of impact they have.

Today, numerous luminaries systems with different lighting characteristics are available for providing good lighting in office and administrative buildings: from the traditional recessed luminaries for direct lighting through direct/indirect surface-mounted, pendant or standard luminaries for variable light distribution to computerized lighting systems.

Major advances in component design have brought about considerable improvements in all luminaries systems in recent years. New electronic ballasts and control systems, reflector materials and lamps make for higher luminous

efficacy, precise optical control, better glare suppression and lower internal power losses. Greater cost efficiency is achieved due to the higher light output ratios of modern types of lighting and marked improvements have been made in convenience and safety.

Selecting the right type of lighting entails striking the right balance between visual performance, visual comfort and visual ambience. It also means meeting the requirements of the technical and statutory regulations governing the lighting levels, harmonious brightness distribution, direct and reflected glare limitation, direction of light, modeling, light colour and colour rendering required for the relevant office activity.

Designing a lighting system calls for detailed specialist knowledge. The expertise and experience of lighting designers and lighting engineers are essential for good results. (Fördergemeinschaft Gutes Licht, 2009)



Figure 2. 1 Direct Lighting

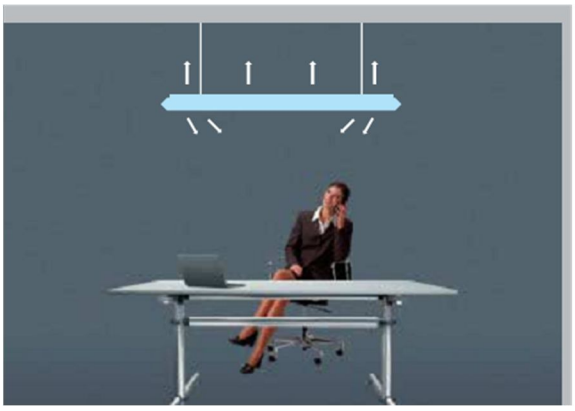


Figure 2. 2 Task Lighting with Special Optical Control

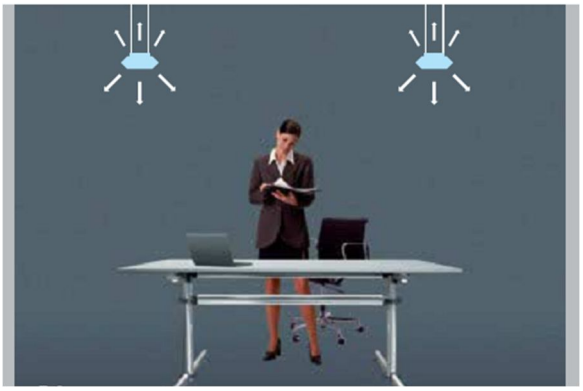


Figure 2. 3 Direct/Indirect Lighting

2.7 Lighting Concept

For office lighting applications, there are three lighting concepts. These concepts are Room-related lighting, Task area lighting and Work surface lighting.(Fördergemeinschaft Gutes Licht, 2009).

2.7.1 Room-related lighting

Uniform lighting throughout the room creating roughly the same visual conditions at all points. This is recommended where the arrangement of task areas is unknown during the planning phase or where the arrangement of task areas needs to be flexible.

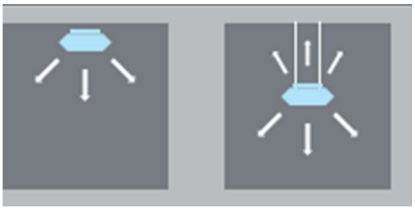


Figure 2.4 Room Related Lighting

2.7.2 Task area lighting

Different lighting for task areas and the space around them. This is recommended where a room contains several task areas, which are used to address different visual tasks and thus have different lighting requirements. It is also an option where visual divisions are needed to identify different workplace clusters.

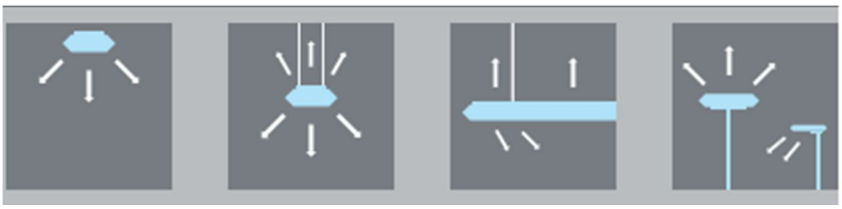


Figure 2.5 Task area lighting

2.7.3 Work surface lighting

Workplace luminaries can be used to supplement “basic lighting” – which can be either room-related or task area lighting – to achieve a level of lighting finely tuned to the requirements of the visual task or to personal needs. DIN 5035-8 sets out requirements/recommendations for workplace luminaries.

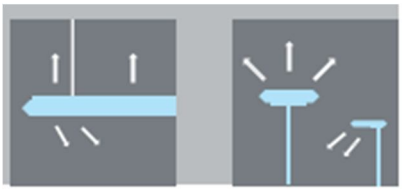


Figure 2. 6 Work surface lighting

2.8 Concept of Electrical Energy Auditing

Energy Audit is the translation of energy conservation ideas into realities by blending technically feasible solutions with economic and other organizational constraints within a specified time frame. It attempts to balance the total input of energy within its use. The type of Energy Audit to be performed depends on:

- The function and type of the industry
- The depth of final Energy Audit needed and
- The potential and magnitude of cost reduction desired

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product or to lower operating costs. Electrical Energy Audit is but a subtask of the General Energy Auditing. However, an Electrical

Energy Audit in isolation can be conducted, but the interactions between electrical energy use and other forms of energy use in the plant and the possible trade-offs between electrical energy and other forms of energy which may result in better overall energy efficiency in the plant may not emerge from such an Electrical Energy Audit. The aim of an exclusive Electrical Energy Audit will be to reduce Specific Electric Energy Consumption per unit product output without increasing the specific energy (other than electrical energy) consumption per unit product output.

The essential aim of EEA is to arrive at concrete project proposals with priority ordering and financial justifications, which if carried out, will result in reduction in Specific Energy Consumption and to monitor the progress and performance of such projects undertaken.

Different steps are to be gone through before the EEA can reach the level of project proposals and recommendations. The first of these will be a Preliminary Audit.

2.8.1 Electrical Auditing Process

An energy audit identifies where energy is consumed and how much energy is consumed in an existing facility, building or structure. Information gathered from the energy audit can be used to introduce energy conservation measures (ECM) or appropriate energy-saving technologies, such as electronic control systems, in the

form of retrofits. Energy audits identify economically justified, cost-saving opportunities that result in significantly lowered electrical, natural gas, steam, water and sewer costs.

An energy audit, therefore, is a detailed examination of a facility's energy uses and costs that generates recommendations to reduce those uses and costs by implementing equipment and operational changes.

An important part of energy auditing is energy accounting/bill auditing. Energy accounting is a process of collecting, organizing and analyzing energy data. For electricity accounts, usage data normally are tracked and should include metered kilowatt-hour consumption, metered peak demand, billed demand, and rate schedules. Similar data are examined for heating fuel and water/sewer accounts.

All of this information can be obtained by analyzing typical energy bills. Creating energy accounting records and performing bill audits can be done internally without hiring outside consulting firms. In addition, while energy audits as a whole will identify excessive energy use and cost-effective conservation projects, bill auditing will assist in identifying errors in utility company bills and beneficial rate and service options. It could provide an excellent opportunity to generate savings without any capital investment. In addition, accurate data from energy accounting/bill auditing is crucial to making informed energy purchasing decisions in a deregulated energy market.

2.8.2 Overview of the Audit Process

Energy auditing evaluates the efficiency of all building components and systems that impact energy use. The audit process begins at the utility meters where the sources of energy coming into a building or facility are measured. Energy flows – inputs and outputs – for each fuel are then identified. These flows are measured and the report should contain documentation of the use and occupancy of the audited buildings, as well as an assessment of the condition of the buildings and the associated systems and equipment. The report also should include recommendations on how to increase energy efficiency through improvements in operation and maintenance (O&M) and installation of energy-saving technologies and energy conservation measures (ECM).Quantified into distinct functions or specific uses, then the function and performance of all building components and systems are evaluated. The efficiency of each of the functions is assessed, and energy and cost-savings opportunities are identified. At the end of the process, an energy audit report is prepared.

2.8.3 Types of Audit

According to Jorge et al (2006), there are three types of audits that are described below in order of increasing degree of detail. The type of audit used is discussed at the preliminary consultation stage. The best way to determine the appropriate type

of audit is to look at the Energy Use Index (EUI) of the facility or building involved.

2.8.3.1 Walk-through audit: This is the least expensive. It involves an examination of the building or facility, including a visual inspection of each of the associated systems. Historic energy usage data are reviewed to analyze patterns of energy use and compare them with sector/industry averages or benchmarks for similar structures. The walk-through audit provides an initial estimate of potential savings and generates a menu of inexpensive savings options usually involving incremental improvements in O&M. Information from this level of audit also serves as a basis for determining if a more comprehensive audit will be needed.

2.8.3.2 Standard Audit: This involves a more comprehensive and highly detailed evaluation. Facilities, equipment, operational systems and conditions are assessed thoroughly and on-site measurements and testing are conducted to arrive at a careful quantification of energy use, including losses. The energy efficiencies of the various systems are determined using accepted energy engineering computational techniques. Technical changes and improvements in each of the systems are analyzed to determine the corresponding potential energy and cost savings. In addition, the standard audit will include an economic analysis of the proposed technological improvements and ECM.

2.8.3.3 Computer Simulation: The computer simulation approach is the most expensive and often is recommended for more complicated systems, structures or facilities. This involves using computer simulation software for prediction purposes (i.e., performance of buildings and systems) and consideration of effects of external factors (e.g., changes in weather another conditions). With the computer simulation audit, a baseline related to facility's actual energy use is established, against which effects of system improvements are compared. This audit often is used for assessing energy performance of new buildings based on different design configurations and equipment packages.

2.8.4 Steps in Energy Auditing

The audit encompasses several steps: preliminary consultation, initial data gathering and assessment, on-site inspection, data analysis and evaluation, and reporting (Jorge et al, 2006). The organization of an energy audit team is a prerequisite to this process.

a. ***Condition survey***: This identifies the most likely locations for the audit, EMOs that could be implemented without further analysis and helps to set priorities for the audit's mandate and scope. It also uses visual inspection of representative areas and equipment. It utilizes checklist for data collection.

b. ***Audit mandate****:* A micro-audit involves a greater level of detail, and its mandate must define the extent of the investigation. This will be driven in part

by the desired level of certainty or, conversely, the uncertainty that can be accepted in the result. The detail required in order to secure financing for proposed measures will need to be provided as well. A micro-audit will often be carried out by an external consultant. In this case, the audit mandate and the subsequent step – developing the audit scope – form an integral part of the consultant's terms of reference.

c. ***Audit scope****:* The micro-audit will often have a scope within the boundaries of a site or within the walls of a building. The scope may be a specific process or piece of equipment. In this situation, defining the audit boundary and the associated energy inputs will be a more difficult undertaking.

d. ***Energy consumption and cost analysis****:* The boundary for a micro-audit may not include utility-metered energy inputs. In some cases, direct measurement of energy inputs may be available from sub-meters for electricity, gas, fuel or steam. In each of these cases, it will be necessary to assess an input cost for each energy form. The incremental or marginal cost may be applied to these inputs.

e. ***Comparative analysis***: The comparative analysis performed in a macro-audit typically deals with monthly utility metered data and impact data. A micro-audit provides an opportunity to perform similar types of analysis on

metered data for individual processes and equipment on a much shorter time scale, possibly weekly or daily.

f. ***Energy use profile****:* The electrical demand profile measured at the service entrance is a common profile used in a macro-audit. Such profiles can be measured for virtually any single electrical load or group of loads. The micro-audit can use detailed profiles to fully describe the operation of many processes, systems or pieces of equipment. More detailed profiles include:

- ✓ Subsystem power (process system, air compressors, refrigeration, etc.)
- ✓ Compressed airflow and pressure
- ✓ Steam flow and pressure
- ✓ Illumination level and occupancy

g. ***Energy use inventory****:* The level of detail to which the inventories are conducted will increase from the macro-audit to the micro-audit. A more detailed breakdown will require more measurements, metering equipment and expertise.

h. ***EMO identification***: The micro-audit mandate and scope may be developed from the list of EMOs and will require further analysis. The micro-audit will further define EMO actions, costs and resulting savings.

i. **Costs and benefits**: A detailed assessment of savings for specific EMOs is usually the primary purpose of the micro-audit. In this case, the macro-audit may

involve a cursory assessment of savings and begin to assemble the data required for more detailed analysis.

j. ***Report for action***: Presenting audit findings in a conventional written report is more appropriate to the tightly focused micro-audit. The contents, including specific data and information arising from the audit, required in a micro-audit report may be specified by the providers of project financing. Such requirements should be clearly specified in the micro-audit mandate.(CIPEC, 2006)

2.8.5 Formula for Calculating Electrical Energy Audit

1. Name an item that uses electricity.
2. How many of those items are there in the audit area?
3. How many hours per day is the item using electricity? (If the item is left on all day and night, count that as 24 hours).
4. Look on the chart or on the item (it should have the Watts labeled on the back or the bottom) to determine how many Watts it uses.
5. How much electricity (in Watt-hours) do all these items use in one day? Multiply how many items are in the audit area (#2), by how many hours the items are on per day (#3) by how many Watts the item uses (#4)? [Formula: (#2) x (#3) x (#4) = Watt-hours]
6. Convert the Watt-hours to kilowatt-hours. Do this by dividing the Watt-hours (#5) by 1000. [Formula: (#5)/1000=kWh]

7. How much electricity (in kilowatt-hours) does the item use per year? Multiply the kilowatt-hours used in a day (#6) by 180 (We are assuming there are 180 days in the school year). [Formula: (#6)/180=kWh]
8. How much does it cost to run the item for one day? Multiply the kilowatt-hours (#6) by unit price of electricity (we are assuming this is the cost of electricity). [Formula: (#6) x (unit price of electricity)= /day

9. How much does it cost to run the item for one year? Multiply the cost per day (#8) by 180. [Formula: (#8) x (180) = /year].(Energy Audit How much electricity do we use?, 2008)

2.9 Energy Efficiency Programme

Energy efficiency does not mean that we should not use energy, but we should use energy in a manner that will minimize the amount of energy needed to provide services. This is possible if we improve in practices and products that we use. If we use energy efficient appliances, it will help to reduce the energy necessary to provide services like lighting, cooling, heating, manufacturing, cooking, transport, entertainment etc. Hence, energy efficiency products essentially help to do more work with less energy. For instance, to light a room with an incandescent light bulb of 60 W for one hour requires 60 W/h (that is 60 watts per hour). A compact fluorescent light bulb would provide the same or better light at 11 W and only use

11 W/h. This means that 49 W (82% of energy) is saved for each hour the light is turned on. (Uyigue et al, 2009).

According to Sambo (2007), Saving Energy Efficiency Programmes will require:

I. Capacity Building Programme

II. Energy Audit/Assessment Programme

III. Energy Pricing/Efficiency Policy

IV. Demand Side Management (DSM)

V. Energy Efficiency Database

VI. Energy Efficiency Awards

CHAPTER THREE

Research Methods

3.1 Research Design.

The study was affected mainly by field survey in which primary data on the subject of interest were obtained through a walk through energy audit (check-list, observation, interview etc). Secondary data from published works, equipment manufacturer's catalogues/manuals and building maintenance records/manuals were also employed.

3.2 Population/Sample Study.

The Commercial Banks in Zaria (12) constitutes the population of the study; out of which four (4) banks were randomly selected for detailed investigation. The four (4) selected banks are; First Bank Plc, United Bank of Africa (UBA) Plc, FinBank Plc and AfriBank Plc.

3.3 Method of Data Collection.

A Walk-through electrical energy audit was employed. In this case, an examination of the building or facility, including a visual inspection of each of the associated systems was carried out. Historical energy usage data were reviewed to analyze

patterns of electrical energy end use and compare them with sector averages or benchmarks for similar structures. (Pages 90 and 92).

3.4 Instruments for Data Sources

The instrument for data collection of this study includes the following:

I. Check lists (Page136)
II. Observation
III. Interview
IV. Questionnaire (Page 136)

3.5 Method of Data Analysis

In order to obtain the best possible result, two methods of data analysis were employed for this study. They are Component Bar Charts using Microsoft excel and One-way Analysis of Variance (ANOVA).Table 4.4

*i) Component Bar Chart***:** Component bar charts were used in presenting the results obtained in order to allow for pictorial and simple visual analysis of the data. It helped to identified trends and anomalies in historical data for energy used (Figures 4.1 – 4.4).

ii) One-way ANOVA: The One-way ANOVA was used in testing the hypothesis as described below. It provided a means of establishing real targets based upon existing consumption pattern;

Hypothesis: Types of electrical appliance in use is one of the sources of variation in the level of electrical energy consumption (Table 4.5).

H_0: There is no significant difference in the energy consumption of electrical appliances between the four (4) Bank buildings.

3.5.1 Energy Audit Procedures

The audit consists of three distinct steps: preliminary data collection and evaluation, site visit, and analysis and reporting. An estimate of the time for each step was made. Allocating time for each step leads to a more comprehensive and useful audit report. The following sections describe the tasks associated with each step of the audit process.

The first task was to collect and review one (1) year worth of utility energy data for all fuels and electricity (Table 4.2). This information was used to analyze operational characteristics, calculate energy benchmarks for comparison to industry averages, estimate savings potential, set an energy reduction target, and establish a baseline to monitor the effectiveness of implemented measures.

Several steps have been taken to ensured of having all the information required to do a thorough and accurate evaluation of energy consumption data.

i. Copies of all monthly utility bills was received (for all meters) and delivered fuel invoices.

ii. Sort utility bills by building or by meter and organize them into 12-months blocks using the meter-read dates.

iii. Determined which building or space is served by which meter.

iv. The floor area (in square metre) for each building was calculated.

Tables and Bar charts to enter, sum, and calculate benchmarks and to graph utility information. Record energy units (kWh, litres etc.), electric demand (kW), and cost for each fuel type. Units of operation (number of units, occupied rooms, bank operational schedules etc.) were also included when energy use depends on bank buildings operational hours. Relationships between energy use and those factors that drive energy were determined by analyzing the data. Some of these factors include occupancy, operational hours, floor area, and outdoor temperatures

3.5.2 Computation of Energy Consumption

i) Energy Consumed

The energy consumed is calculated using the formula in chapter two (2.8.5). This formula is given by:

$$E_C = \frac{N \times H \times W \times D}{1000}$$

Where E_c = Energy consumed

N = No. of items

H = Hours per day of use of the item

W = Watt of the item

D = Number of days

The result of the calculation of this work is shown in Appendix I.

ii) Values Used

Cost of one kWh = ₦8.50

Cost of one litre of Diesel (AGO) = ₦90.00

CHAPTER FOUR

Data Presentation, Analysis and Discussion

4.1 The Bank Units and Operating Schedules

The Four Bank buildings with an approximate total area of 566M^2 (First Bank) 499 M^2 (UBA) 536 M^2 (FinBank) and 647 M^2 (AfriBank); it is made up of several rooms of various sizes depending on the level activities as well as number of occupants.

Table 4. 1 The Bank units and its operating schedules.

Area/Zone	Floor Area(M^2)			
	First Bank	**UBA**	**FinBank**	**AfriBank**
Banking Hall	105	100	100	154
Manager's Office	55	48	45	50
Manager's Secretary Office	35	40	25	30
Strong Room	40	38	25	35
Computer Room	40	35	45	25
Computer Room Corridor	NIL	NIL	30	NIL
Counting Room	50	35	45	60
Marketing Section	40	NIL	40	NIL
Mosque	NIL	NIL	NIL	40
General Toilet	50	38	35	45
Auditor's Office	35	NIL	35	NIL
Stationary Store	36	30	25	35
Scrap Furniture Store	NIL	NIL	NIL	75
Generator Room	40	45	50	55
ATM Room	20	20	16	18
Gateman Room	20	20	20	25
Total	**566**	**499**	**536**	**647**

Source: Field work 2008

The banking hall has largest area within the bank buildings as per table 4.1 above while the sizes of other operational areas are specified in the table 4.1 above. The Bank Buildings are open for business from Monday to Friday as from 7.00 am to 6.00 pm but customers services are usually terminated at 4.00pm. The ATM services and Gateman room are under special services of the banking operations and are open for customers from Monday to Sunday for 24 hours daily.

4.2 Electrical Energy Consumption Pattern (PHCN Bills & Generator Fuel Used) in the Four (4) Bank Buildings.

The energy audit result shows on table 4.5 below, the consumed electrical energy (PHCN Bills & Generator Diesel Used) of the four (4) bank buildings for one calendar year. Data collected includes both the PHCN and fossil fuel generator consumption and cost for the study period from March 2007 to February 2008.

Table 4. 2 Electrical Energy Consumed per Month and Cost for the Four (4) Bank Buildings

Electrical Energy Consumption and Cost								
	FinBank Building		AfriBank Building		UBA Building		First Bank Building	
Month	Consumption(kWh)	Cost(₦.K)	Consumption(kWh)	Cost(₦.K)	Consumption(kWh)	Cost(₦.K)	Consumption(kWh)	Cost(₦.K)
March 2007	18675	158,737.50	25226	214,421.00	21950	186,579.25	25349	215,466.50
April 2007	17576	149,396.00	24940	211,990.00	21258	180,693.00	21381	181,738.50
May 2007	16121	137,028.50	23914	203,269.00	20018	170,148.80	26252	223,142.00
June 2007	16961	144,168.50	23516	199,886.00	20239	172,027.30	21878	185,963.00
July 2007	14229	120,946.50	17076	145,146.00	15653	133,046.30	16753	142,400.00
Aug. 2007	12740	108,290.00	18114	153,969.00	15427	131,129.50	14410	122,485.00
Sept. 2007	14781	125,638.50	24673	209,720.50	19727	167,679.50	20817	176,944.50
Oct. 2007	9276	78,846.00	9854	83,759.00	9565	813,02.50	100180	851,500.00
Nov. 2007	13514	114,869.00	15460	131,410.00	14487	1231,39.50	14589	124,006.50
Dec 2007	11787	100,189.50	13450	114,325.00	12619	1,072,57.30	12639	107,431.50
Jan 2008	9830	83,555.00	10162	86,377.00	9996	84,966.00	8931	75,913.50
Feb 2008	9830	83,555.00	12892	109,582.00	11361	96,568.50	12298	104,533.00
TOTAL	**165320**	**1,405,219.50**	**219277**	**1,863,854.50**	**192299**	**1,634,537.00**	**205315**	**1,745,177.50**

Source: Field work 2008

The energy consumed per month were converted to cost (₦.K) based on the earlier estimated PHCN tariff and generator's fossil fuel cost of ₦8.50 per kWh and ₦90.00 per liter of diesel respectively.

These make it possible to compare the energy consumed with the actual energy supposed to be consumed based on manufacturer's nameplate, in order to establish waste or otherwise. Table 4.3 show the comparison for the four bank buildings studied. (Page 82)

4.3 The Relationship between Energy Consumed and the Actual Electrical Loads Profile.

4.3.1 FinBank

Fig 4.1 shows the difference between energy consumed and the actual electrical load profile for the four banks. It can be seen that there is a great disparity between the electricity consumed and the actual electrical load for all the banks. Fig 4.1 shows that for FinBank, whereas the consumed was fluctuating, the actual is constant. The highest power was consumed in March (18,675 kWh), followed by April (17,576 kWh), then May (16,121 kWh). June (16,961 kWh) however recorded a slightly higher consumption rate. July and August continued the downward trend (14,229 kWh and 12,740kWh respectively), September recorded an increase (14,781 kWh) as October had a significant drop (9,276kWh). Nevertheless, November, December and January decreased continually (13,514 kWh, 11,787 kWh and 9,830 kWh) and it was

maintained in February (9,830 kWh). This fluctuation can be attributed to the seasonal changes in weather as it relates to the use of the office appliances.

4.3.2 AfriBank

From Fig. 4.2, the highest power was consumed in March (25,226 kWh), followed by April (24,940 kWh), then September (24,673 kWh). May and June recorded 23,914 and 23,516 kWh respectively. However there was a significant drop in July (17,076 kWh) with a slight increase in August (18,114 kWh).October (9,854 kWh) the least, nonetheless, November, December and January decreased continually (15,460 kWh, 13,450 kWh and 10,162 kWh respectively) and it finally increased in February (12,892 kWh). All this fluctuations can be attributed to the seasonal changes in weather as it relates to the use of the office appliances.

4.3.3 UBA

Fig 4.3 shows the difference between energy consumed and the actual electrical load profile for the four banks. It can be seen that there is a great disparity between the electricity consumed and the actual electrical load for all the banks. Fig 4.3 shows that for FinBank, whereas the consumed was fluctuating, the actual is constant. The highest power was consumed in March (21,950kWh), followed by April (20,018kWh), then May (20,239kWh). June (20,239kWh) however recorded a slightly higher consumption rate. July and August continued the downward trend (15,653kWh and 15,427.00kWh respectively); September recorded an increase

(19,727 kWh) as October had a significant drop (19,565 kWh). Nevertheless, November, December and January decreased continually (14,487 kWh, 12,619 kWh and 10,996 kWh) and it was maintained in February (11,361 kWh). This fluctuation can be attributed to the seasonal changes in weather as it relates to the use of the office appliances.

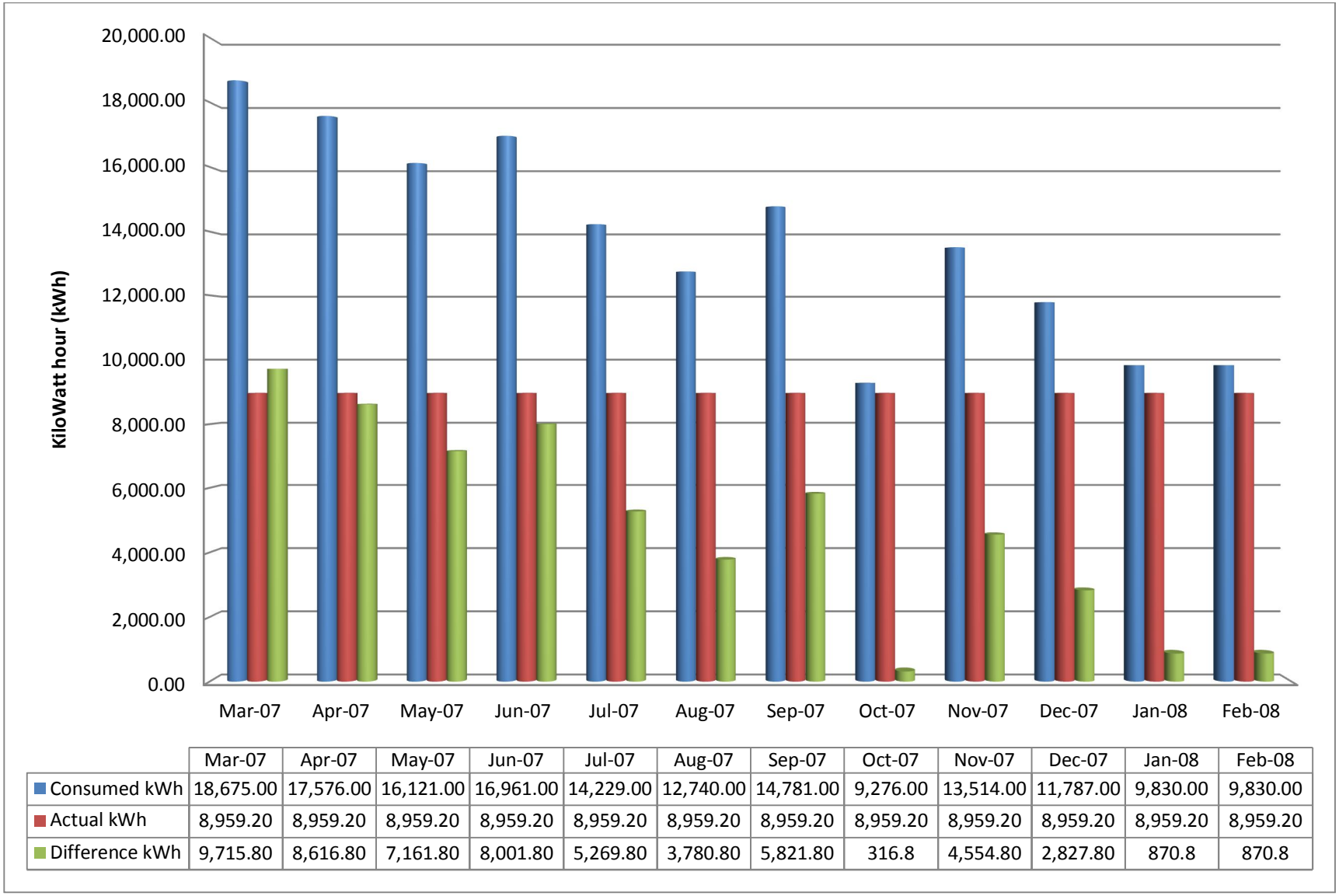
4.3.4 First Bank

Fig 4.4 shows the difference between energy consumed and the actual electrical load profile for the four banks. It can be seen that there is a great disparity between the electricity consumed and the actual electrical load for all the banks. Fig 4.4 shows that for FinBank, whereas the consumed was fluctuating, the actual is constant. The highest power was consumed in May (26,252 kWh), followed by March (25,349 kWh), then June (21,878 kWh). April however recorded (21,381 kWh). July and August continued the downward trend (16,753 kWh and 14,410.00kWh respectively), September recorded an increase (20,817 kWh) as October had a fairly significant drop (15,180kWh). Nevertheless, November,and December January decreased continually (14,589kWh, and13,639kWh) while a slight increase in January (13,298kWh)and finally a drop to18,931kWh in February. This fluctuation can be attributed to the seasonal changes in weather as it relates to the use of the office appliances.

Table 4. 3 Difference between Energy Consumed with Actual Electrical load Profile

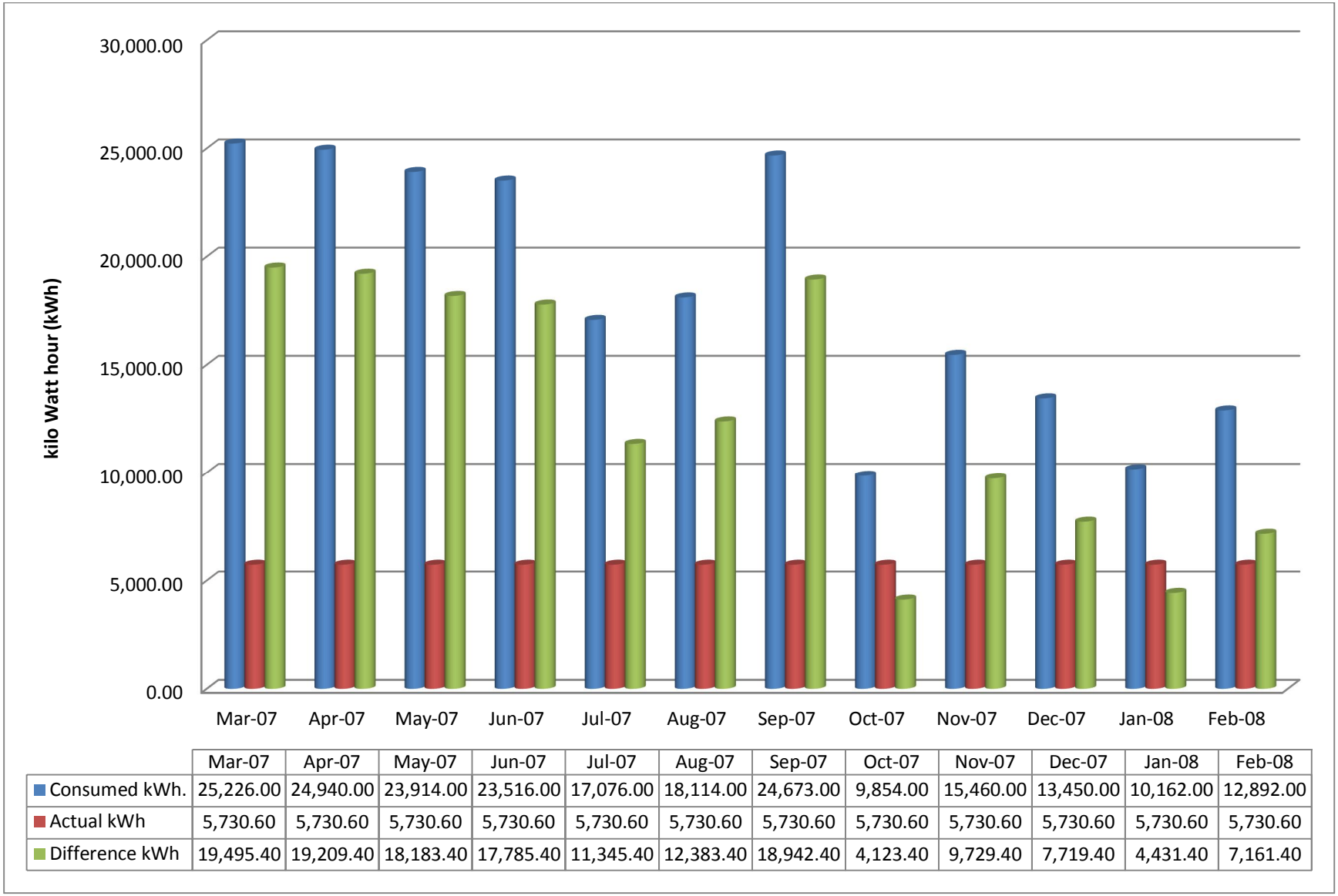
	FinBank				AfriBank				UBA				First Bank			
Month	**Consumed**	**Actual**	**Difference**		**Consumed**	**Actual**	**Difference**		**Consumed**	**Actual**	**Difference**		**Consumed**	**Actual**	**Difference**	
	kWh	**kWh**	**kWh**	**₦.K**	**kWh**	**kWh**	**kWh**	**₦.K**	**kWh**	**kWh**	**kWh**	**₦.K**	**kWh.**	**kWh**	**kWh**	**₦.K**
March 2007	18,675.00	8,959.20	9,715.80	82,584.30	25,226.00	5,730.60	19,495.40	165,710.90	21,950.00	9,588.20	12,361.00	105,068.50	25,349.00	11,098.40	14,250.60	121,130.10
April 2007	17,576.00	8,959.20	8,616.80	73,242.80	24,940.00	5,730.60	19,209.40	163,279.90	21,258.00	9,588.20	11,669.80	99,193.30	21,381.00	11,098.40	10,282.60	87,402.10
May 2007	16,121.00	8,959.20	7,161.80	60,875.30	23,914.00	5,730.60	18,183.40	154,558.90	20,018.00	9,588.20	10,429.80	88,563.30	26,252.00	11,098.40	15,153.60	128,805.60
June 2007	16,961.00	8,959.20	8,001.80	68,015.30	23,516.00	5,730.60	17,785.40	151,175.90	20,239.00	9,588.20	10,650.80	90,531,80	21,878.00	11,098.40	10,779.60	91,626.60
July 2007	14,229.00	8,959.20	5,269.80	44,783.30	17,076.00	5,730.60	11,345.40	96,435.90	15,653.00	9,588.20	6,064.80	51,550.80	16,753.00	11,098.40	5,654.60	48,064.10
Aug 2007	12,740.00	8,959.20	3,780.80	32,136.80	18,114.00	5,730.60	12,383.40	105,258.90	15,427.00	9,588.20	5,838.80	49,629.80	14,410.00	11,098.40	3,311.60	28,148.60
Sept 2007	14,781.00	8,959.20	5,821.80	49,485.30	24,673.00	5,730.60	18,942.40	161,010.40	19,727.00	9,588.20	10,138.80	86,179.80	20,817.00	11,098.40	9,718.60	82,608.10
Oct 2007	9,276.00	8,959.20	316.80	2,692.80	9,854.00	5,730.60	4,123.40	35,048.90	19,565.00	9,588.20	9,976.80	84,802.80	15,180.00	11,098.40	4,081.60	34,693.60
Nov 2007	13,514.00	8,959.20	4,554.80	38,715.80	15,460.00	5,730.60	9,729.40	82,699.90	14,487.00	9,588.20	4,898.80	41,639.80	14,589.00	11,098.40	3,490.60	29,670.10
Dec 2007	11,787.00	8,959.20	2,827.80	24,036.30	13,450.00	5,730.60	7,719.40	65,614.90	12,619.00	9,588.20	3,030.80	25,761.80	13,639.00	11,098.40	2,540.60	21,595.10
Jan 2008	9,830.00	8,959.20	870.80	7,401.80	10,162.00	5,730.60	4,431.40	37,666.90	10,996.00	9,588.20	1,407.80	11,966.30	18,931.00	11,098.40	7,832.60	66,577.10
Feb 2008	9,830.00	8,959.20	870.80	7,401.80	12,892.00	5,730.60	7,161.40	60,871.90	11,361.00	9,588.20	1,772.80	15.068.8	13,298.00	11,098.40	2,199.60	18,696.60
Total	**165,320.00**	**107,510.40**	**57,809.60**	**491,381.60**	**219,277.00**	**68,767.20**	**150,509.80**	**1,279,333.30**	**203,300.00**	**115,058.40**	**88,240.80**	**749,945.80**	**222,477.00**	**133,180.80**	**89,296.20**	**759,017.70**

Source: Field work 2008



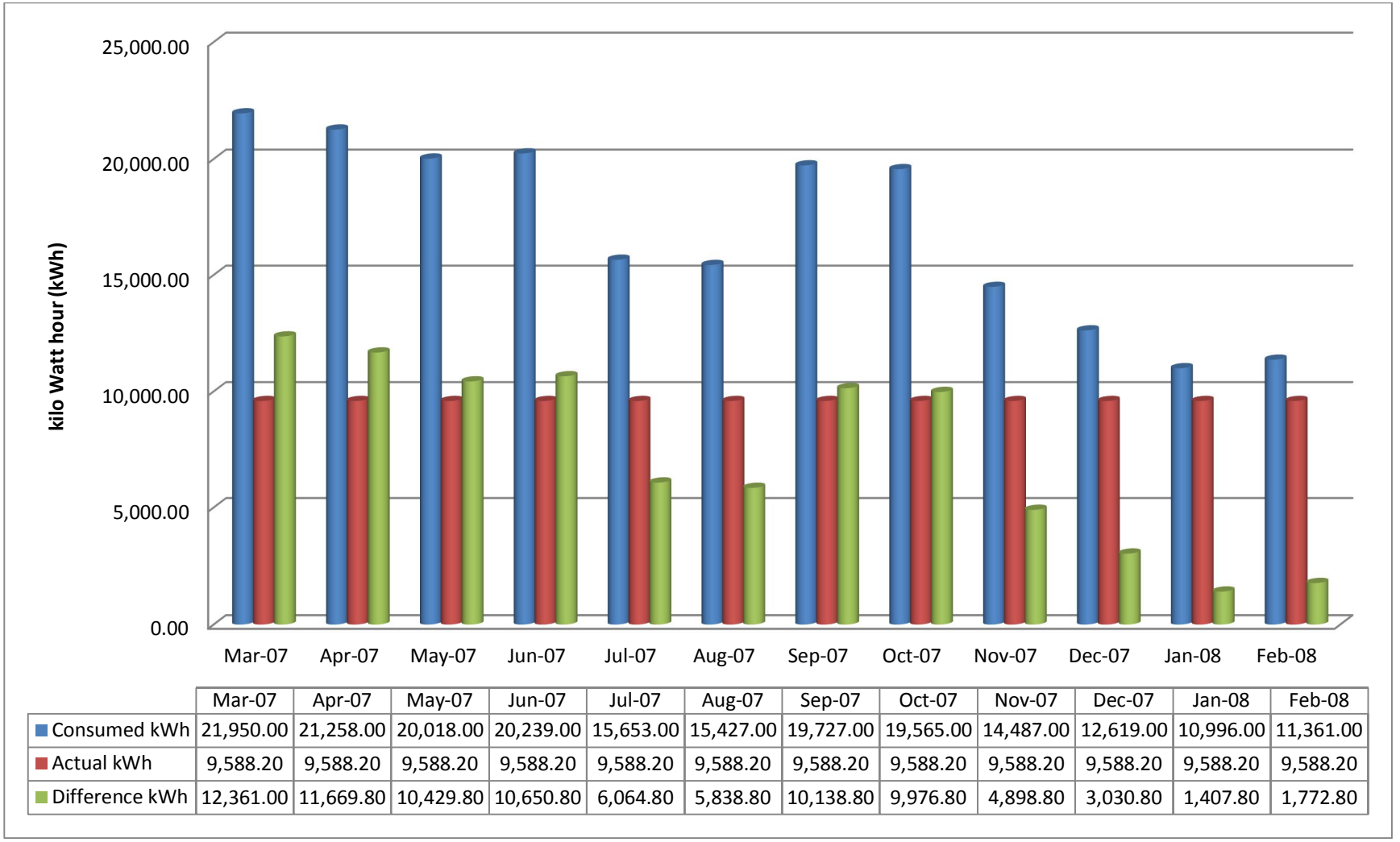
	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
Consumed kWh	18,675.00	17,576.00	16,121.00	16,961.00	14,229.00	12,740.00	14,781.00	9,276.00	13,514.00	11,787.00	9,830.00	9,830.00
Actual kWh	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20	8,959.20
Difference kWh	9,715.80	8,616.80	7,161.80	8,001.80	5,269.80	3,780.80	5,821.80	316.8	4,554.80	2,827.80	870.8	870.8

Figure 4. 1 Difference between Energy Consumed with Actual Electrical load Profile of FinBank



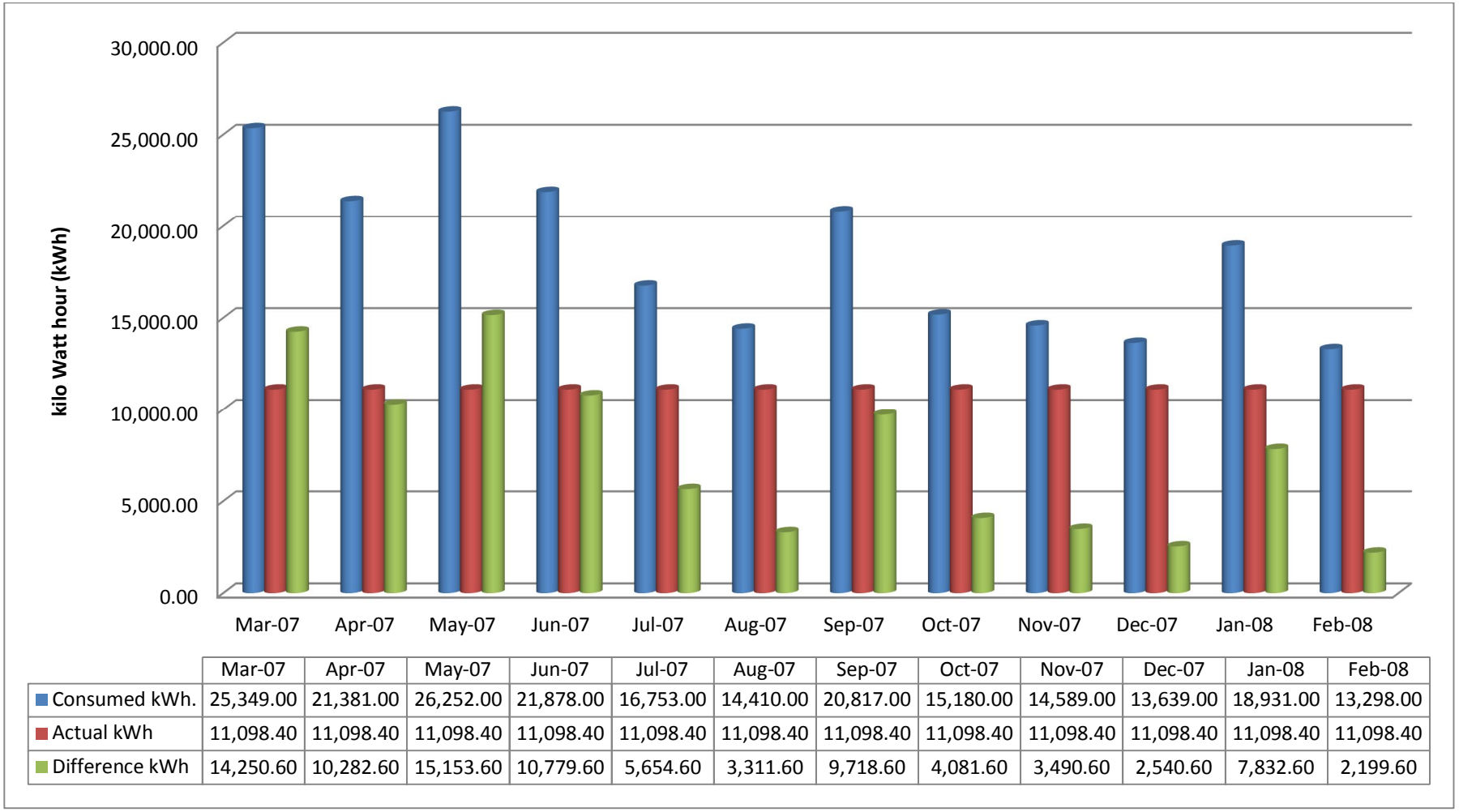
	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
Consumed kWh.	25,226.00	24,940.00	23,914.00	23,516.00	17,076.00	18,114.00	24,673.00	9,854.00	15,460.00	13,450.00	10,162.00	12,892.00
Actual kWh	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60	5,730.60
Difference kWh	19,495.40	19,209.40	18,183.40	17,785.40	11,345.40	12,383.40	18,942.40	4,123.40	9,729.40	7,719.40	4,431.40	7,161.40

Figure 4. 2 Difference between Energy Consumed with Actual Electrical load Profile AfriBank



	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
Consumed kWh	21,950.00	21,258.00	20,018.00	20,239.00	15,653.00	15,427.00	19,727.00	19,565.00	14,487.00	12,619.00	10,996.00	11,361.00
Actual kWh	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20	9,588.20
Difference kWh	12,361.00	11,669.80	10,429.80	10,650.80	6,064.80	5,838.80	10,138.80	9,976.80	4,898.80	3,030.80	1,407.80	1,772.80

Figure 4. 3 Difference between Energy Consumed with Actual Electrical load Profile UBA



	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
Consumed kWh.	25,349.00	21,381.00	26,252.00	21,878.00	16,753.00	14,410.00	20,817.00	15,180.00	14,589.00	13,639.00	18,931.00	13,298.00
Actual kWh	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40	11,098.40
Difference kWh	14,250.60	10,282.60	15,153.60	10,779.60	5,654.60	3,311.60	9,718.60	4,081.60	3,490.60	2,540.60	7,832.60	2,199.60

Figure 4. 4 Difference between Energy Consumed with Actual Electrical load Profile FirstBank

Based on the differences obtain from the table and figures above, the researcher was able to established a waste of 57,809.60 kWh and ₦ 491,381.60 at FinBank Building, 150,509.80 kWh and ₦ 1,279,333.30 at AfriBank Building88,240.80 kWh and ₦ 749,945.80 at UBA and 89,296.20 kWh and ₦ 759,017.70 at FirstBank, thus this called for immediate need for redesigning the systems, thus lighting and cooling systems consumed outright kWh in order to retrofit with the more energy efficient system for saving cost and reducing carbon emission for better climatic conditions.

4.4 One-way Analysis of Variance (One-way ANOVA)

One-way analysis of variance is the scheme of classification according to a factor that measures the variability of a mean of different functions and establishes whether to accept or reject hypothesis. The condition was chosen with respect to basic data and working conditions for this study.

Test to hypothesis with respect to basic data

Table 4. 4 One-Way ANOVA: Energy consumed versus actual electrical load profile of FinBank

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	171958807.4	3	57319602	2.783749	0.051901	2.816465817
Within Groups	905995060.5	44	20590797			
Total	1077953868	47				

Source: Field work 2008

Decision rule: Using the above One-Way ANOVA result, we conclude based on the decision rule earlier described in the methodology that, since the calculated F value (for both FinBank, AfriBank, UBA and First Bank) is less than the F-critical, the null hypothesis is accepted. This implies that there is nosignificant difference in the energy consumption of electrical appliances between the four (4) Bank buildings.

4.5 Re-Design and Retrofitting of Lighting Systems in the Four(4) Bank Buildings.

Lighting represents about 13% of the electricity consumption in a commercial bank buildings establishment, not including its impact on cooling loads. Lighting retrofits can save 30 to 50 percent of lighting energy as well as 10 to 20 percent of cooling energy. In high-bay areas like banking hall with ceiling heights greater than 10 meters, efficient linear fluorescent lighting, either T5 or high performance T8 lamps, can reduce energy consumption by 35% or more compared to T12 lighting. Furthermore, cooling system is by far the largest load in a bank building, representing an average of 43% of bank building electricity usage. Significant energy savings can be gained not only from regular cooling system tune-ups and maintenance but also through retrofits and cost-effective replacement of older cooling system equipment.

4.5.1 FinBank Building Lighting System and Energy Consumed.

The bank building has 20 and 40 watts linear fluorescent tubes (T12) inductive Choke type, incandescent filament bulbs (60-200 watt), and halogen filament lamp (1500 watt). These lighting appliances are used for indoor lighting; outdoor security lighting and outside sign post lighting. In addition, Mercury linear fluorescent tubes 40 watts inductive choke type (T12) is used at the cashier's desk for detecting of fake currency notes. The summary of the number used and location is as shown in Page 82

a) Economic Appraisal:

i) Energy Saving After Retrofit:

After redesigning and retrofitting of the lighting system of the bank building with energy saving compact fluorescent Lamp (CFL) model T8 as shown from Table 4.4 above the total energy saving per month is 1465.2 kWh and cost of ₦12,454.20.

ii) Simple Payback Period:

Total Cost saved per month = ₦12,454.20

Cost of Retrofitting = ₦500,000.00

Pay Back Period = Cost of Retrofitting ÷ Total Cost Saved per month

Pay Back Period = 500,000.00 ÷ 12,454.20 = **40 Months.**

4.5.2 AfriBank Building Lighting System and Energy Consumed.

The bank building has 20watts and 40 watts Linear Fluorescent Tubes (T12) inductive Choke type, incandescent filament bulbs (60-200 watt), and halogen filament lamp (1500 watt). These lighting appliances are used for indoor lighting; outdoor security lighting and outside sign post lighting. In addition, Mercury Linear Fluorescent tubes 40watts, inductive choke type (T12) are used at the cashier's desk for detecting of fake currency notes. The summary of the number used and location are as shown in Page 82.

a) Economic Appraisal:

i) Energy Saving After Retrofit:

After redesigning and retrofitting of the lighting system of the bank building with energy saving Compact Fluorescent Lamp (CFL) model T8 as shown from Table 4.4 above the total energy saving per month is 1030.32 kWh and cost of ₦8,575.72.

ii) Simple Payback Period:

Total Cost saved per month = ₦8,575.72

Cost of Retrofitting = ₦450,000.00

Pay Back Period = Cost of Retrofitting ÷ Total Cost Saved per month

Pay Back Period = 450,000.00 ÷ 8,575.72 = **52 Months**.

4.5.3 UBA Building Lighting System and Energy Consumed.

The bank building has majorly 40 watts linear fluorescent tubes (T12) inductive Choke type, incandescent filament bulbs with rating between 60-200 watt, and halogen filament lamp (1500 watt). These lighting appliances are used for indoor lighting; outdoor security lighting and outside sign post lighting. In addition, Mercury linear fluorescent tubes 60 watts inductive choke type (T12) is used at the cashier's desk for detecting of fake currency notes.

4.5.4 First Bank Building Lighting System and Energy Consumed.

First bank building has a combination of both 20 and 40 watts linear fluorescent tubes (T12) inductive Choke type, incandescent filament bulbs (60-200 watt), and halogen filament lamp (1500 watt). These lighting appliances are used for indoor lighting; outdoor security lighting and outside sign post lighting. In addition, Mercury linear fluorescent tubes 40 watts inductive choke type (T12) is used at the cashier's desk for detecting of fake currency notes

4.6 Analysis of Energy Consumed by Cooling System of the Four(4) Bank Buildings .

4.6.1 FinBank Building Cooling System (HVAC) and Energy Consumed.

The building has thirteen (13) wall mounted split units air conditioning systems as shown from the Table 4.6 below: The space cooling in the bank building works by electrical energy; it covers about three quarter of the total volume.

Table 4. 2 FinBank Building Cooling System and Actual Rated Energy per Usage.

Cooling System and Actual Rated Energy Usage Within Bank Building

Location	Specification	Qty	Rating(w)	Existing Duty Cycle/Month (hrs)	Total Load(kWh)
Banking Hall	LG – 2hp (Split Unit)	7	1221	240	2051.20
Manager office	LG – 2hp (Split Unit)	1	1221	240	293.04
Manager's Secretary Office	National – 2hp (Split Unit)	1	1221	240	293.04
Counting Room	National – 2hp (Split Unit)	1	1221	240	293.04
Computer Room	National – 2hp (Split Unit)	1	1221	240	293.04
Marketing Office	National – 2hp (Split Unit)	1	1221	240	293.04
Auditor's office	LG – 2hp (Split Unit)	1	1221	240	293.04
ATM room	LG – 2hp (Split Unit)	2	1221	240	586.08
	TOTAL				**4,395.52**

Source: Field work 2008

These units are used to cooling the building space during the hot period of the year (i.e. March, April, May, June and July). The energy consumption in the system could be estimated by calculating the difference of energy average consumption from winter to summer.

The average electrical energy consumption in Cold season (without operating cooling system) could be taken as the average of consumption between Hot and Cold seasons.

Table 4. 3 Electrical Energy Consumed in Cold (Harmattan) and Hot Seasons.

Hot Season			Cold Season (Harmattan)		
Month	**Consumption (kWh)**	**Cost (₦.K)**	**Month**	**Consumption (kWh)**	**Cost (₦.K)**
March	18,675	619,752.00	October	9,276	78,846,00
April	17,576	149,396.00	November	13,514	114,869.00
May	16,121	137,028.50	December	11,787	100,189.50
June	16,961	144,168.50	January	9,830	83,555.00
July	14,229	120,946.50	February	9,830	83,555.00
TOTAL	**83562**	**710,277.00**		**54237**	**461,014.50**

Source: Field work 2008

Therefore: Average Electrical Energy Consumption in Cold Season (Harmattan): Cooling System not fully operational.

$\Rightarrow$ 54237 ÷ 5 = 10,847.4 kWh/Month

$\Rightarrow$ 461,014.50 ÷ 5 = ₦ 92,202.90/Month

Average Electrical Energy Consumption in Hot Season (Cooling System fully operational)

$\Rightarrow$ 83562 ÷ 5 = 16,712.4 kWh/Month

$\Rightarrow$ 710,277.00 ÷ 5 = ₦142, 055.40/Month

Now the difference between these averages equals the space cooling consumption of the building:

$\Rightarrow$ 16712.4 – 10847.4 = 5,865 kWh/Month

The average space cooling system cost = ₦142, 055.40 – ₦ 92,202.90 = ₦49, 852.50/Month

4.6.2 AfriBank Building Cooling System (HVAC) and Energy Consumed.

The building has nine (9) wall mounted split units air conditioning systems as shown from the Table 4.8 below: The space cooling in the bank building works by electrical energy; it covers about three quarter of the total volume.

Table 4. 4 AfriBank Building Cooling System and Actual Rated Energy per Usage.

Cooling System and Actual Rated Energy Usage Within Bank Building					
Location	**Specification**	**Qty**	**Rating (w)**	**Existing Duty Cycle /Month (hrs)**	**Total Load (kWh)**
Banking Hall	LG – 2hp (Split Unit)	6	1221	240	2051.20
Manager office	LG – 2hp (Split Unit)	1	1221	240	293.04
Manager's Secretary Office	National – 2hp (Split Unit)	1	1221	240	293.04
Counting & Computer Room	National – 2hp (Split Unit)	1	1221	240	293.04
ATM room	National – 2hp (Split Unit)	2	1221	240	586.08
	TOTAL				**3,316.40**

Source: Field work 2008

These units are used to cooling the building space during the hot period of the year (i.e. March, April, May, June and July). The energy consumption in the system could be estimated by calculating the difference of energy average consumption from Cold to Hot season.

The average electrical energy consumption in cold season (without operating cooling system) could be taken as the average of consumption between hot and cold seasons.

Table 4. 5 Electrical Energy Consumed in cold and hot seasons.

Hot Season			Cold Season(Harmattan)		
Month	**Consumption (kWh)**	**Cost (₦.K)**	**Month**	**Consumption (kWh)**	**Cost (₦.K)**
March	25,226	214,421.00	October	9,854	83,759.00
April	24,940	211,990.00	November	15,460	131,410.00
May	23,914	203,269.00	December	13,450	114,325.00
June	23,516	199,886.00	January	10,162	86,377.00
July	17,076	145,146.00	February	12,892	109,582.00
TOTAL	**114,672**	**974,712.00**		**61,818**	**525,453.00**

Source: Field work 2008

Therefore: Average Electrical Energy Consumption in Cold Season (Cooling System not operational).

$\Rightarrow$ 61,818 ÷ 5 = 12,363.6 kWh/Month

$\Rightarrow$ 525,453.00 ÷ 5 = ₦ 105,090.60/Month

Average Electrical Energy Consumption in Hot Season (Cooling System fully operational).

$\Rightarrow$ 114,672 ÷ 5 = 22,934.4 kWh/Month

$\Rightarrow$ 974,712.00 ÷ 5 = ₦194, 942.40/Month

Now the difference between these averages equals the space cooling consumption of the building:

$\Rightarrow$22,934.4 – 12,363.6 = 10,570.80 kWh/Month

The average space cooling system cost = ₦194, 942.40 – ₦ 105,090.60 = ₦89, 851.80/Month

4.6.3 UBA Building Cooling System (HVAC) and Energy Consumed.

The building has thirteen (13) wall mounted split units air conditioning systems as shown from the Table 4.6 below: The space cooling in the bank building works by electrical energy; it covers about three quarter of the total volume.

Table 4. 6 UBA Building Cooling System and Actual Rated Energy per Usage.

Cooling System and Actual Rated Energy Usage Within Bank Building

Location	Specification	Existing			
		Qty	Rating (w)	Duty Cycle /Month (hrs)	Total Load (kWh)
Banking Hall	Samsung – 1.5hp (Split Unit)	9	1221	240	2637.36
Manager office	Samsung – 2hp (Split Unit)	1	1221	240	293.04
Manager's Secretary Office	National – 2hp (Split Unit)	1	1221	240	293.04
Counting Room	National – 2hp (Split Unit)	1	1221	240	293.04
Computer Room	National – 2hp (Split Unit)	2	1221	240	586.08
Marketing Office	National – 2hp (Split Unit)	1	1221	240	293.04
Auditor's office	LG – 2hp (Split Unit)	1	1221	240	293.04
ATM room	LG – 2hp (Split Unit)	2	1221	240	586.08
	TOTAL				**5,274.72**

Source: Field work 2008

These units are used to cooling the building space during the hot period of the year (i.e. March, April, May, June and July). The energy consumption in the system could be estimated by calculating the difference of energy average consumption from winter to summer.

The average electrical energy consumption in Cold season (without operating cooling system) could be taken as the average of consumption between Hot and Cold seasons.

Table 4. 7 Electrical Energy Consumed in Cold (Harmattan) and Hot Seasons.

Hot Season			Cold Season (Harmattan)		
Month	**Consumption (kWh)**	**Cost (₦.K)**	**Month**	**Consumption (kWh)**	**Cost (₦.K)**
March	21,950	186,575.00	October	19,565	78,846,00
April	21,258	180,693.00	November	14,487	114,869.00
May	20,018	170,153.50	December	12,619	100,189.50
June	20,239	172,031.50	January	10,996	83,555.00
July	15,653	133,050.50	February	11,361	83,555.00
TOTAL	**99,118**	**842,503.00**		**69,028**	**586,738.00**

Source: Field work 2008

Therefore: Average Electrical Energy Consumption in Cold Season (Harmattan): Cooling System not fully operational.

⇒69,028.00÷ 5 = 13,805.60 kWh/Month

⇒ 586,738.00 ÷ 5 = ₦117,347.60/Month

Average Electrical Energy Consumption in Hot Season (Cooling System fully operational)

⇒99,118.00÷ 5 = 19,823.60 kWh/Month

⇒842,503.00÷ 5 = ₦168,500.60/Month

Now the difference between these averages equals the space cooling consumption of the building:

⇒19,823.60 – 13,805.6 = 6,018.00 kWh/Month

The average space cooling system cost = ₦168,500.60 – ₦117,347.60= ₦51,153.00/Month

4.6.4 First Bank Building Cooling System (HVAC) and Energy Consumed.

The building has thirteen (13) wall mounted split units air conditioning systems as shown from the Table 4.6 below: The space cooling in the bank building works by electrical energy; it covers about three quarter of the total volume.

Table 4. 8 First Bank Building Cooling System and Actual Rated Energy per Usage.

Cooling System and Actual Rated Energy Usage Within Bank Building					
Location	**Specification**	**Existing**			
		Qty	**Rating (w)**	**Duty Cycle /Month (hrs)**	**Total Load (kWh)**
Banking Hall	LG – 2hp (Split Unit)	11	1221	240	3223.44
Manager office	LG – 2hp (Split Unit)	1	1221	240	293.04
Manager's Secretary Office	National – 2hp (Split Unit)	2	1221	240	586.08
Counting Room	National – 2hp (Split Unit)	2	1221	240	586.08
Computer Room	National – 2hp (Split Unit)	1	1221	240	293.04
Marketing Office	National – 2hp (Split Unit)	1	1221	240	293.04
Auditor's office	LG – 2hp (Split Unit)	1	1221	240	293.04
ATM room	LG – 2hp (Split Unit)	2	1221	240	586.08
	TOTAL				**6,153.84**

Source: Field work 2008

These units are used to cooling the building space during the hot period of the year (i.e. March, April, May, June and July). The energy consumption in the system could be estimated by calculating the difference of energy average consumption from winter to summer.

The average electrical energy consumption in Cold season (without operating cooling system) could be taken as the average of consumption between Hot and Cold seasons.

Table 4. 9 Electrical Energy Consumed in Cold (Harmattan) and Hot Seasons.

Hot Season			Cold Season (Harmattan)		
Month	**Consumption (kWh)**	**Cost (₦.K)**	**Month**	**Consumption (kWh)**	**Cost (₦.K)**
March	25,349	619,752.00	October	15,180	78,846,00
April	21,381	149,396.00	November	114,589	114,869.00
May	26,252	137,028.50	December	13,639	100,189.50
June	21,878	144,168.50	January	18,931	83,555.00
July	16,753	120,946.50	February	13,298	83,555.00
TOTAL	**111,613**	**948,710.50**		**75,637**	**642,914.50**

Source: Field work 2008

Therefore: Average Electrical Energy Consumption in Cold Season (Harmattan): Cooling System not fully operational.

⇒75,637÷ 5 = 15,127.40 kWh/Month

⇒642,914.50 ÷ 5 = ₦128,582.80/Month

Average Electrical Energy Consumption in Hot Season (Cooling System fully operational)

⇒111,613÷ 5 = 22,322.64 kWh/Month

⇒ 948,710.50 ÷ 5 = ₦189,742.10/Month

Now the difference between these averages equals the space cooling consumption of the building:

⇒22,322.64 – 15,127.40 = 7,195.24 kWh/Month

The average space cooling system cost = ₦189,742.10– ₦128,582.80= ₦61,159.30/Month

Table 4. 10 Cooling System Energy Use Analysis of the Four (4) Bank Buildings

Energy Use of Analysis of the Cooling System for the Bank Buildings				
Location	**Cooling System Energy Use**		**Savings(Waste) Energy/Month**	
	Consumed Energy (kWh)	**Actual Rated Energy (kWh)**	**kWh**	**₦.K**
FinBank Building	5,865.00	4,395.52	1,469.48	12,490.58
AfriBank Building	10,570.80	3,316.40	7,254.40	61,662.40
UBA Building	6,018.00	5,274.72	743.28	6,317.88
First Bank Building	7,195.24	6,153.84	1,041.40	8,851.90

Source: Field work 2008

In the diagnosis phase, it was noticed that the thermostat setting (temperature control) was set on 16°C at both the bank buildings inspected and it is too low; on the other hand the temperature of the cooled space was about 28° C; this means there was a large amount of air leakage in the buildings because of windows not properly closed/sealed or open doors for longer period. Also, noticed during the inspection was the movement of unrestricted stream of hot air from the not air-conditioned zones (e.g. toilets, corridor, etc.) to the air-conditioned zones (e.g. banking hall) within the buildings.

Saving could be achieved by increasing the temperature of the thermostat setting as per manufacturer's operation manual. The energy saving opportunity is very attractive because it could be done without any initial investment cost and the

SPBP is immediate. The above saving from table 4.10 saves considerable amount of kg $C0_2$ that translates to reduction in greenhouse gas emission to the atmosphere.

CHAPTER FIVE

Summary, Conclusion and Recommendation

5.1 Summary

Detail literature review, scrutiny of utilities bills and energy audits has enabled electrical energy efficiency improvement of commercial buildings were conducted. The study shows the electrical energy efficiency of some selected bank buildings in Zaria is not dependent on the capacity or size of buildings/equipment. The study could be summarized as follows:-

5.1.1 Bank Units and Operating Schedules

The study revealed that the four (4) bank buildings have an average floor area of 562$M^2$and Banking Hall having the largest floor area within operational units of the bank building with an average area of 114.75M2. The bank buildings open for business for 8 hours daily for 5 days of a week which translates to 20 days in a month with 240 days in a year inclusive of public holidays (i.e. less than 240 days in a year).However, the operational hours for ATM services and security units within the bank buildings are 24 hours per day.

5.1.2 Electrical Energy Consumption Pattern in the Four (4) Bank Buildings

The pattern of electrical energy consumption of the bank buildings is largely dependant on the occupancy, seasonal operational changes, and good maintenance culture for buildings/equipment. The four (4) bank buildings have an average electrical energy consumption of 195,552.75 Kwh per year with an

average cost of ₦1,662,197.13. The average electrical energy consumption for the cooling Systems, Lighting systems and Plug loads are 14,928,50 kWh/year, 7120 kWh/year and 14,754 kWh/year respectively.

5.1.3 The Relationship between Energy Consumed and the Actual Electrical Load Profile of the Four (4) Bank Buildings

The study shows that there are large disparities between consumed and actual electrical energy in the bank buildings. The consumed energy is based on utilities bills/invoices of electricity purchased from PHCN and fuel purchased for on-site electricity generation. The tabulation of actual electrical energy is based on the audit carried out on the manufacturer's nameplate for the electrical equipment/appliances in the buildings. The study also established that there is an average electrical energy wastage from the four (4) bank buildings of 96,464.10 Kwh and ₦819,919.60 per year.

5.1.3 One-Way Analysis of Variance (One-Way ANOVA)

The study concluded that the patterns of electrical energy consumption are the same between the four (4) bank buildings as per one-way analysis of variance (one-way ANOVA).However; there are areas of electrical energy wastage from the individual bank building.

5.1.4 Re-Design and Retrofitting of Lighting Systems in the Four (4) Bank Buildings

The study established that the bank buildings are fitted with obsolete lighting system with high energy consumption (i.e. T12 inductive choke type fluorescent tubes, incandescent filament bulbs, Halogen filament lamps & Mercury linear fluorescent lamps).The retrofitting to modern technologically energy saving lighting system is to saved energy/ cost(i.e. energy saving compact fluorescent lamp(CFL) model T5 and T8).The study established an average cost saving of 35% from lighting retrofitting in the banking hall of the bank buildings where floor to ceiling height are greater 10 metres. Furthermore, economic appraisal on lighting system retrofitting carried on four (4) bank buildings revealed an average energy saving of 8038.68 Kwh with average cost saving of N68,326.64 per month. Also, the established total average cost of retrofitting of ₦637,500.00 with an average pay back period of 10 months.

5.1.5 Analysis of Energy Consumed by Cooling System of the Four(4) Bank Buildings

The study established that the cooling system of the bank buildings represents an average of 43% of total electrical energy consumption. The bank buildings uses wall mounted split units air conditioning system (1.5 – 2 horse power compressor). Significant energy savings can be gained not only from regular cooling system tune-up and maintenance but also through retrofit building

components and cost-effective replacement of older cooling system equipment. The energy consumption for cooling of the bank buildings are at its highest peak during the Hot season from March to July while the energy consumption drops during the cold season(Harmattan) from October to February. The average electrical energy consumption and cost for the four (4) bank buildings are 7,412.26 kWh/month and ₦63,004.14/months. Also, the average electrical energy and cost savings after retrofitting and replacement of older cooling system equipment/improved operational control are 2,627.14 kWh/month and ₦22,330.69/month.

5.1 Conclusion

5.2.1 The study revealed that 14,917.5 kWh of electrical energy is required for cooling of an average area of 114.75 $M^2$of banking hall at effective temperature of 20 ◦c and cost N126,798,75 per year. The electrical energy required for cooling of one (1) $M^2$of floor area in the Banking Hall at effective temperature of 20 ◦c is 130 kWh per year and cost ₦1,105.00. The operational hours and working characteristics of banking Hall is quite different from all other rooms within the bank building. Also, the number of air-conditioning units (split type) installed at the banking hall are too many compared to unit performance specified by the manufacturer. However, there are opportunities of energy saving by addressing the problem of discrepancies that exists between measured energy consumed and estimated

energy (actual) consumed by the cooling systems. The setting of air conditioning unit compressor at economy mode will improve compressor's efficiency in order to reduce the parasitic energy consumption of the system. More leakages of conditioned air have been discovered in rooms with non insulated Walls, through open corridors to hot zones and non continuous closed door.

5.2.2 The average electrical energy consumption for the cooling Systems, Lighting systems and Plug loads are 14,928,50 kWh/year, 7120 kWh/year and 14,754 kWh/year respectively. The research work established that different energy consumption/ cost as a result of variation in basic building data and working characteristics of the rooms within the bank building. The Highest electrical energy consumption within the bank building is from the banking hall where almost all the banking activities are carried out. The banking hall required bright lighting for handling of documents by both large population of customers and bank staff, effective temperature cooling to create conducive working environment and the banking hall accommodates 70% of plug loads in the bank building.

5.2.3 The study established that there is an average electrical energy wastage from the four (4) bank buildings of 96,464.10 Kwh and ₦819,919.60 per year, which translates to up to 35% of total energy usage. The established energy wastage is as a result of discrepancies between consumed and actual electrical energy use by the lighting system, cooling system and plug loads.

The differences between the consumed and actual energy are termed as waste energy or saving. The waste energy is as a result of problems associated with occupancy, seasonal operational changes and maintenance/operational practices.

5.2.4 The actual electrical energy estimation is based on the audit carried out on the manufacturer's nameplate for electrical equipment/appliances in the buildings. The study concluded that the patterns of electrical energy consumption are the same between the four (4) bank buildings as per one-way analysis of variance (one-way ANOVA).However, there are areas of electrical energy wastage from the individual bank building. The study shows that there are large disparities between consumed and actual electrical energy in the bank buildings. The consumed energy is based on utilities bills/invoices of electricity purchased from PHCN and fuel purchased for on-site electricity generation.

5.1.5 The study established an average cost saving of 35% from lighting retrofitting in the banking hall of the bank buildings where floor to ceiling height are greater 10 metres. Furthermore, economic appraisal on lighting system retrofitting carried on four (4) bank buildings revealed an average energy saving of 8038.68 Kwh with average cost saving of ₦68,326.64 per month. Also, the total average cost of retrofitting of ₦637,500.00 with an average pay back period of 10 months.

5.1.6 The study established that the bank buildings are fitted with obsolete lighting system with high energy consumption (i.e. T12 inductive choke type fluorescent tubes, incandescent filament bulbs, Halogen filament lamps & Mercury linear fluorescent lamps).The retrofitting to modern technological energy saving lighting system will save energy and cost(i.e. energy saving compact fluorescent lamp (CFL) model T5 and T8).

5.1.7 The energy consumption for cooling of the bank buildings are at its highest peak during the Hot season from March to July while the energy consumption drops during the cold season(Harmattan) from October to February. The average electrical energy consumption and cost for the four (4) bank buildings are 7,412.26 kWh/month and ₦63,004.14/months. Also, the average electrical energy and cost savings after retrofitting and replacement of older cooling system equipment/improved operational control are 2,627.14 kWh/month and ₦22,330.69/month. The study established that the cooling system of the bank buildings represents an average of 43% of total electrical energy consumption. The bank buildings uses wall mounted split units air conditioning system (1.5 – 2 horse power compressor). Significant energy savings can be gained not only from regular cooling system tune-up and maintenance but also through retrofit building components and cost-effective replacement of older cooling system equipment.

5.3 Recommendations

Based on the third objective and the findings from this study, an energy efficiency programme for the commercial bank buildings is recommended as follows:

i. Replace incandescent lights with compact fluorescent lights (CFLs) or light-emitting diodes (LEDs) for desk lamps and overhead lighting. Using CFLs instead of comparable incandescent bulbs can save about 50% on your lighting costs.
ii. Switch off all unnecessary lights.
iii. Use dimmers, motion sensors, or occupancy sensors to automatically turn off lighting when not in use to reduce energy use and costs.
iv. Turn off lights when you leave at night.
v. Use natural lighting or day lighting. When feasible, turn off lights near windows
vi. Use task lighting; instead of brightly lighting an entire room, focus the light where you need it, to directly illuminate work areas.
vii. Close or adjust window blinds to block direct sunlight to reduce cooling needs during warm months. Overhangs or exterior window covers are most effective to block sunlight on south-facing windows.

viii. In the winter months, open blinds on south-facing windows during the day to allow sunlight to naturally heat your workspace. At night, close the blinds to reduce heat loss.

ix. Unplug equipment that drains energy when not in use (i.e. cell phone chargers, fans, coffeemakers, desktop printers, radios, etc.).

x. Replace desktop computers with thin clients or notebook computers and docking stations.

xi. Replace cathode ray tube (CRT) monitors with LED or liquid crystal display (LCD) monitors.

xii. Turn off your computer and monitors at the end of the work day, if possible. If you leave your desk for an extended time, turn off your monitor. (See Office Equipment.)

xiii. Turn off photocopier at night or purchase a new copier with low standby feature. Purchase printers and fax machines with power management feature and use it.

xiv. Coordinate with vending machine vendor to turn off advertising lights.

xv. Have a qualified professional perform an energy audit. Check with your utility company for names of qualified auditors.

xvi. Ensure HVAC ductwork/evaporator to condenser pipes is well insulated and replace dust filters regularly as recommended.

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APPENDIX I

Energy Audit Results of FinBank Building, Zaria

Banking Hall - Appliances Rating and Electricity Consumption for FinBank Building

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦:K
1	Lighting Fluorescent Tube (2ft)	100	20	2000	12	24	204:00
2	Mercury Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
3	Fax Machine	1	105	105	12	1.26	10:71
4	Air Conditioning Unit(2HP)	7	1221	8547	12	102.56	871:76
5	Computer(Monitor + CPU)	7	230	1610	12	19.32	164:22
6	Computer UPS	7	130	910	12	10.92	92:82
7	Printer	2	320	640	10	6.4	54:40
8	Photo Coping Machine	1	1500	1500	10	1.5	12:75
9	Computer Scanner	1	60	60	8	0.48	4:08
10	Money Counting Machine	3	300	900	8	7.2	61:20
11	Television Set	1	108	108	12	1.296	11:01
12	Hot & Cool Water Machine	1	1000	1000	10	10	85:00
13	Automatic Electric Door	2	1500	3000	10	30	255:00
14	Stamping Machine	2	108	216	10	2.16	18:36
	TOTAL			20836		220	1869:79

Source: Field study 2011

APPENDIX II

Manager and Secretary's Office - Appliances Rating & Electricity Consumption (FinBank Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Lighting Filament Lamp	2	100	200	12	2.4	20.40
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	2	230	460	12	5.52	46:92
5	Computer UPS	2	130	260	12	3.12	26:52
6	Television Set	1	108	108	12	1.296	11:01
7	PBAX Exchange Machine	1	120	120	10	1.2	10:20
	Total			3830		45.716	388:58

Source: Field study 2011

APPENDIX III

Strong Room - Appliances Rating & Electricity Consumption (FinBank Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Lighting Filament Lamp	3	100	300	12	3.6	30.60
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Industrial UPS	1	2400	2400	12	28.80	244.80
5	CCTV Receiver	1	130	130	10	1.30	11:05
6	V-Sat Receiver	1	180	180	12	2.16	18:36
7	Money Counting Machine	1	300	300	10	3	25:50
8	Fridge	1	450	450	24	10.8	91:50
	TOTAL			6442		81.84	695:28

Source: Field study 2011

APPENDIX **IV**

Marketing and Auditor's Offices - Appliances Rating & Electricity Consumption (FinBank Building)

S/N	Appliances	Qty	Rating(W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	2	230	460	12	5.52	46:92
5	Computer UPS	2	130	260	12	3.12	26:52
6	CCTV	1	108	108	12	1.296	11:01
	TOTAL			3510		42.116	357:98

Source: Field study 2011

APPENDIX v

Bank's Compound Facility and Security Lighting - Appliances Rating & Electricity Consumption (FinBank Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	16	40	640	12	7.68	65:28
2	Lighting Filament Lamp	7	100	700	12	8.4	71:40
3	Lighting Halogen Lamp	2	1500	3000	12	36	306:00
	Total			4340		52.08	442:68

Source: Field study 2011

APPENDIX VI

Overall Electricity Load Evaluation of the Bank Building(FinBank)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (2ft)	100	20	2000	12	24	204:00
2	Lighting Fluorescent Tube (4ft)	34	40	1360	12	16.32	138:72
3	Lighting Filament Lamp	12	100	1200	12	14.4	122:40
4	Lighting Halogen Lamp	2	1500	3000	12	36	306:00
5	Mercury Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
6	Fax Machine	1	105	105	12	1.26	10:71
7	Air Conditioning Unit(2HP)	13	1221	15,873	12	190.50	1619:25
8	Computer(Monitor + CPU)	12	230	2760	12	33.12	281:52
9	Computer UPS	12	130	1560	12	18.72	159:12
10	Printer	2	320	640	10	6.4	54:40
11	Photo Coping Machine	1	1500	1500	10	1.5	12:75
12	Computer Scanner	1	60	60	8	0.48	4:08
13	Money Counting Machine	3	300	900	8	7.2	61:20
14	Television Set	2	108	216	12	2.16	22:02
15	Hot & Cool Water Machine	1	1000	1000	10	10	85:00
16	Automatic Electric Door	2	1500	3000	10	30	255:00
17	Stamping Machine	2	108	216	10	2.16	18:36
18	PBAX Exchange Machine	1	120	120	10	1.2	10:20
19	Industrial UPS	1	3200	3200	12	38.40	326:40
20	CCTV Receiver	1	130	130	12	1.56	13:26
21	V-Sat Receiver	1	180	180	12	2.16	18:36
22	CCTV	1	108	108	12	1.296	11:01
	TOTAL			39304		442	3758:24

Source: Field study 2011

APPENDIX VII

Percentage of Energy Consumption in the Building(FinBank)

S/N	Building Section	Total Power(w)	KWh	Energy Cost ₦:K	%
1	Banking Hall	20836	220	1889:79	50
2	Manager & Secretary's Offices	3830	45.716	388.58	10
3	Strong room, Counting room, Computer room & Corridor	6442	81.84	695.28	19
4	Marketing & Auditor's Offices	3510	42.116	357.98	9
5	Other Bank's Facility & Security Lighting	4340	52.08	442.68	12
	TOTAL	39304	442	3758:24	100

Source: Field study 2011

APPENDIX VIII

Summary of Load Evaluation for Electricity/Fuel Rating &Equivalent (kWh) Per Principal Services in the Bank building(FinBank).

S/N	Fuel Type/Element	Rating Units kWh	Equivalent kWh	Percentage (%)
	Electricity			
1	Lighting	7980	7980	19
2	Cooling/air-conditioning systems	15,873	15,873	38
3	Equipment & others	16,890	16,890	41
	Generator Fuel	**Litre**		
4	Diesel	75	750	2
	TOTAL		42,013	100

Source: Field study 2011

APPENDIX IX

Actual Meter Reading Values & Cost for Bank Building for one year (FinBank)

S/N	DATE	Monthly Meter Reading			Monthly Energy Cost Including 5% VAT
		Last Reading(kWh)	New Reading(kWh)	Monthly Value(kWh)	
1	March 2007	184023	184718	675	11,032.88
2	April 2007	184718	185794	1076	13,950.30
3	May 2007	185794	186915	1121	14,093.43
4	June 2007	186915	187876	961	13,165.43
5	July 2007	187876	188605	729	9,645.83
6	August 2007	188605	189345	740	10,468.50
7	September 2007	189345	190629	1284	15,565.20
8	October 2007	190629	190905	276	7,122.00
9	November 2007	190905	191519	614	8,619.45
10	December 2007	191519	192306	787	10,887.98
11	January 2008	192306	193136	830	11,271.75
12	February 2008	193136	193443	307	7,182.00
13	March 2008	193443	193831	388	7,326.90

Source: PHCN 2011 Zaria Office.

APPENDIX X

Energy Audit Results of AfriBank Building ZariaBanking Hall
Appliances Rating & Electricity Consumption

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N:K
1	Lighting Fluorescent Tube (2ft)	72	20	1440	12	17.28	146:88
2	Lighting Fluorescent Tube(4ft)	4	40	160	12	1.92	16:32
3	Mercury Fluorescent Tube (4ft)	3	40	120	10	1.20	10:20
4	Air Conditioning Unit(2HP)	6	1221	7326	12	87.91	747:24
5	Computer(Monitor + CPU)	11	230	2530	12	30.36	258:06
7	Printer	2	320	640	10	6.4	54:40
8	Photo Coping Machine	1	1500	1500	10	15	127:50
9	Computer Scanner	1	60	60	8	0.48	4:08
10	Money Counting Machine	2	300	600	8	4.8	40.80
11	Television Set	2	108	216	12	2.529	21:50
12	Radioscopic Machine	1	80	80	4	0.8	6.80
13	Laminating Machine	1	1500	1500	4	6	51:00
	TOTAL			16172		174.68	1484:70

Source: Field study 2011

APPENDIX XI

Manager and Secretary's Office Appliances Rating & Electricity Consumption (AfriBank)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (2ft)	12	20	240	12	2.88	24:48
2	Lap-Top Computer	1	105	105	10	1.05	8:295
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	1	230	230	12	2.76	23:46
5	Printer	1	320	320	10	3.2	27:20
6	Television Set	1	108	108	12	1.296	11:01
7	Hot Water Kettle	1	1500	1500	8	12	102:00
8	Electric Typewriter	1	150	150	4	0.6	5.1
	TOTAL			5095		53	450:60

Source: Field study ,2011

APPENDIX XII

Strong room, Counting room, Computer room & Corridor
Appliances Rating & Electricity Consumption (AfriBank)

S/N	Appliances	Qty	Rating(W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Standing Fan	1	50	50	12	0.5	0.425
3	Air Conditioning Unit(2HP)	1	1221	1221	12	14.65	124.53
4	Central UPS	1	3200	3200	12	38.4	326:40
6	V-Sat Receiver	1	180	180	12	2.16	18:36
7	Money Counting Machine	4	300	1200	10	12	102:002
	TOTAL			6091		70.59	596:20

Source: Field study 2011

APPENDIX XIII

Other Bank Facility & Security Lighting
Appliances Rating & Electricity Consumption(AfriBank)

S/N	Appliances	Qty	Rating(W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (2ft)	8	20	160	12	1.92	23.04
2	Lighting Fluorescent Tube (4ft)	17	40	680	12	8.16	69:36
3	Lighting Filament Lamp	10	60	600	12	7.2	61:20
5	Lighting Halogen Lamp	1	1500	1500	12	18	153.00
	TOTAL			2940		35.28	306:60

Source: Field study 2011

APPENDIX XIV

Overall Electricity Load Evaluation in the Bank Building(Afribank)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (2ft)	92	20	1840	12	22.08	187:68
2	Lighting Fluorescent Tube (4ft)	27	40	1080	12	12.96	110:06
3	Lighting Filament Lamp	10	60	60	12	1.2	10:20
4	Lighting Halogen Lamp	1	1500	1500	12	18	153:00
5	Mercury Fluorescent Tube (4ft)	3	40	120	12	1.2	10:20
6	Standing Fan	1	50	50	10	0.5	4.25
7	Air Conditioning Unit(2HP)	9	1221	10,989	12	131.86	1120.81
8	Computer(Monitor + CPU)	12	230	2760	12	33.12	281:52
9	Radioscopic Machine	1	80	80	4	0.32	2:72
10	Printer	3	320	960	10	11.52	97:92
11	Photo Coping Machine	1	1450	1450	10	14.5	123:25
12	Computer Scanner	1	60	60	8	0.48	4:08
13	Money Counting Machine	6	300	1800	8	9.6	81:61
14	Television Set	2	108	216	12	2.16	22:02
15	Hot Water Kettle	1	1500	1500	4	6	51:00
16	Lap-Top Computer	1	105	105	4	0.42	3:57
17	V-Sat Receiver	1	150	150	12	1.8	15:30
18	Electric Type Writer	1	150	150	4	0.6	5:10
19	Central UPS	1	3200	3200	12	38.40	326:40
	TOTAL			29540		333.55	2835:18

Source: Field study 2011

APPENDIX XV

Percentage (%) Load Evaluation for the Bank Building

Percentage of Energy Consumption in the Building(AfriBank)

S/N	Building Section	Total Power(w)	KWh	Energy Cost ₦:K	%
1	Banking Hall	16172	174.68	1484.70	52
2	Manager & Secretary's Offices	5095	53	450.60	16
3	Strong room, Counting room, Computer room & Corridor	6091	70.59	596.20	21
4	Other Bank's Facility & Security Lighting	2940	35.28	306.60	11
	TOTAL	29540	333.55	2835:18	100

Source: Field study 2011

APPENDIX XVI

Summary of Electricity/Fuel Rating & Equivalent (kWh) Per Principal Services in the Bank building &Surrounding (AfriBank).

S/N	Fuel Type/Element	Rating Units kWh	Equivalent kWh	Percentage (%)
	Electricity			
1	Lighting	5,260	5,260	17
2	Cooling/air-conditioning systems	10,984	10,984	36
3	Equipment & others	13,519	13,519	44
	Generator Oil			
4	Diesel	100	1000	3
	TOTAL		30,763	100

Source: Field study 2011

APPENDIX XVII

Actual Meter Reading Values & Cost in the bank Building for one year (AfriBank)

S/N	DATE	Monthly Meter Reading			Monthly Energy Cost Including 5% VAT
		Last ReadingkWh)	New Reading(kWh)	Monthly Value(kWh)	
1	March 2007	18062	19788	1726	20,717.50
2	April 2007	19788	21728	1940	24,076.50
3	May 2007	21728	23642	1914	23,844.45
4	June 2007	23642	27158	3516	38,142.30
5	July 2007	27158	29234	2076	23,841.30
6	August 2007	29234	31348	2114	24,904.95
7	September 2007	31348	34021	2673	28,686.53
8	October 2007	34021	34879	858	12,467.65
9	November 2007	34879	36539	1660	20,370.00
10	December 2007	36539	37989	1450	19,220.25
11	January 2008	37989	39151	1162	14,959.35
12	February 2008	39151	40043	892	13,274.10
13	March 2008	40043	41102	1059	14,523.08

APPENDIX XIX

Energy Audit Results of UBA Building, Zaria

Banking Hall - Appliances Rating and Electricity Consumption for UBA Building

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦:K
1	Lighting Fluorescent Tube (2ft)	100	20	2000	12	24	204:00
2	Mercury Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
3	Fax Machine	1	105	105	12	1.26	10:71
4	Air Conditioning Unit(2HP)	7	1221	8547	12	102.56	871:76
5	Computer(Monitor + CPU)	7	230	1610	12	19.32	164:22
6	Computer UPS	7	130	910	12	10.92	92:82
7	Printer	2	320	640	10	6.4	54:40
8	Photo Coping Machine	1	1500	1500	10	1.5	12:75
9	Computer Scanner	1	60	60	8	0.48	4:08
10	Money Counting Machine	3	300	900	8	7.2	61:20
11	Television Set	1	108	108	12	1.296	11:01
12	Hot & Cool Water Machine	1	1000	1000	10	10	85:00
13	Automatic Electric Door	2	1500	3000	10	30	255:00
14	Stamping Machine	2	108	216	10	2.16	18:36
	TOTAL			20836		220	1869:79

Source: Field study 2011

APPENDIX XX

Manager and Secretary's Office - Appliances Rating &Electricity Consumption (UBA Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Lighting Filament Lamp	2	100	200	12	2.4	20.40
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	2	230	460	12	5.52	46:92
5	Computer UPS	2	130	260	12	3.12	26:52
6	Television Set	1	108	108	12	1.296	11:01
7	PBAX Exchange Machine	1	120	120	10	1.2	10:20
	Total			3830		45.716	388:58

Source: Field study 2011

APPENDIX XXI

Strong & Counting Rooms - Appliances Rating & Electricity Consumption (UBA Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Lighting Filament Lamp	3	100	300	12	3.6	30.60
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Industrial UPS	1	2400	2400	12	28.80	244.80
5	CCTV Receiver	1	130	130	10	1.30	11:05
6	V-Sat Receiver	1	180	180	12	2.16	18:36
7	Money Counting Machine	1	300	300	10	3	25:50
8	Fridge	1	450	450	24	10.8	91:50
	TOTAL			6442		81.84	695:28

Source: Field study 2011

APPENDIX XXII

Marketing and Auditor's Offices - Appliances Rating & Electricity Consumption (UBA Building)

S/N	Appliances	Qty	Rating(W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	2	230	460	12	5.52	46:92
5	Computer UPS	2	130	260	12	3.12	26:52
6	CCTV	1	108	108	12	1.296	11:01
	TOTAL			3510		42.116	357:98

Source: Field study 2011

APPENDIX XXIII

Bank's Compound Facility and Security Lighting - Appliances Rating & Electricity Consumption (UBA Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	16	40	640	12	7.68	65:28
2	Lighting Filament Lamp	7	100	700	12	8.4	71:40
3	Lighting Halogen Lamp	2	1500	3000	12	36	306:00
	Total			4340		52.08	442:68

Source: Field study 2011

APPENDIX XXIV

Overall Electricity Load Evaluation of the Bank Building (UBA).

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (2ft)	100	20	2000	12	24	204:00
2	Lighting Fluorescent Tube (4ft)	34	40	1360	12	16.32	138:72
3	Lighting Filament Lamp	12	100	1200	12	14.4	122:40
4	Lighting Halogen Lamp	2	1500	3000	12	36	306:00
5	Mercury Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
6	Fax Machine	1	105	105	12	1.26	10:71
7	Air Conditioning Unit(2HP)	13	1221	15,873	12	190.50	1619:25
8	Computer(Monitor + CPU)	12	230	2760	12	33.12	281:52
9	Computer UPS	12	130	1560	12	18.72	159:12
10	Printer	2	320	640	10	6.4	54:40
11	Photo Coping Machine	1	1500	1500	10	1.5	12:75
12	Computer Scanner	1	60	60	8	0.48	4:08
13	Money Counting Machine	3	300	900	8	7.2	61:20
14	Television Set	2	108	216	12	2.16	22:02
15	Hot & Cool Water Machine	1	1000	1000	10	10	85:00
16	Automatic Electric Door	2	1500	3000	10	30	255:00
17	Stamping Machine	2	108	216	10	2.16	18:36
18	PBAX Exchange Machine	1	120	120	10	1.2	10:20
19	Industrial UPS	1	3200	3200	12	38.40	326:40
20	CCTV Receiver	1	130	130	12	1.56	13:26
21	V-Sat Receiver	1	180	180	12	2.16	18:36
22	CCTV	1	108	108	12	1.296	11:01
	TOTAL			39304		442	3758:24

Source: Field study 2011

APPENDIX XXV

Percentage of Energy Consumption in the Building(UBA).

S/N	Building Section	Total Power(w)	KWh	Energy Cost ₦:K	%
1	Banking Hall	20836	220	1889:79	50
2	Manager & Secretary's Offices	3830	45.716	388.58	10
3	Strong room, Counting room, Computer room & Corridor	6442	81.84	695.28	19
4	Marketing & Auditor's Offices	3510	42.116	357.98	9
5	Other Bank's Facility & Security Lighting	4340	52.08	442.68	12
	TOTAL	39304	442	3758:24	100

Source: Field study 2011

APPENDIX XXVI

Summary of Load Evaluation for Electricity/Fuel Rating &Equivalent (kWh) Per Principal Services in the Bank building(UBA).

S/N	Fuel Type/Element	Rating Units kWh	Equivalent kWh	Percentage (%)
	Electricity			
1	Lighting	7980	7980	19
2	Cooling/air-conditioning systems	15,873	15,873	38
3	Equipment & others	16,890	16,890	41
	Generator Fuel	**Litre**		
4	Diesel	75	750	2
	TOTAL		42,013	100

Source: Field study 2011

APPENDIX XXVII

Actual Meter Reading Values & Cost for UBA Building for one year

S/N	DATE	Monthly Meter Reading			Monthly Energy Cost Including 5% VAT
		Last Reading(kWh)	New Reading(kWh)	Monthly Value(kWh)	
1	March 2007	184023	184718	675	11,032.88
2	April 2007	184718	185794	1076	13,950.30
3	May 2007	185794	186915	1121	14,093.43
4	June 2007	186915	187876	961	13,165.43
5	July 2007	187876	188605	729	9,645.83
6	August 2007	188605	189345	740	10,468.50
7	September 2007	189345	190629	1284	15,565.20
8	October 2007	190629	190905	276	7,122.00
9	November 2007	190905	191519	614	8,619.45
10	December 2007	191519	192306	787	10,887.98
11	January 2008	192306	193136	830	11,271.75
12	February 2008	193136	193443	307	7,182.00
13	March 2008	193443	193831	388	7,326.90

Source: PHCN 2011 Zaria Office.

APPENDIX XXVIII

Energy Audit Results of First Bank Building, Zaria

Banking Hall - Appliances Rating and Electricity Consumption for First Bank Building

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦:K
1	Lighting Fluorescent Tube (2ft)	100	20	2000	12	24	204:00
2	Mercury Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
3	Fax Machine	1	105	105	12	1.26	10:71
4	Air Conditioning Unit(2HP)	7	1221	8547	12	102.56	871:76
5	Computer(Monitor + CPU)	7	230	1610	12	19.32	164:22
6	Computer UPS	7	130	910	12	10.92	92:82
7	Printer	2	320	640	10	6.4	54:40
8	Photo Coping Machine	1	1500	1500	10	1.5	12:75
9	Computer Scanner	1	60	60	8	0.48	4:08
10	Money Counting Machine	3	300	900	8	7.2	61:20
11	Television Set	1	108	108	12	1.296	11:01
12	Hot & Cool Water Machine	1	1000	1000	10	10	85:00
13	Automatic Electric Door	2	1500	3000	10	30	255:00
14	Stamping Machine	2	108	216	10	2.16	18:36
	TOTAL			20836		220	1869:79

Source: Field study 2011

APPENDIX XXVIX

Manager and Secretary's Office - Appliances Rating & Electricity Consumption (First Bank Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Lighting Filament Lamp	2	100	200	12	2.4	20.40
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	2	230	460	12	5.52	46:92
5	Computer UPS	2	130	260	12	3.12	26:52
6	Television Set	1	108	108	12	1.296	11:01
7	PBAX Exchange Machine	1	120	120	10	1.2	10:20
	Total			3830		45.716	388:58

Source: Field study 2011

APPENDIX XXX

Strong & Counting Rooms- Appliances Rating & Electricity Consumption (First Bank Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost N :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
2	Lighting Filament Lamp	3	100	300	12	3.6	30.60
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Industrial UPS	1	2400	2400	12	28.80	244.80
5	CCTV Receiver	1	130	130	10	1.30	11:05
6	V-Sat Receiver	1	180	180	12	2.16	18:36
7	Money Counting Machine	1	300	300	10	3	25:50
8	Fridge	1	450	450	24	10.8	91:50
	TOTAL			6442		81.84	695:28

Source: Field study 2011

APPENDIX XXXI

Marketing and Auditor's Offices - Appliances Rating & Electricity Consumption (First Bank Building)

S/N	Appliances	Qty	Rating(W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
3	Air Conditioning Unit(2HP)	2	1221	2442	12	29.30	249:05
4	Computer(Monitor + CPU)	2	230	460	12	5.52	46:92
5	Computer UPS	2	130	260	12	3.12	26:52
6	CCTV	1	108	108	12	1.296	11:01
	TOTAL			3510		42.116	357:98

Source: Field study 2011

APPENDIX XXXII

Bank's Compound Facility and Security Lighting - Appliances Rating & Electricity Consumption (First Bank Building)

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (4ft)	16	40	640	12	7.68	65:28
2	Lighting Filament Lamp	7	100	700	12	8.4	71:40
3	Lighting Halogen Lamp	2	1500	3000	12	36	306:00
	Total			4340		52.08	442:68

Source: Field study 2011

APPENDIX XXXIII

Overall Electricity Load Evaluation of the First Bank Building

S/N	Appliances	Qty	Rating (W)	Total Power (W)	Duty Cycle (Hrs)	Kwh	Energy Cost ₦ :K
1	Lighting Fluorescent Tube (2ft)	100	20	2000	12	24	204:00
2	Lighting Fluorescent Tube (4ft)	34	40	1360	12	16.32	138:72
3	Lighting Filament Lamp	12	100	1200	12	14.4	122:40
4	Lighting Halogen Lamp	2	1500	3000	12	36	306:00
5	Mercury Fluorescent Tube (4ft)	6	40	240	12	2.88	24:48
6	Fax Machine	1	105	105	12	1.26	10:71
7	Air Conditioning Unit(2HP)	13	1221	15,873	12	190.50	1619:25
8	Computer(Monitor + CPU)	12	230	2760	12	33.12	281:52
9	Computer UPS	12	130	1560	12	18.72	159:12
10	Printer	2	320	640	10	6.4	54:40
11	Photo Coping Machine	1	1500	1500	10	1.5	12:75
12	Computer Scanner	1	60	60	8	0.48	4:08
13	Money Counting Machine	3	300	900	8	7.2	61:20
14	Television Set	2	108	216	12	2.16	22:02
15	Hot & Cool Water Machine	1	1000	1000	10	10	85:00
16	Automatic Electric Door	2	1500	3000	10	30	255:00
17	Stamping Machine	2	108	216	10	2.16	18:36
18	PBAX Exchange Machine	1	120	120	10	1.2	10:20
19	Industrial UPS	1	3200	3200	12	38.40	326:40
20	CCTV Receiver	1	130	130	12	1.56	13:26
21	V-Sat Receiver	1	180	180	12	2.16	18:36
22	CCTV	1	108	108	12	1.296	11:01
	TOTAL			39304		442	3758:24

Source: Field study 2011

APPENDIX XXXIV

Percentage of Energy Consumption in the Building (First Bank).

S/N	Building Section	Total Power(w)	KWh	Energy Cost ₦:K	%
1	Banking Hall	20836	220	1889:79	50
2	Manager & Secretary's Offices	3830	45.716	388.58	10
3	Strong room, Counting room, Computer room & Corridor	6442	81.84	695.28	19
4	Marketing & Auditor's Offices	3510	42.116	357.98	9
5	Other Bank's Facility & Security Lighting	4340	52.08	442.68	12
	TOTAL	39304	442	3758:24	100

Source: Field study 2011

APPENDIX XXXV

Summary of Load Evaluation for Electricity/Fuel Rating &Equivalent (kWh) Per Principal Services in the Bank building(First Bank).

S/N	Fuel Type/Element	Rating Units kWh	Equivalent kWh	Percentage (%)
	Electricity			
1	Lighting	7980	7980	19
2	Cooling/air-conditioning systems	15,873	15,873	38
3	Equipment & others	16,890	16,890	41
	Generator Fuel	**Litre**		
4	Diesel	75	750	2
	TOTAL		42,013	100

Source: Field study 2011

APPENDIX XXXVI

Actual Meter Reading Values & Cost for First Bank Building for one year

S/N	DATE	Monthly Meter Reading			Monthly Energy Cost Including 5% VAT
		Last Reading(kWh)	New Reading(kWh)	Monthly Value(kWh)	
1	March 2007	184023	184718	675	11,032.88
2	April 2007	184718	185794	1076	13,950.30
3	May 2007	185794	186915	1121	14,093.43
4	June 2007	186915	187876	961	13,165.43
5	July 2007	187876	188605	729	9,645.83
6	August 2007	188605	189345	740	10,468.50
7	September 2007	189345	190629	1284	15,565.20
8	October 2007	190629	190905	276	7,122.00
9	November 2007	190905	191519	614	8,619.45
10	December 2007	191519	192306	787	10,887.98
11	January 2008	192306	193136	830	11,271.75
12	February 2008	193136	193443	307	7,182.00
13	March 2008	193443	193831	388	7,326.90

Source: PHCN 2011 Zaria Office.

APPENDIX XXXVII

CHECKLIST

Address

(Location)……

Characteristics of Building Energy-End uses:…….....

Operational Schedules per units:……..

Actual Rated Energy used per Equipment/Appliance:…….

Non-Electrical Energy Consumption and Cost:……

Electrical Energy Consumption and Cost:……

Season of the Year:……..

Number of Occupant and activities……..

Principal Building Function…….

System/Appliance Capacity and Brand……

Date and Time……..

QUESTIONS

How frequent Equipment/Appliances controls are adjusted and clean?

How frequent air purifying filter are replaced?

When last lighting system retrofits was carried out?

What determine Equipment/Appliances duty cycles in the Building?

How frequent the management of the building call for energy audit?

How frequent the cooling system compressor gas is refill?