ANALYSIS OF TECHNICAL AND FINANCIAL BENEFITS OF ENERGY EFFICIENT PRACTISES IN SELECTED ELECTRICITY COMPANY OF GHANA (ECG) BUILDINGS IN ACCRA

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DECLARATION

I hereby declare that this submission is my own work towards the Masters. and that, to the best of my knowledge, it contains no material previously published by another person, nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

Energy is a critical resource for human development. However, for many people, the option to conserve energy by using energy efficient appliances and machines and proper maintenance culture is not practiced. Research has shown that the total energy use of a building can be reduced by implementing energy efficient design strategies at the design stage of a building. Passive energy efficient design techniques like proper building orientation, use of sun shading, selection of materials more suitable to prevailing climatic conditions can considerably reduce a building's energy use and reflect in economic gains to all stakeholders. The present study set out to analyse and outline the technical and financial benefits of energy efficient practices in Electricity Company of Ghana buildings in Accra. A case study of the two regional buildings (Accra East and Accra West) was conducted in order to compare their energy efficiency profiles. Data collected from comprehensive energy audits formed the basis of the projections. A reliable and previously validated, standardized Energy Audit Tool complete with an operating manual was used to make study findings readily comparable and verifiable. The mean total energy consumption for Accra West was 414,077kWh while that for Accra East was 659,477 kWh. Accra East consumed approximately 150% of energy compared to Accra West. Over the period, the mean occupancy-adjusted energy consumption for Accra West and Accra East was 1,648 and 2688 kWh/person respectively. The present data shows that the energy efficient practices in place at the Accra West building is able to save on the average 1040 kWh/person every year. At the current rate of GH₵0.4712 , this translates to a cost benefit of GH₵ 490.048 (0.4712 X 1040) per person per year for the Accra West building. For a total staff roster of 245 workers, therefore the point can indeed be made that the Accra West facility accrues a financial gain of GH₵ 120,061.76 (490.05 X 245) per year. We conclude that the Accra West regional office of the Electricity Company of Ghana performs better as a model energy efficient building than the Accra East regional office building and could be emulated.

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Due recognition is also given to Emmanuel Timmy Donkoh and James Osei-Yeboah for their diverse contributions to the success of this work. Nonetheless, I accept responsibility for the contents of this work.

DEDICATION

This work is dedicated to my sweet Wife, Joyce Akyeamah Quaye-Larbi (Mrs), my lovely children, Henry, Baaba and Oforiwah and my beloved mum, Agnes Araba Okyirba Afful.

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GLOSSARY OF TERMS

AE	Accra East
AMR	Automatic Meter Reading
AW	Accra West
CD	Carbon Dioxide
CFL	Compact fluorescent Lamp
CLASP	Collaborative Labeling and Appliance Standards Program
CSD	Customer Service Directorate
DSM	Demand-Side Management
EC	Energy Commission
ECG	Electricity Company of Ghana
ESC	Energy Service Commission
GDP	Gross Domestic Product
GWP	Global Warming Potential
IEA	International Energy Agency
kVA	Kilovolt-ampere
kVARE	Kilovolt-ampere Reactive Energy
kWh	Kilowatt-hour
LCC	Life-Cycle Cost
LED	Light-emitting Diodes
LEED	Leadership in Energy and Environmental Design
MDAs	Ministries, Departments and Agencies
MoE	Ministry Of Energy

MTS	Metering and Technical Services
MW	Mega Watts

NES	Natural Energy Savings
NGO	Non-Governmental Organization
NPV	Net Present Value
OPEC	Organization of Petroleum Exporting Countries
PAMS	Policy Analysis Modeling Spreadsheet
PC	Personal Computers
PF	Power Factor
PIR	Passive Infra -Red
PURC	Public Utility Regulatory Commission
SO_2	Sulphur Dioxide
UK	United Kingdom
WEC	World Energy Commission

CHAPTER ONE:

INTRODUCTION

1.1 Background

Energy is a critical resource for human development (EC, 2009). However, for many people, the option to conserve energy by using energy efficient appliances and machines and proper maintenance culture is not practiced (EC, 2009) For many others, the option to use known renewable energy sources is out of reach (EC and MoE, 2012). Buildings consume 40% to 50% of the total energy use in Ghana through lighting, ventilation and air conditioning, powering of household electrical fittings, *etc*. (EC and MoE, 2012). Research conducted by the World Energy Commission (WEC, 2010) has also shown that the total energy use of a building can be reduced by implementing energy efficient design strategies at the design stage of a building. Passive energy efficient design techniques like proper building orientation, use of sun shading, selection of materials more suitable to our prevailing climatic conditions have often been sacrificed for aesthetics. Excessive use of glazing has suddenly become the yardstick by which good designs are measured. The appliance labelling program currently in place is a system which requires new electrical equipment sold on the market to have energy star rating (Energy Commission and Energy Foundation, 2009). However most of the electrical equipment presently in use in the country are imported slightly-used and are not subject to the energy star rating (Energy Commission, 2009). Furthermore, very few consumers are aware of the current rating system and how to make informed buying decisions based on these ratings (Energy Commission, 2009). Unlike in other countries in Europe and in the United States, Ghana has no building energy performance standards (Energy Commission, 2009). Energy Performance Certification (EPC) is being implemented in Europe, by the Leadership in Energy and Environmental Design (LEED) program in the United States to conserve energy. It has been realized that saving a kilowatt of energy is often cheaper than generating it.

Most consumers associate energy efficiency with expensive technologies like solar panels and wind turbines, even though in reality, a considerable amount of energy can be saved through behavioural changes at the workplace and at home. For instance, switching off lights, air-conditioners and fans when they are not in use, using washing machines only at full loads can significantly reduce electricity bills. This research focuses on assessing the technical and financial benefits of energy conservation practices in selected Electricity Company of Ghana (ECG) buildings in Accra.

1.2 Statement of the Problem

Electricity supply in Ghana suffered a serious decline in 2011 as a result of several factors but mainly due to the disruption of activities in the West African gas pipeline, which accounts for a sizable fraction of Ghana's generated electricity. The shortage, which became known as the "power crisis", also coincided with a period when the Public Utilities Regulatory Commission (PURC) had initiated tariff adjustments aimed at removing price subsidies to enable the utilities meet the high cost of power production and distribution, and also attract private investments into the Power Sector.

Recent electricity tariff adjustments and high incidents of electrical energy waste have been identified as some of the primary causes of high government recurrent expenditure (Energy Foundation, 1999). The managers of public buildings, whose utility bills are paid from state funds, must therefore be constantly looking for opportunities to reduce electricity costs. Government Ministries, Departments and Agencies (MDAs) must make efforts aimed at reducing expenditure on utilities especially, electricity.

1.3 Justification for Study

The growing demand in electricity consumption in recent times has contributed to the current rampant power outages due to the inability of the current system to meet rising demand. This has disrupted electricity supplies which is adversely affecting the performance of the Ghanaian economy. One way to minimize the load demand on the system is to minimize consumption through energy conservation practices.

Since the Ministry of Energy conducted comprehensive energy audit (Energy Foundation, 1999) became public, a lot of interest has been generated in energy conservation in public offices. In spite of this interest there is paucity of evidence (data) to support or debunk their findings. Again, there is no evidence to show that other public offices have implemented these recommendations to good effect.

In 2003, the ECG commissioned its new Accra-West regional office. It was expected that this new office would incorporate several energy efficient features compared to older ones and therefore serve as a model of energy-efficient buildings in Ghana. Hence this study seeks to compare the old and new office buildings of the ECG in Accra as a test case of the technical and financial benefits of energy efficient buildings in Ghana.

1.4 General Objective

The main objective of this thesis is to analyze the technical and financial benefits of energy efficient practices in ECG buildings in Accra.

1.4.1 Specific Objectives

1. To analyse the technical benefits of energy efficient practices in ECG selected buildings in Accra.

2. To analyse the financial benefits of energy efficient practices in selected ECG buildings in Accra.

1.5 Scope of Work and Thesis Organization

This research covers energy consumption and ways of ensuring energy efficiency. It focuses on energy consumption for ECG buildings as well as technical and financial analysis of energy efficiency in those buildings. This work also reviews the policies geared towards energy performance of buildings in Ghana.

Chapter One (1) gives an introduction to this thesis and lays down the background for the work, stating the problem that is to be mitigated by the study. **Chapter Two (2)** gives an overview of relevant literature of work already done in this area to serve as reference. It focuses on the relevant objectives of the study and gives an account of the existing body of knowledge regarding those themes. **Chapter Three (3)** presents the methodology used in carrying out this work in order to fulfil the outlined objectives. **Chapter Four (4)** presents the technical assessment of the data and measurements conducted and presents a comparative analysis of technical and financial benefits of selected buildings. **Chapter Five (5)** presents a discussion of the findings from our data and the conclusions and recommendations of the thesis.

1.6 Profile of Study Area

The profile of the study area is presented here. To put it in proper perspective, a brief profile of Ghana is presented to set the tone for a specific profile of Accra where the two facilities are located.

1.6.1 Profile of Ghana

The republic of Ghana is a country located in West Africa. It shares borders with Burkina Faso to the north, Togo to the east, Ivory Coast to the west and the Gulf of Guinea (550 km) to the south (Figure 1). The total land area of Ghana is about 238,539 square kilometers; it lies between latitudes 4º 30' S to 11º N and longitudes of 1º 10' E to 3º 15' W. The prevailing climatic condition is tropical with high mean annual precipitation in the southern part of the country and in the northern part, extreme savannah with dry conditions. The national population of Ghana is estimated to be 25 million with a growth rate of 1.822 % (CIA World Fact book, 2011). The entire country is divided into ten administrative regions: Greater Accra,

Western, Central, Volta, Brong-Ahafo, Eastern, Ashanti, Northern, Upper East and Upper West Region. Each region is further subdivided into districts; these districts serve as the basic units for development. Greater Accra Region is the administrative capital city of Ghana and is important for both its business and industrial activities.

1.6.2 Profile of Accra

Accra, the capital city of Ghana, has a total land area of 201sq km. The City of Accra is a large metropolis with a 2009 estimated residential population of slightly more than 2.1 million (World Bank, 2010). Whatever the actual residential population, an additional half a million commuters stream in from radial areas daily to work in administrative, educational, industrial and commercial concerns (World Bank, 2010).

1.6.2.1 Ecosystem and climate:

Accra lies within the coastal-savannah zone with low annual rainfall averaging 810mm distributed over less than 80 days. The rainfall pattern of the town is bimodal with the major season falling between the months of March and June, and a minor rainy season around October. Mean temperatures vary from 24 ºC in August to 27 ºC in March (UN HABITAT, 2009).

Figure 1: Political map of Ghana showing Accra in the Greater Accra Region.

(Source: UN, 2005).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the relevant objectives of the study and gives an account of the existing body of knowledge regarding those themes. This is important to establish a solid background for the study and to facilitate the appreciation of the scope of the study and also provide a basis for interpretation of the findings from the study.

2.2 Energy Efficiency and the Challenge of Wastage

Adequate and reliable supply of energy is required to ensure sustainable development. However, the use and conversion of primary energy most of the time results in wastage of useful energy. To reduce this wastage requires the judicious application of energy resources, and technology, appropriate incentives (IAEA, 2005). The judicious use of energy resources and technology to reduce the negative impacts of energy use are firmly embodied in two (2) concepts namely “energy efficiency” and “energy management”.

Energy management refers to the strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems (Chakarvarti, 2011).

Energy efficiency on the other hand is defined as a ratio between an output of performance, service, goods or energy, and an input of energy (EU, 2006). Thus, energy efficiency improvement basically refers to the reduction of energy input for a given service, goods or output.

Notably, these two concepts advocate for the use of energy resources in a manner that will save energy (natural resources) and ensure minimal wastage, consequently promoting environmental sustainability. In response to the wave of challenges related to energy use, some industries around the world have reduced energy intensities by adopting and developing energy efficient technologies and management strategies. This is a justification for their high energy end-use and high contribution to energy related environmental problems. By doing so, industries have not only gained improvement in environmental protection, but also gained economic and social dividends. Numerous studies have highlighted the tremendous gains of implementing industrial energy efficiency and management measures (Energy Foundation, 2010; Apeaning, 2012). Notably, some of these studies reveal that greater savings can be realized in developing countries (UNIDO, 2011).

Unfortunately, industries in developing countries like Ghana are lagging behind in the adoption of energy efficiency and management measures and as such missing the benefits of implementation (UNIDO, 2011). Most of these industries are limited by some critical factors, organizational failures and irrational human behaviour (UNIDO, 2011). These factors (barriers) inhibit the adoption or encourage the slow adoption of cost effective energy efficient technologies. These barriers continue to persist in developing countries (despite having been known for years) because of the prevalence of lack of information, poor decisionmaking and choices, lack of financing and many hidden costs (UNIDO, 2011).

2.3 Electricity Generation and Usage in Ghana

Using public domain data from the Volta River Authority and other public agencies (VRA, 2014), the total installed and effective capacity in Ghana as at July 2014 stood at 2,846 and 2,492 megawatts (MW) respectively. Currently, VRA contributes 75% of the total generation in Ghana (VRA, 2014) with independent power producers (IPPs) filling in the deficit.

The bulk of this supply, comprising about 52% of this generation capacity, comes from hydrobased sources mainly the Akosombo dam and the yet to be fully commissioned Bui hydro project which contributes an estimated 5%. These hydroelectric plants convert water trapped in a dam into electrical energy by using the gravitational force of flowing water to turn a turbine coupled to a generator. While hydroelectricity has the advantage of supply reliability, and security, it is affected by inflow variability and has inadequate generation capacity reserve. The remaining 48% of Ghana's energy supply comes from thermal based plants operated by the VRA and IPPs (12%) which function by converting energy stored in fossil fuels such as oil and natural gas into electrical energy. Thermal power generation suffers from fuel supply challenges, soaring world prices of crude oil, and a lack of gas supply which usually limits thermal generation (VRA, 2014).

Electricity is one of the major modern energy forms supporting the economy of Ghana; it is mainly used in the residential sector, followed by the industrial and commercial (nonresidential) sectors. In 2012, the residential, industrial and commercial sectors accounted for 48%, 35% and 17% respectively of the total electricity end-use in Ghana (Energy Commission, 2013). The electricity distribution infrastructure is extensive and provides access to about 66% of Ghana's population (Ministry of Energy, 2010) with a large proportion in urban areas. For domestic use, urban areas accounts for 88% of residential electricity use whiles rural domestic use accounts for the remaining 12%; the use of electricity by urban residents usually includes lighting, ironing, refrigeration, air conditioning, television, radio, etc, however, the use of electricity for domestic cooking is very negligible (Ministry of Energy, 2010). Ghana's electricity supply market currently has an estimated 10 to 15% yearon-year demand growth boosted by increasing domestic and industrial demand (Acheampong and Stephenson, 2014). Recent generation problems prompted a partial load sharing regime in January 2014. Local media reported in January 2014 that the Electricity Company of Ghana (ECG), the power distributor had to temporarily cut down supplies because of supply constraints from Ghana Grid Company (GRIDco), the network and transmission coordinator (Essel, 2014). For example, the shut in of production from two units at Bui, low gas pressure from the plants at Tema and operational issues at TAPCO forced about 200MW of load to be shed on 10 January 2014.

Some of these generation problems have persisted throughout the year and led to between 30 and 200MW being shed as requested leaving very little to meet the 10% reserve requirement (Essel, 2014). It is imperative therefore that the nation finds new generation sources which can satisfy this demand, revamp the transmission and distribution infrastructure to cope with the increased throughput and invest in energy efficient technology at all levels of society.

2.3.1 Commercial Electricity Billing in Ghana

Commercial electricity billing in Ghana consists of the following elements:

1. Maximum demand in kVA
2. Electrical Energy Consumption in kWh
3. Power Factor surcharge
4. National Electrification Scheme (NES) Levy per kWh
5. Street Lighting Levy per kWh and a Service Charge

The maximum demand is charged according to highest kVA consumed over a period of fifteen minutes during the month. Industries are also charged per unit kWh used in a month; industrial electricity bills also include the charging of power factor surges experienced. Commercial electricity bills are charged with the NES (National Electrification Scheme) and street light levies to subsidize domestic electricity use (PURC, 2013).

2.3.2 Electrical Demand (kW) and Electrical Energy Consumption (kWh)

Knowing how electricity use is billed and how demand and energy charges are calculated will help to understand and manage total energy costs more efficiently (Western Energy, 2010). Appendix E shows the difference between Energy Consumption and Demand**.**

Energy Consumption is the calculation of the amount of electricity kilowatt-hours (kWh) consumed during the billing period. Supposing each of ten light bulbs uses 100 watts of electricity, if all ten are lit for one hour, they will have consumed one kWh of electricity: 10 light bulbs x 100 watts x one hour = 1,000 watt-hours (1 kWh). The electricity meter may record the amount of energy used on-peak and off-peak and apply the appropriate conditional charges. ***Energy Demand*** is the rate at which electricity is consumed – or the amount needed to power a facility at any given point in time. Demand charges are based on the highest level of electricity supplied at one time during the billing period and at the time of day it's needed by a facility. Assuming that a hypothetical light bulb in the above example *demands* 100 watts of electricity at any given moment. In the energy charge example, the ten light bulbs will demand 1,000 watts (1 kW) of electricity to operate.

2.3.3 The Reason for Separate Charges

Utility companies invest in generation and distribution equipment to meet the maximum demand that all customers may require at one time. Utilities use peak demand to properly size electric service for their customers and to ensure that there is sufficient generating capacity available. Separate charges for energy consumption and demand more fairly distribute the costs of providing service to customers who use large amounts of energy. Energy consumption charges are based only on the total amount of energy you consume. Energy demand charges are based on the highest level of electricity supplied at one time during the billing period and at the time of day it's needed by a consumer.

2.4 Power Factor

An electrical system may comprise different types of load: resistive, inductive, and capacitive elements. The significance of these different types of load is that true or useful power can only be consumed in the resistive part of the load, where the current is in phase with the voltage (Energy Foundation, 2010). However, the total (apparent) power used includes nonproductive power consumed in the inductive and capacitive elements. The ratio of true power to apparent power is known as the power factor. For an ideal, pure resistor, the power factor would be 1. When the actual ratio is less than 1, it means that some of the current drawn from the electricity supplier is non- productive (Energy Foundation, 2010).

2.4.1 Power Factor and Demand

The lower the Power Factor of an electrical system, the greater will be the non-productive current drawn from the supply, and the power utilities will have to generate much more current than is theoretically required to meet the demand (Energy Foundation, 2010). The power supply system becomes inefficient, and the cost of electricity is correspondingly increased. Low power factor also means that the size of cabling, switchgear, fuse gear and transformers will all have to be greater than necessary and therefore more costly. In such cases, an improvement in power factor is necessary to reduce waste. To ensure that the generators and cables are not overloaded with reactive current, power utilities often impose penalties for low power factor (Energy Foundation, 2010).

2.5 Aspects of Energy Efficiency

Energy efficiency is a measure of useful energy output versus energy input, and it comes in four levels: technology, equipment, operation, and performance (World Energy Council, 2010).

2.5.1 Performance Efficiency

Performance efficiency of an energy system is a measure of energy efficiency which is determined by external but deterministic system indicators such as energy security, production, cost, energy sources, environmental impact and technical indicators amongst others (World Energy Council, 2010).

2.5.2 Operation Efficiency

Operation efficiency is a system wide measure which is evaluated by considering the proper coordination of different system components. This coordination of system components consists of the physical, time, and human coordination parts. Operation efficiency has the following indicators: physical coordination indicators (sizing and matching); time coordination indicator (time control); and human coordination (World Energy Council, 2010).

2.5.3 Equipment Efficiency

Equipment efficiency is a measure of the energy output of isolated individual energy equipment with respect to given technology design specifications. The equipment efficiency is usually considered being separated from the system and having little interactive effect to other equipment or system components. Equipment efficiency is evaluated by considering the following indicators: capacity, specifications, standards, constraints, and maintenance (World Energy Council, 2010). Equipment efficiency is specifically characterized by its standardization and constant maintenance (World Energy Council, 2010).

2.5.4 Technology Efficiency

Technology efficiency is a measure of efficiency of energy conversion, processing, transmission, and usage; and it is often limited by natural laws such as the energy conservation law. Technology efficiency is often evaluated by the following indicators: feasibility; life-
cycle cost and return on investment; and coefficients in the conversing/ processing/transmitting rate (Weston, 1992).

2.6 Energy Efficiency Regulators in Ghana

In Ghana, the Energy Commission, Energy Foundation and Electricity Company of Ghana (ECG) are the bodies officially responsible for providing and disseminating energy efficiency information. The Energy Commission is a regulatory body in charge of ensuring both energy providers and clients manage energy in an effective and efficient manner and is therefore regarded by consumers as the best source of energy efficiency information (Apeaning, 2012); the Energy Foundation Ghana is a non-profit, private sector institution devoted to promoting energy efficiency in Ghana; whiles, ECG is an electricity utility company. There are other unofficial sources in existence like trade union, energy consultants, colleagues within firms and written sources like journals and manuals (Apeaning, 2012).

2.7 Approaches to Measuring Energy Efficiency

2.7.1 Energy Consumption Data

One approach frequently used to assess the energy performance of buildings is the analysis of energy consumption data. Several standardized tools are available for this purpose. The Canadian Industry Program for Energy Conservation (CIPEC), a joint initiative of Canadian industry and the Office of Energy Efficiency of Natural Resources Canada have developed a very useful energy audit toolkit and manual. The spreadsheet tool has several advantages including simplicity and standardization of findings. In addition it can easily be used to conduct a sound energy audit even in resource-limited settings. Mungwititikul and Mohanty (1996) performed an energy audit of the consumption of office equipment, operation patterns and energy saving possibilities. Based on this approach, they concluded that it is possible to save up to 25% of the electricity cost by managing idle times of the office equipment.

2.7.2 Estimating Energy Consumption of Buildings by Simulation Software

Energy consumption simulations constitute an important role in building energy performance evaluation. Crawley et al. (2008) reviewed twenty simulation programs which are widely used for simulating energy consumption such as BLAST, Ecotect, DOE, ESP-r, EnergyPlus, IES, and TRNSYS, and compared their capabilities and features. The review covers important aspects of energy assessment software such as modelling features, building envelope treatment, day lighting and HVAC system and equipment.

Conceição and Lúcio (2008) studied thermal performance of a school building located in a mild climate (Portugal) with a high solar radiation level. EnergyPlus software is used to be able to observe the effects of the temperatures of internal surfaces and glazing. Simulation is performed with actual occupancy, infiltration and ventilation data to derive PMV (Predicted Mean Vote) thermal comfort index for different zones. After uncomfortable zones were identified, two solutions were proposed to improve thermal comfort, namely electrical air heaters and air solar collectors.

2.8 Saving Energy in Commercial Buildings

Commercial buildings include a wide variety of building types such as offices, hospitals, schools, police stations, places of worship, warehouses, hotels, libraries, shopping malls, etc. These different commercial activities all have unique energy needs but, as a whole, commercial buildings use more than half their energy for cooling and lighting.

In commercial buildings the most common fuel type used is electricity. Occasionally commercial buildings also utilize another source of energy in the form of locally generated electricity from power generators.

2.8.1 Controlling Electricity Costs

The industrial/commercial electricity user in Ghana can easily reduce costs by:

a) Reducing the maximum demand;

b) Reducing the electrical energy consumption, and

c) Improving power factor to avoid paying Power Factor Surcharges.

The kVA maximum demand charge is levied against the highest kVA demand a consumer makes on the electricity supply system over a period of 15 minutes, during the month.

$$kVA = kW/pf \qquad \text{Eqn. 1}$$

where, **kW** is actual power consumed and **pf** is the power factor of the consumer's system, measured by the demand meters installed by the utilities (Energy Foundation, 2010). As a result of the inverse linear relationship between the power factor and the maximum demand (kVA), a company can ensure greater energy discipline and, therefore, reduce their electricity tariff by reducing the power factor of their system (Energy Foundation, 2010). Unlike taxes or levies, the Power Factor Surcharge is avoidable. It is, therefore, highly recommended for industrial (including mining) and public and private sector commercial consumers to avoid this surcharge by improving plant power factor to 0.90 or above.

2.8.2 Power Factor Correction

Power factor correction is one of the most cost effective measures dominantly used in Ghana. In a Ghanaian study, it is claimed that the implementation of power factor correction reduced a firm's annual electricity bill by 5%-10% (Energy Foundation, 1999). Unfortunately however, most companies have not yet implemented power factor correction; the low patronage may be attributed to lack of funds or ignorance of the benefits (Energy Foundation, 1999).

2.8.3 Reducing Power Factor

There are several methods available for improving power factor; two are described here. It has been suggested that for inductive loads, which are much more common, it is feasible to improve power factor by installing capacitors across the input lines feeding the affected equipment. This is done by energy service engineers who use special equipment to determine the size of capacitor necessary (Energy Foundation, 2010). The second method involves the use of synchronous motors. In this instance, an improved power factor may be obtained by adjusting the field excitation of the motors. Synchronous motors used in this way are termed synchronous condensers. The use of this method is however limited to cases where the synchronous motors are in constant use to provide the required field excitation at all times. The high cost of such motors is also a limiting factor to its widespread use (Energy Foundation, 2010).

The potential to improve energy efficiency by improving power factor is well illustrated in the examples from the University of Ghana and the Ministry of Energy (Energy Foundation, 1999). As a sequel to an energy audit at the University of Ghana in Accra, a 100kVAR automatic capacitor bank was installed to improve power factor which was 0.8 at the time to 0.96. Although the maximum demand of the building at the time was only 90kVA, this action reduced it further to 80kVA, allowing more air conditioners to be installed in 1998 without a significant increase in maximum demand. The total cost of equipment purchase, installation and two year warranty was ¢5,500,000 cedis (Energy Foundation, 2000). As a result of the power factor improvement exercise, the Ministry of Energy recorded a cash saving for 1999, totalling ¢4,453,524. In addition, savings amounting to ¢2,673,000 in 1999 were also made on reductions in maximum demand of 243kVA. Power factor surcharges of about ¢1,780,524 was also avoided.

Figure 2: Power factor improvement by installation of capacitor bank (Source Energy Foundation, 2000)

2.9 Energy Efficiency in Buildings

Energy efficiency in buildings encompasses practices that are primarily aimed at minimizing the amount of energy (for heating, cooling, equipment and lighting) that is required to maintain comfort conditions in a building.

2.9.1 What is an Energy Efficient Building?

Very often claims to energy efficiency are substantiated by mere compliance to minimum requirements, or the installation of particular energy-efficient equipment (Meier *et al.*, 2002). Currently, "energy efficient" aspects are impossible to assess, because of the lack of knowledge of what exactly is an energy efficient building. The 3 features frequently mentioned under the subject cover an adequate definition of an energy efficient building (Meier *et al.*, 2002). Therefore, a commercial building satisfying these 3 elements can be said to be “energy efficient”:

1. Containing energy efficient technologies, operating as designed, in reducing energy use.

2. Supplying the required amenities and features expected for the standard use of the building, for at least 60 hours per week.

3. Operated in a manner to be efficient, which gives evidence of low energy use when compared to other similar buildings.

Opportunities to minimize energy requirements through energy efficiency and passive renewable energy in buildings include the building design, building materials, heating, cooling, lighting, and appliances. Opportunities for improving energy efficiency are greatest when other changes occur, eg refurbishment, fit-out, alteration, and plant replacement. Here the best results ensue from a good brief, good design with attention to detail, sound construction and commissioning, and good control and management (BPP, 2000).

2.9.2 Building Envelope

An important factor impacting on energy efficiency is the building envelope. The nature of the building envelope which includes all of the components of a building that regulate the internal and external environment such as: walls, windows, doors, roof and foundations are very significant in ensuring energy efficiency. All of these components must work together in order to keep the building warm in the winter and cool in the summer (CIPEC, 2010).

The building envelope consists of the roof, exterior walls and floor of a structure. These elements form a barrier that separates the interior of the building from the outdoor environment. According to the website of the Pew Center on Climate Change, the building envelope determines how much energy will be needed to maintain a comfortable indoor environment relative to outdoor conditions (TSU, 2001). A properly designed building envelope can substantially reduce heating costs in the cold seasons and cut cooling costs in hot seasons. The amount of energy consumed varies depending on the design of the fabric of the building and its systems and how they are operated (TSU, 2001). The heating and cooling systems consume the most energy in a building, however, controls such as programmable thermostats and building energy management systems can significantly reduce the energy use of these systems. Some buildings also use zone heating and cooling systems, which can reduce heating and cooling in the unused areas of a building (TSU, 2001). In commercial buildings, integrated space and water heating systems can provide the best approach to energy-efficient heating. For example, the energy used to heat water can be reduced by insulating water pipes to minimize heat loss from water heaters.

2.9.3 The Challenges in Designing Energy Efficient Features into Buildings

It is easier to design energy efficient features into new buildings, however existing buildings comprise approximately 99% of the building stock. This sector thus provides the greater challenge for implementation of energy efficiency as well as the greater opportunity for overall energy efficiency gains (World Energy Council, 2010). Although energy efficiency initiatives for existing buildings can be demonstrated to be cost effective, there has been limited success in convincing large organizations and building owners to undertake energy efficiency projects such as retrofits, and retro commissions. Economic viability of building renovations can be evaluated by software simulations which estimate the response of the building to the retrofit. Florides et al. (2002) used TRNSYS software to simulate thermal loads of houses. Controlling for variables such as natural and mechanical ventilation, solar shading, glazing type, orientation and shape of the building, insulation and thermal mass, energy load calculations were supported with economical analysis. The Life-cycle Cost Method was used to show the costeffectiveness of the measures intended to lower the consumption. Their results indicated that for hot climates roof insulation and solar shadings pay back in 3-5 years while wall insulation pays back up to 10 years.

2.9.4 Improvement in Building Fabric at the Ministry Of Energy

Following a successful audit, several energy efficient measures of not were implemented at the Ministry of Energy in Ghana. For instance, in order to reduce the high incidents of ventilation heat gains, all the lower level louvered windows were replaced with solid flush wooden panels, whilst the old louver frames which did not allow for firm closure of windows were either repaired or replaced. The air conditioners were moved from the ground level to heights of 1.5-2meters above the floor level to set up an efficient circulation pattern, borrowing from fundamental knowledge that cool air tends to fall as warm air rises.

Figure 3: Front view of the Minister of Energy's office

Replacing the lower louvered windows with solid flush wooden panels particularly allowed for even and easy circulation of cool air in the offices. It also prevented furniture and other objects from blocking the areas in front of air conditioner units, which could prevent or hamper air circulation. After this exercise it became possible to use one air conditioner instead of two in some of the large offices where two air conditioner units were installed since hot air infiltration was reduced to the minimum (Energy Foundation, 2000).

2.10 Energy Audit

An energy audit is a process undertaken to develop an understanding of the specific energy-using patterns of a particular facility (CIPEC, 2010). An energy audit is key to developing an energy management program. Although energy audits have various degrees of complexity and can vary widely from one organization to another, every audit typically involves: data collection and review, plant surveys and system measurements, observation and review of operating practices, and data analysis.

The audit is designed to determine where, when, why and how energy is being used. This information can then be used to identify opportunities to improve efficiency and decrease energy costs. Energy audits can also verify the effectiveness of energy management opportunities (EMOs) after they have been implemented (CIPEC, 2010). Energy audits can be conducted as a useful way of determining how energy efficient building is and what improvements can be made to enhance efficiency. Here, tests are undertaken to ensure that the heating, cooling, equipment and lighting all work together effectively and efficiently.

2.11 Internal and External Audits

Audits may be performed internally using company machinery or externally by expert consultants. In this regard, there are usually different advantage scenarios: audits performed externally tend to focus on energy-saving technologies and capital improvements. Audits conducted in-house tend to reveal energy-saving opportunities that are less capital intensive and focus more on operations (CIPEC, 2010). Organizations that conduct an energy audit internally gain considerable experience in how to manage their energy consumption and costs. By going through the auditing process, employees come to regard energy as a manageable expense, are able to analyse critically the way their facility uses energy, and are more aware of how their day-to-day actions affect company energy consumption.

To establish the level of waste and to identify opportunities for its reduction, an external energy audit was conducted at the Ministry of Energy (MOE) building in Accra, Ghana by a team of local and international consultants and MOE staff led by NIFES Consulting Group of the UK

(Energy Foundation, 1999). The audit, which was conducted in 1997, established the pattern of electricity use in the building, which is typical of other Government Ministry buildings such as the Electricity Company of Ghana offices assessed in this work. It was determined that about 30% of electricity cost could be saved if certain energy saving measures were taken.

The audit found that several measures could be implemented to conserve energy in government buildings at very little or no cost all to the implementing agency. Such measures include regularly defrosting refrigerators, ensuring that PCs, lights, Air conditioners and photocopiers were not left “on” continuously during the day when the equipment were not in use or the rooms were not occupied as is common in most government facilities. Also, it was found that the number of fluorescent tubes could be reduced by 50% and a number of high wattage (40W), 38mm diameter fluorescent tubes could be replaced with 36Watt energy efficient 26mm diameter tubes.

With the availability of funds, other measures could be implemented to further reduce energy consumption. These are the installation of capacitor banks to improve power factor from 0.80 to 0.96, installation of passive infra-red (PIR) sensors to control airconditioners and internal lights and the improvement in the building fabric (Energy Foundation, 1999).

Based on the recommendations of the audit, the Ministry organized workshops for its staff and managers of other government ministries to educate them on simple but effective housekeeping measures that can be implemented to eliminate waste and reduce electricity consumption. The absence of adequate follow-up measures and swift implementation of recommendations is a major problem in most developing countries.

However, in this case, the participants were educated on measures such as switching off lights, air conditioners and office equipment when leaving offices for long periods or when the equipment is not in use. Other energy savings tips included drawing of curtains to avoid direct sun rays into air conditioned rooms and firm closing of windows and doors to air-conditioned rooms, as well as regular defrosting of refrigerators.

Fifty percent of the lamps, in the 144 twin fluorescent lamp fittings in the offices were removed since it was established after experimenting for 12 months, that two lamps were enough to provide the needed level of illumination for office tasks instead of the 4 that were installed in each of the 72 offices. The tubes were also cleaned to improve the illumination levels in the offices. The result of this exercise was a reduction in the lighting load by 5.76kW. Together with another eighty-one single tube fittings, all the 40W standard-38mm diameter fluorescent lamps were replaced with energy efficient 26mm diameter 36W tubes. This resulted in a further demand saving of 1.452kW. Thus the entire measures on lighting resulted in a demand saving of 7.212kW and an energy saving of 15,577kWh per annum. The demand savings at an existing power factor of 0.8 translates into a kVA saving of 9kVA per month or 108kVA per annum costing ¢1,188,000. The energy cost savings is ¢3,118,515 per annum. The MOE spent a total of
¢7,000,000 on the lighting retrofits, resulting in a simple payback period of 2 months (Energy Foundation, 2000).

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents the methodology used in undertaking the technical and financial assessments in order to fulfil the objectives of this work.

3.2 Study Design

A case study of two Electricity Company of Ghana building sites was conducted in order to compare their energy efficiency profiles based on electricity consumption data carried out via energy audits.

3.3 Study Setting

The study was conducted at the two (2) regional headquarters of the Electricity Company of Ghana (ECG) namely, Accra-East and Accra-West Regional office buildings. From June 2012 to May 2013, electricity consumption and demand data at these sites spanning year 2000 to year 2012 was collected over the course of the present study and forms the basis of the analyses conducted here. The Accra West and East offices were chosen because of their similar sizes and functions which provides a sound basis for comparative tests drawn to fulfill the objectives of the study

3.3.1 Exchange Rate

During the period of the conduct of the study, the average exchange rate of the United States dollar stood at 1.936 against the Ghana cedi. The minimum rate was 1.875 recorded on October 25, 2012 and the maximum rate was 1.997 on May 31, 2013.

3.4 Description of Buildings

In order to facilitate the appreciation of the energy assessment carried out and the findings of the present study, it is important to first give brief descriptions of the two buildings of the ECG pertaining to the study.

3.4.1 Accra East Office

The Administrative building of the Accra East office is a 2-storey building located at Makola, in the South-Eastern geographical demarcated area of ECG in Accra. The building houses seven departments of the ECG, namely: Customer service, Material and Transport, Human Resource, Finance and Audit, Engineering, Operations and ICT. This is the older of the two offices. As shown in Figure 4, single glazed louvred windows occupies about 30% of the total surface. This feature permits high rates of air infiltration and ex-filtration, thereby contributing to high heat gains by placing higher demand on the HVAC system.

Figure 4: Accra East office building of the ECG

3.4.2 Accra West Office

The Accra West Administrative building is a 2-storey building located at Avenor, in the South-Western geographical demarcated area of ECG on the east-west axis on open ground. The building houses seven departments of the ECG, namely: Customer service, Material and Transport, Human Resource, Finance and Audit, Engineering, Operations and ICT. Anecdotal evidence suggests that this building was built to incorporate contemporary energy efficient technology and serves as the reference point in this study. The building was designed with features such as east-west orientation, and overhangs that reduce the impact of solar gain and therefore improves energy efficiency.

Figure 5: Accra West office building of the ECG (a)

Figure 6: Accra West office building of the ECG (b)

3.5 Institutional Approval

Written permission to undertake this study was first sought from the Regional Managers. After the permission was granted, a meeting was then scheduled with the Regional Engineer to brief him on the rationale of the work.

3.6 Data Collection Techniques and Tools

This research analyses the energy-related benefits of the new ECG office complex building in Accra West in relation to the older office complex at Accra East. It provides comprehensive information about the energy culture of ECG buildings from primary data sources. The methods used in this research are exploratory and qualitative, tailored to answer and satisfy both the aims and research question. The research employs an extensive review of relevant theories and literature related to energy security, energy management, and energy efficiency. The study employed the use of standardized spreadsheet templates to gather primary data related to energy efficiency and management practice in the selected sites. Interviews were conducted with stakeholders and summarized in organized excel spreadsheets.

3.6.1 Energy Audit Tool and Manual

In this study, a standardized Energy Audit Tool and Manual was used. This manual, which was developed by Natural Resources Canada under the auspices of the Canadian Industry Program for Energy Conservation (CIPEC, 2010), presents a practical, userfriendly method of undertaking energy audits in industrial facilities.

3.6.2 Energy Audit Procedure

In conducting the energy audit of the two buildings, the steps taken were as follows:

1. The Condition Survey – The condition survey audits facilities for their implementation of and adherence to energy efficiency practices. It basically

comprises a checklist with various energy efficiency indicators. With the aid of a comprehensive and systematic enquiry form, qualitative data pertaining to the energy condition of the selected study sites were collected by assigning a numerical score to each survey observation to help determine the scope and urgency of prescribed corresponding corrective actions (Appendix C).

The general level of repair, housekeeping and operational practices that have a bearing on energy efficiency were assessed. Areas and lag situations that warrant further assessment as the audit progresses were noted.

Table 1: Reference Sheet Matching Condition Survey Ratings with Corrective Actions.

Range of score	Action required
0 - 20	Immediate corrective action required
20 - 40	Urgent corrective action required
40 - 60	Corrective action required
60 - 80	Evaluation for potential improvement required
80 - 100	No corrective action required

Source: CIPEC (2010).

Although the Condition Survey precedes the main audit, it can also identify energy management opportunities (EMOs). The survey rating system helps to identify and prioritize areas of the facility that should be assessed more extensively. However, direct observations of housekeeping, maintenance and other procedures can lead to EMOs that need no further assessment and that can be acted on right away. For example, fixing leaks in the steam system, broken glazing and doors that won't close will pay off immediately in reduced energy consumption (CIPEC, 2010).

2. Establishing the audit mandate –commitment was obtained from management for the study and the expectations and outcomes of the audit were clearly defined at this stage.

3. Establishing the audit scope – The audit was defined to cover all electricity consuming systems that were logged onto the main electric meters at the two premises.

4. Analysis of energy consumption and costs –energy consumption and costs from historical energy billings and the pertinent tariffs were collected, organized, summarized and analysed.

[1] The complete tool-kit which comprise several spreadsheet templates for capturing relevant data is available online at http://www.nrcan.gc.ca/energy/efficiency/industry/cipec/5161.

5. Comparison of energy performance –Energy use indices were computed and compared internally from before and after the year 2007 and externally between the two sites. Owing to

the lack of national and regional energy standards, it was impossible to compare these findings. The year 2007 is notable because it is the year when the government in a bid to reducing inefficiencies in the country introduced the use of the compact fluorescent lamps to replace the existing incandescent light bulbs in the country. It is therefore expected that there will be heterogeneity in the energy use profiles pre- and post 2007.

6. Inventory of energy use –a list of all energy-consuming loads in the audit areas were prepared and their consumption and demand characteristics were detailed.

7. Identification of Energy Management Opportunities (EMOs) –Operational and technological measures to reduce energy waste were outlined.

8. Assessment of benefits –potential energy and cost savings are measured.

3.6.3 Energy Auditing

Electricity consumption of the buildings was measured by two central electricity meters located at the two Regional offices. Power analyzers were installed to these electricity meters to track electricity consumption.

Measurement was carried-out with the help of ZERA Energy Analyzer Instrument (Model MT300-310-320) and Automatic Meter Reading (AMR) system of the metering and Technical Services (MTS) of ECG. The above instruments have been installed at various metering points of the two regional offices. Measurements were taken automatically by these instruments and the readings were collected on monthly basis throughout the stipulated study period.

3.6.4 Energy Indices

There are several indicators for quantifying energy use with respect to certain units of energy consumption. These indicators can be used with reference to either a single building, or in relation to similar others. In this study, a few of these standard indicators were calculated, namely:- Annual final energy use (kWh/year), annual final energy use per occupant (kWh/person), annual final energy use per occupant per year (kWh/person/year) and the cummulative annual peak power demand (kVA/year) (Heng, 2003).

3.7 Statistical Analysis

Descriptive statistics was used for data expression. Where applicable, data was presented as figures with percentage in parenthesis. Student's unpaired t-test was used to compare mean values of group continuous data. Graph Pad Prism version 6.00 for windows (Muzyka *et al.*, 2007) and SPSS version 20 (SPSS, 2011) were used for statistical analyses.

CHAPTER FOUR: RESULTS

This chapter presents the results obtained from the fieldwork. The present study conducted an energy audit of two buildings of the Electricity Company of Ghana to determine available energy efficient practices and the financial benefits of such energy efficient practices. A summary of the condition of the two buildings is presented and then areas in need of improvement are subsequently suggested. The electrical load inventory for the two buildings spanning several years is also scrutinized.

4.1 Condition Survey

An initial walk-through inspection of the Accra West (AW) and Accra East (AE) office buildings of the ECG was carried out to identify obvious opportunities for energy savings that could be implemented with little or no further assessment. The condition survey provided an orientation of the entire facility to observe the major uses of energy and the factors that influence those uses.

Table 2 shows the total points rating and overall percentage rating for the two buildings analysed. This score is used to indicate the urgency of corrective action, based on an appropriate standard scale (Table 1).

Overall, the Accra East (AE) and Accra West (AW) buildings obtained average scores of 61.33 and 82.67, representing an overall size-adjusted rating of 86.19% and 84.00% respectively. The crucial import of the overall rating scores is that based on the conditional survey, the initial assessment ratings for five sub-categories out of a total of nine covered by the preliminary survey namely: Lighting, Air-conditioning, Ceiling, Food Areas, and Roofing were all higher for Accra West (AW) than the Accra East (AE)

building.

Table 1: Comparative analysis of Total Points and Overall Rating for building descriptors

Parameter	**Total Points**		**Rating of Location (%)**	
	Accra West (AW)	***Accra East (AE)***	***Accra West (AW)***	***Accra East (AE)***
Lighting	64.00	87.00	80.00	79.09
Windows	64.00	88.00	80.00	80.00
Air Conditioning	48.00	55.00	85.71	83.33
Ceiling	48.00	66.00	100	85.71
Electric power Distribution	72.00	104.00	90.00	94.55
Food Area	120.00	159.00	100	96.36

Exterior Door	32.00	44.00	40.00	40.00
Exterior Walls	56.00	77.00	100	100
Roofing	48.00	64.00	100	96.97
Total	552.00	744.00	775.71	756.01
Average	61.33	82.67	86.19	84.00

Data is presented as figures (points) and percentages (Ratings). Scores/points are percentage-standardized as ratings and indicate the urgency of corrective action, based on predefined scale (Appendix C). Source: Authors's field work (2013).

In three remaining sub-categories, namely: Exterior Walls, Exterior Doors and Windows, both facilities scored similar ratings. In general, the findings of the condition survey showed that the Accra West building performed better in as many as five areas covered by the survey than the Accra East building. However, with respect to electrical power distribution, Accra West (AW) scored lower, with 90.00% as against 94.55% scored by the Accra East building (Appendix D). The electrical power distribution checklist takes into consideration factors such as:

1. The presence and operation of a recording ammeter,
2. If a definite preventive maintenance schedule is followed,
3. If equipment is maintained or repaired only when it breaks down,
4. If there is a systematic determination of hourly electrical usage pattern of building,
5. The installation of a power peak warning system,
6. If overall system power factor of 90% or above is maintained,

7. Whether there is a deliberate check to eliminate power peak demands and
8. If definite standard operating procedures are used.

These must be written and posted near the control panel. From the energy audit, the study found that the reason for the low score in electrical power distribution for Accra West was that there is not a deliberate check to eliminate power peak demands at the facility.

This represents an energy management opportunity.

4.1.1 Energy efficient conditions at the Accra West (AW) office building compared to the Accra East (AE) building.

In general, as shown in Table 2, the Accra West building is more energy efficient and adheres to stricter energy efficiency practices than the Accra East building. This is in tandem with the fact that this is the newer of the two buildings; as it would be reasonable to expect that the newer building should be designed to be more energy savvy than the older.

For example, with respect to environmental shading, the study found that the Accra East building offers far less sun-shading than the Accra West building. Figure 6 (page 42) is a picture of the Accra West office building (b) showing extensive shading afforded by glazed windows, balcony, fins and recessed wall.

Excessive sunlight penetration of the offices can lead to an elevation of the internal office temperature and therefore increase the amount of energy required by air-conditioners for maintaining optimum and comfortable working environment thereby reducing the overall cost burden. In addition, the Accra West building is suitably oriented in the East-West direction. This orientation ensures that too much sunlight does not enter the offices and prevents overheating. Figure 4 shows the Accra West office building showing extensive shading afforded by glazed windows, balcony, fins and recessed wall. The AW office building has several glazed windows in place to provide additional shading of work areas. This measure saves energy by requiring less from air-conditioners. In addition, the windows are tightly fitted to prevent infiltration of warm outside air and subsequent energy leakage into the outside.

On the contrary, Most of the windows at AE office are single glazed louvred windows which permit high rates of air infiltration and ex-filtration, thereby contributing to high heat gains through ventilation.

The offices at AW mainly have ceramic-tiled floors while only a few isolated offices at AE have floor tiles. Ceramic tiles have shiny reflective surfaces that contribute to good light distribution and provide a cooling effect in rooms. In addition, the distance from floor to ceiling in the AW office is higher than in the AE office. The AW office building has an efficient lighting system in place that makes little use of decorative lighting.

Although the Condition Survey precedes the main audit, it can also identify EMOs. The survey rating system helped to identify and prioritize areas of the facility that should be assessed more extensively (CIPEC, 2010).

4.2 Electrical Load Inventory

The electrical load inventory describes in quantitative detail the systems that consume energy in a facility. The inventory indicates where energy is being consumed, how much is consumed by each system, and how all the systems add up as an aggregate load. It is helpful to know how the total energy load is distributed among various systems.

4.2.1 Energy Consumption Data

The overall patterns of consumption can help direct focus in later stages of the audit. In this audit, the demand profile was investigated (i.e. the characterization of the electrical loads in terms of time of use and size) was investigated to gain an appreciation of the actual burden of the different types of loads on the energy system.

Figure 7A and 7B shows the demand profile of energy in the two buildings in 2012 stratified by equipment type. At the Accra West facility, air-conditioning equipment contributed the highest (53.6%) fraction of metered electrical demand in 2012 followed by Desk equipment (27.7%), followed by other equipment (10.1%). Similarly the largest contributor to peak electrical demand (kVA) at the Accra East office was air-conditioning (55%) followed by Desk equipment (30%), followed by the other equipment category (9%). The same trend was also observed from the electrical consumption break-down.

Figure 7C and 7D shows the consumption patterns of energy in 2012 stratified by equipment type. At the Accra West facility, air-conditioning equipment recorded the highest (53.5%) fraction of electricity consumption in 2012 followed by Desk equipment (27.7%), followed by other equipment (14.9%). Similarly the largest consumer of electrical energy (kWh) at the Accra East office was air-conditioning (53.5%) followed by Desk equipment (33%), followed by the other equipment category (10%).

Lighting and fans exerted the least influence on the energy-use signature of the two facilities. This suggests that the two buildings have very similar operation. In fact one difference between the two facilities rests with the fact that the Accra West building has many departments on more than one floor.

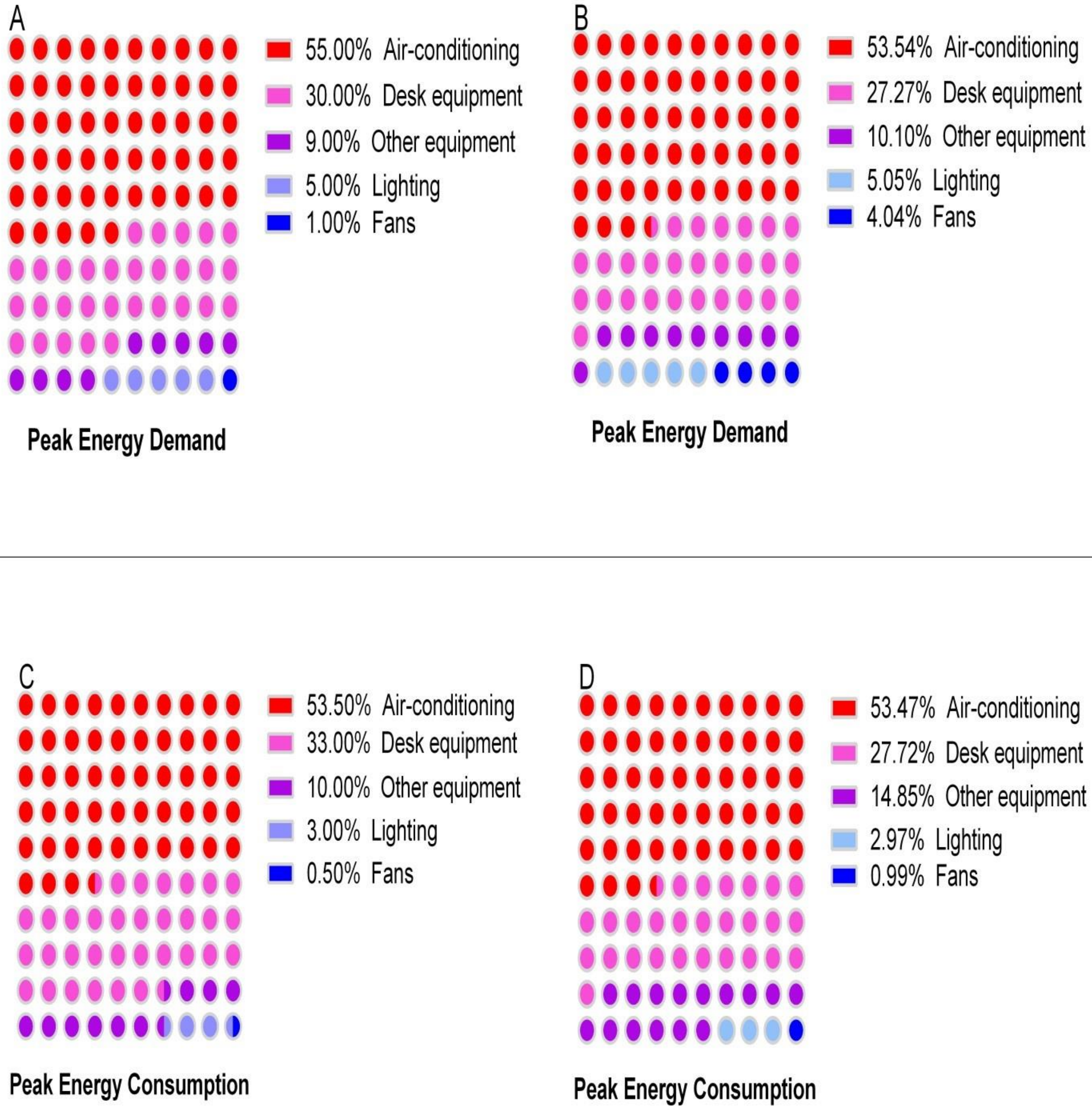


Figure 7: Colour grid showing demand and consumption patterns of energy in ECG buildings in Accra. A &C- Accra East, B&D –Accra West.

Source: Authors’s field work (2013).

The import of an energy audit, is to have an idea of how energy is utilized in the various systems of a plant. For example, in an industrial plant, one wishes to establish how much energy is used up by the distillation or canning systems. Such knowledge will provide information on where to turn attention to maximize energy efficiency.

However, in an office setting, which is organized around departmental operations, it is more prudent to establish energy use according to the several relevant departments.

Table 2 (page 49) shows the energy consumption profile of the various departments at AE and AW facilities stratified by the class of equipment. In both office buildings, the Customer Service Departments account for the largest consumer of electrical energy. The AE building has two Customer Service Departments (CSDs) on separate floors while the AW has only one on the ground floor. Table 2 shows that the bulk of this electrical consumption emanates from air-conditioning equipment. Together, the two separate Customer Service sub-Departments at the AE office of the ECG houses 50 air conditioners as compared to AW's total of 19 air-conditioners. The full impact of this disparity in A/C numbers can be well appreciated when one takes into account the fact that the staff numbers of both facilities are almost identical; making it impossible to justify the energy consumption at the AE CSD based on greater productivity either. Rather, the disparity in the number of air conditioning units is a situational one. A PROMINENT feature of the AW office, was the open office system with several staff desks in a vast office spaces. This feature allows for more central air-conditioning in contrast to the situation at AE where staff work in separate rooms requiring separate airconditioning.

Table 2: Departmental peak energy consumption distribution stratified by equipment types

Parameter	Desk Equipment	Air Condition	Lighting	Fans
Customer Service	4500.00	8504.40	378.00	375.00

Accra West ECG Building	Maintenance 600.00 1790.40 67.20 - Human Resource 1620.00 2685.60 100.80 - Fin & Audit 3240.00 6266.40 302.40 - Engineering 900.00 895.20 33.60 - Operations 1440.00 4476.00 168.00 - ICT 1080.00 1342.80 50.40 -				
	Compound	-	-	36.00	-
	Others	-	-	235.20	-
	Average 1531.09±2.03 375.00 Customer Service		[illegible]	[illegible] 107.15±2.52	
Accra East ECG Building	Maintenance	1350.00	[illegible]	[illegible]	6.00
	Human Resource 1620.00 3580.80 352.80 22.50 Fin & Audit 8820.00 9399.60 504.00 31.50				
	Engineering	1080.00	895.20	33.60	2.25
	Operations	2520.00	7573.80	235.20	29.25
	ICT	1080.00	1747.80	50.40	2.25
	Compound	-	-	36.00	-
	Others	-	-	336.00	-
	Average	2552.70±2.75	4226.69±2.99	178.24±3.62	11.35±3.53

Data is presented as mean ± standard deviation of the mean. Fin-Finance, ICT- Source: Authors's field work (2013)

4.2.1.1 Annual Energy Consumption Profiles

Tabulating historical bills also facilitates a graphical analysis of consumption patterns of all purchased energy forms. Figure 8 illustrates the patterns of electricity use by the two different facilities. The overall usage pattern of energy consumption is driven to some extent by a facility's type of equipment, systems and process. Therefore, in any audit, it is important to have an idea of historical as well as present consumption patterns. Figure 8 is a graphical presentation of annual energy consumption and demand patterns at AE and AW regional offices of the ECG. A little over the past decade, the peak demand has ranged from a low of 40409.62 kVA in 2002 before gradually rising to a maximum of 59317.13 kVA in 2006 at the AW regional office. Since 2006, there has been a steady decline in the annual average peak demand at the AW office. Electrical consumption at AW generally followed a very identical trend throughout the period except for a secondary, less intense peak in 2008. This shows that the Ministry of Energy's directive to replace incandescent light bulbs with compact fluorescent lamps in 2007 had significant effect on consumption patterns.

In the same period from 2000 to 2012, the peak demand at AE followed a U-shaped curve from 2000 to 2007. Within this period, the least demand was recorded in 2003 and the highest in 2007. Unlike at AW, the peak demand began to plummet in 2007 until 2011 when it rose again. Energy consumption was at its lowest in 2004 at AE. By 2007, consumption had hit a plateau but rose slightly in 2010 before declining further to date.

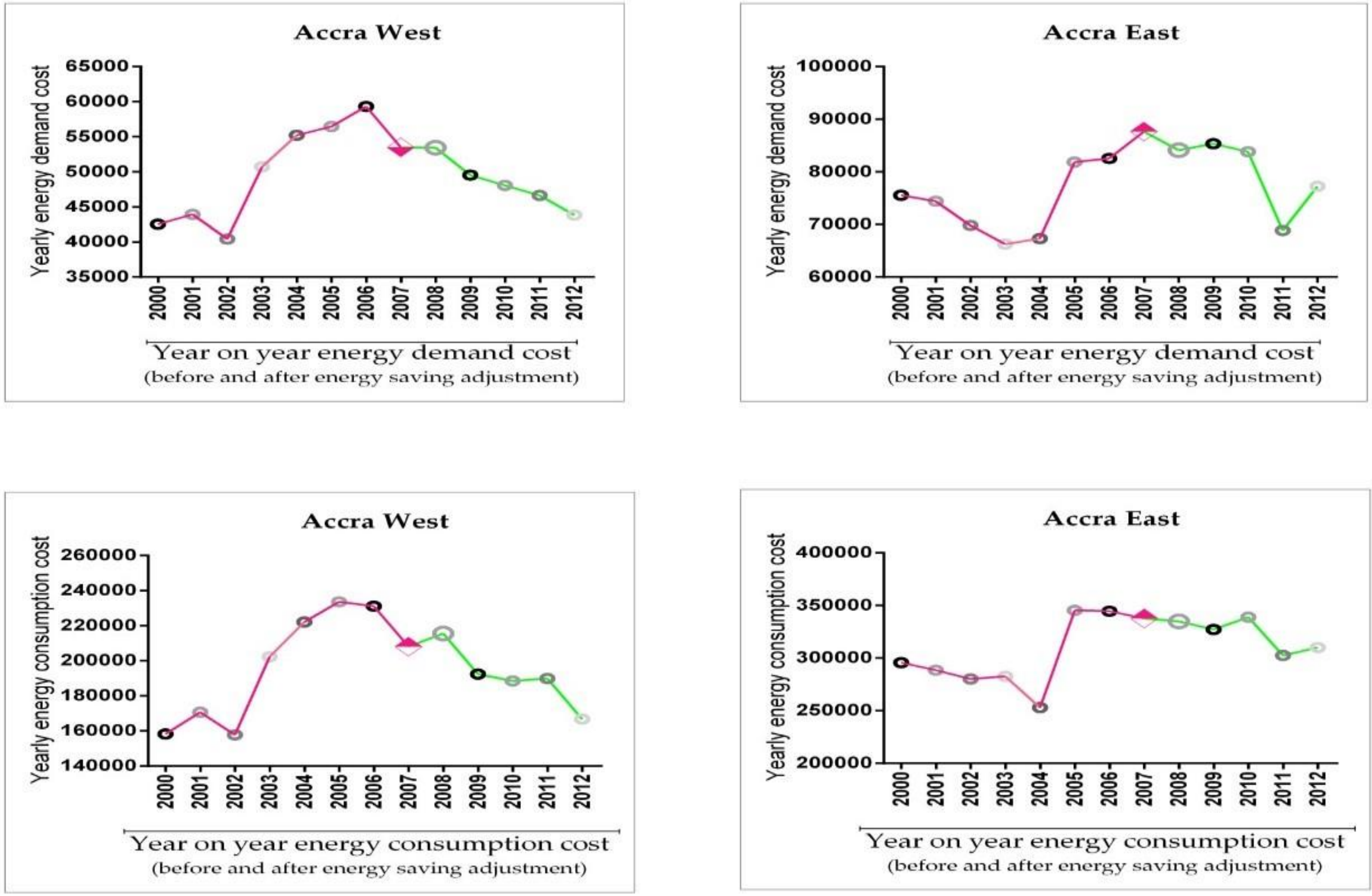


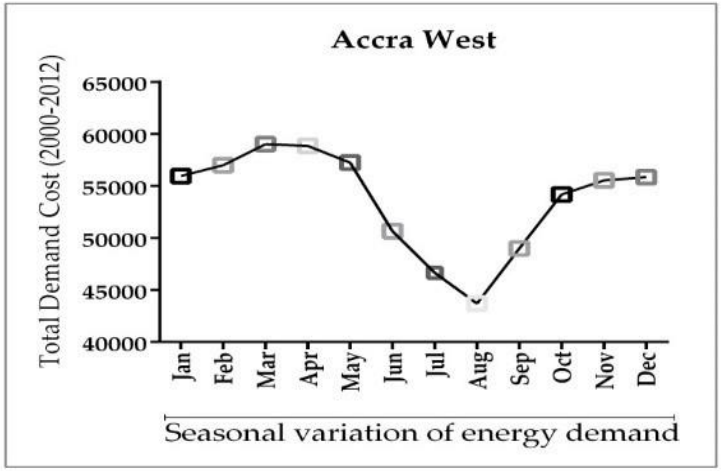
Figure 8: Graphical Presentation of Annual Energy Consumption (kWh) and Demand (kW) cost patterns at AE and AW regional offices of the ECG. Red lines reflect pre-2007 trend and green lines reflect post-2007 trends. Costing is done in Ghana cedis (GhȻ).

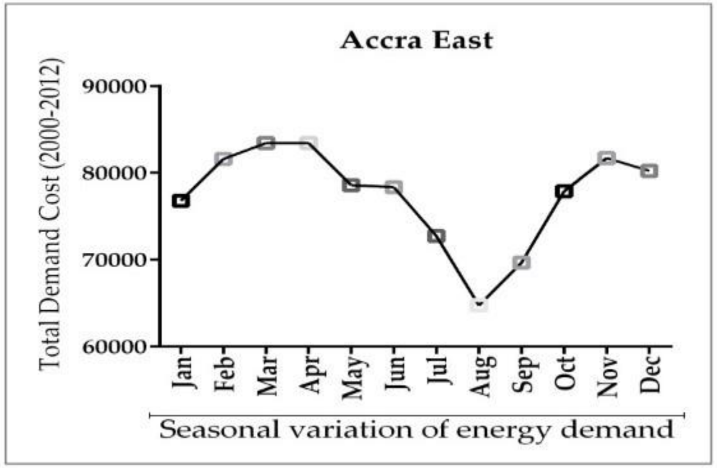
4.2.1.2 Seasonal Variation in Energy Consumption

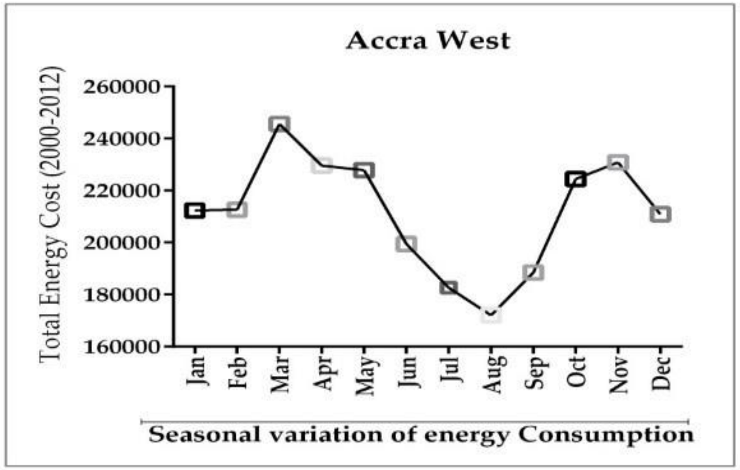
Figure 9 shows a graphical presentation of monthly energy consumption and demand patterns at AE and AW regional offices of the ECG. Data is presented as monthly averages from year 2000 to 2012. The peak demand rose gently from January to a maximum of 229558.70 kVA in April before it fell off to the minimum of 172060.60 kVA in August before rising steadily to a plateau from November at the AW regional office. A similar trend was also observed at the AE office.

At all the two study sites, electrical consumption trends followed the same pattern for demand with the exception of two deviations. Unlike electrical demand, energy consumption peaks in the month of March, a month earlier than demand which peaks in April. Again, there is no second plateau in the month of November, but rather, a decline in the last month of the year.

In this survey, The annual pattern of energy use that was found at both facilities is typical and well documented for buildings with a heavy reliance on air-conditioning and other temperature controlling appliances (CIPEC, 2010). Such characteristic patterns are expected for light process outfits such as office buildings, and go to confirm that there are a number of drivers of energy use in a facility. The available data shows that most significant of all these drivers is perhaps, the weather. At both the AW and AE buildings, a seasonal trend in electrical consumption and demand patterns was observed. Both AW and AE regional offices recorded the least demand (kVA) figures in the month of August which, incidentally, is the coolest month of the year.


Accra West
Total Demand Cost (2000-2012)
65000
60000
55000
50000
45000
40000
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Seasonal variation of energy demand


Accra East
Total Demand Cost (2000-2012)
90000
80000
70000
60000
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Seasonal variation of energy demand


Accra West
Total Energy Cost (2000-2012)
260000
240000
220000
200000
180000
160000
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Seasonal variation of energy Consumption

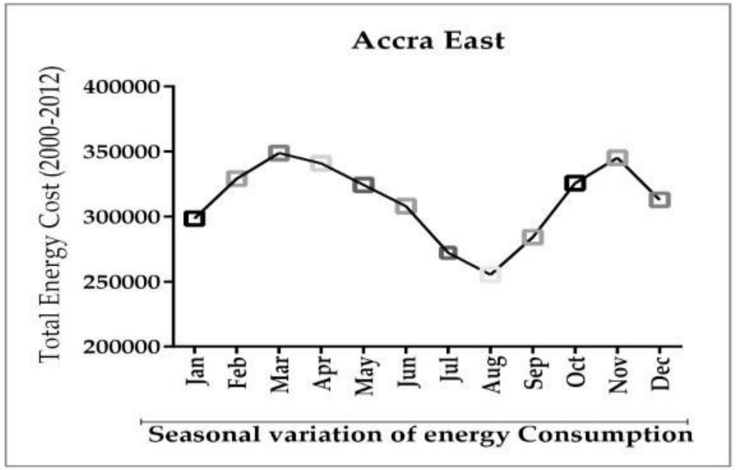

Accra East
Total Energy Cost (2000-2012)
400000
350000
300000
250000
200000
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Seasonal variation of energy Consumption

Figure 9: Graphical presentation of monthly energy consumption and demand patterns at AE and AW regional offices of the ECG*.
*Data is presented as monthly averages from year 2000 to 2012.

CHAPTER FIVE:

DISCUSSION

This chapter presents an assessment of the costs and benefits of energy efficient practices identified in the energy audit. The present study conducted an energy audit of two buildings of the Electricity Company of Ghana to determine available energy efficient practices and the financial benefits of such energy efficient practices to inform decision making. A summary of the condition of the two buildings is presented and then areas in need of improvement are subsequently suggested. The main conclusions are presented here and recommendations are made on the efficient use of energy in public buildings and for further studies.

5.1 Existing Conditions

The roof insulation in the ICT department of the AE building is aged and in poor condition, representing an energy improvement opportunity.

The condition survey determined some walls in the Customer Service, Material and Transport, Finance and ICT departments that open into unconditioned space through unclosed plumbing or duct openings.

Majority of the doors on-site have a hold-open feature. Only a few doors were identified to have a mechanical closer mechanism, which were mostly spring mechanism.

Air-conditioning and refrigeration accounts for the bulk of energy consumption. Some refrigerator doors were not properly closed. Again some refrigeration equipment were also found to be faulty. This represents an important energy management opportunity for management.

While some departments have a definite preventive maintenance schedule, which is followed, the practice in some also is that equipment is maintained or repaired only when it breaks down. The unfortunate consequence and import of this is that at any point in time, faulty and defective high consumption equipment may also be in operation; causing electrical demand and consumption to spike.

5.2 Financial Benefits

A basic analysis of historical energy bills provides insight into the unit cost of all purchased energy. Table 4 shows the cumulative yearly energy consumption and the occupancy-adjusted energy consumption for Accra West and Accra East regional offices of the ECG. Over the entire period, the mean total energy consumption for AW stood at 414,077kWh while that for AE was 659,477 kWh. From the present data, AE consumed approximately 150% of energy compared to AW. In order to eliminate the effect of building size, we used building occupancy as a surrogate marker of building size and to standardize energy consumption. Over the period, the mean occupancy adjusted energy consumption for AW and AE was 1,648 and 2688 kWh/person respectively. The present data shows that the energy efficient practices in place at the AW building is able to save on the average 1040 kWh/person every year. At the current rate of GH₵0.4712, this translates to a cost benefit of GH₵ 490.048 (0.4712 X 1040) per person per year for the AW building. For a total staff roster of 245 workers. Therefore the point can indeed be made that the AW facility accrues a financial gain of GH₵ 120,061.76 (490.05 X 245) per year.

Table 3: cumulative yearly energy consumption and the occupancy-adjusted energy consumption for Accra West and Accra East regional offices of the ECG

Parameter	Annual final energy use		Annual final energy use per occupant	
	Total KWh		KWh/Person	
Year	***Accra West***	***Accra East***	***Accra West***	***Accra East***
2000	335,771	627,313	1,371	2,561
2001	362,203	612,004	1,497	2,498
2002	334,844	594,496	1,356	2,427
2003	429,161	599,641	1,710	2,448
2004	471,179	536,815	1,752	2,191
2005	495,609	732,879	2,023	2,991
2006	490,339	731,057	1,985	2,984
2007	441,616	716,352	1,636	2,924
2008	457,290	710,458	1,706	2,631
2009	408,248	694,016	1,666	2,639
2010	399,894	718,931	1,632	3,099
2011	403,006	641,641	1,645	2,852
2012	353,843	657,596	1,444	2,695
Average	414,077	659,477	1,648	2,688

Source: Authors's field work (2013).

In August 2007, the Ministry of Energy launched the National Compact Fluorescent Exchange Programme at the peak of the nation's power crisis. It was expected that the programme would save the nation about 200-220MW of peak electricity supply (Energy Commission, 2009). It is generally held that, a higher penetration of CFLs for household lighting could reduce growth in electricity demand, reduce fossil fuel use for thermal electricity generation and lessen environmental impacts (Energy Commission, 2009).

Figure 10: A roadside sign erected in support of the Energy Commission's mandatory CFL replacement exercise in 2007.

In that same year, in a bid to reduce energy usage and promote the efficient use of electricity in Ghana, the ECG directed its own internal nationwide mandatory replacement of all incandescent lighting units for the more efficient CFL bulbs.

Table 5 shows the cost of energy in AE building of ECG before and after energy efficiency changes in year 2007 and the difference between the two values. For purposes of comparison, the corresponding monthly and daily values are also shown. The total cost of electricity before and after 2007 are 419,003.3 and 456,995.1 Gh¢ respectively. Notably, the total cost of electricity increased after the implementation of the CFL replacement exercise.

Table 4: Cost of energy in AE building of ECG before and after energy efficiency changes in year 2007 and the difference.

	Parameter	Total	Before	After	Difference
	East ECG Building				
Annual	Demand Cost (kVA)	155130.9	73962.07	81168.87	-7206.8
	Energy Cost (kWh)	623534.3	298485.3	325049	-26563.7
	Total Cost (Gh¢)	875998.4	419003.3	456995.1	-37991.8
Monthly	Demand Cost (kVA)	12927.58	6163.506	6764.072	-600.567
	Energy Cost (kWh)	51961.19	24873.78	27087.42	-2213.64
	Total Cost (Gh¢)	72999.87	34916.94	38082.92	-3165.98
Daily	Demand Cost (kVA)	425.0163	202.6358	222.3805	-19.7447
	Energy Cost (kWh)	1708.313	817.7681	890.5452	-72.7771
	Total Cost (Gh¢)	2399.996	1147.954	1252.041	-104.087

Source: Authors's field work (2013). Before: Year 2000-2006; After: Year 2007-2013.

Table 6 shows the cost of energy in AW building of ECG before and after energy efficiency changes in year 2007 and the difference between the two values. For purposes of comparison, the corresponding monthly and daily values are also shown. The total cost of electricity before and after 2007 are 277,082.8 and 273,000.1 Gh¢ respectively. The difference of 4082.719 Gh¢ represents the financial gain after the implementation of the mandatory replacement of all incandescent bulbs with CFL lights at the AW office premises. Data collected in this study suggests that the measure may have had a significant impact in considerably reducing the energy consumption levels of the AW regional office of the ECG. Although other factors may also have a part to play in this effect, the trend as seen from figure 8 is very strong.

Table 5: Cost of energy in AW building of ECG before and after energy efficiency changes in year 2007 and the difference

Accra West ECG Building

	Parameter	Total	Before	After	Difference
Annual	Demand Cost (kVA)	98967.03	49798.31	49168.72	629.593
	Energy Cost (kWh)	389995.6	196497.5	193498	2999.491
	Total Cost (Gh¢)	550082.9	277082.8	273000.1	4082.719
Monthly	Demand Cost (kVA)	8247.253	4149.859	4097.393	52.46609
	Energy Cost (kWh)	32499.63	16374.79	16124.84	249.9576
	Total Cost (Gh¢)	45840.24	23090.24	22750.01	340.2266
Daily	Demand Cost (kVA)	271.1426	136.4337	134.7088	1.724912
	Energy Cost (kWh)	1068.481	538.3494	530.1316	8.217783
	Total Cost (Gh¢)	1507.077	759.131	747.9455	11.18553

Source: Authors's field work (2013). Before: Year 2000-2006; After: Year 2007-2013.

5.3 Proposed Conditions

Leaky spots in the roof must be repaired as well to improve building energy performance. Defective ceiling panels represent another energy management opportunity for most departments. To reduce air infiltration and energy losses, the building's internal environment must be tightly regulated by sealing it off as much as possible from the external environment. Doors with open-hold feature must be replaced with doors that have a mechanical closer mechanism, to conserve energy used by air conditioning to cool the internal environment and energy losses from doors left opened. All departments should have a definite preventive maintenance schedule, which must be adhered to, in order to prevent the operation of faulty and defective high consumption equipment which cause electrical demand and consumption to go up and increase energy costs.

5.4 Summary of Study

This study has determined the financial benefits of energy efficient practices in ECG buildings in Accra. The Accra West regional office of the ECG was used as a test case to determine notable measures that can be incorporated into new and existing buildings (especially government buildings) to make them more energy efficient and reduce government energy expenditure. For an appropriate control, the Accra East regional office building was selected. Several energy efficient measures were identified which have been highlighted elsewhere in the thesis.

5.5 Recommendations

The Electricity Company of Ghana must periodically organise workshops for its staff and managers of other government institutions to educate them on simple but effective housekeeping measures that can be implemented to eliminate waste and reduce electricity consumption. All staff must be kept educated on measures such as switching off lights, air conditioners and office equipment when leaving offices for long periods or when the equipment is not in use. Steps must be taken to ensure that PCs, lights, Air conditioners and photocopiers are not left "on" continuously during the day when the equipment are not in use or the rooms are not occupied.

Air-conditioning is the largest energy consuming equipment in office settings. Simple measures such as drawing of curtains to avoid direct sun rays into air conditioned rooms and firm closing of windows and doors to air conditioned rooms, can save massive amounts of energy.Refrigerators must be regularly defrosted to reduce wastage.

To reduce the high incidents of ventilation heat gains, all the louvred windows at AE must be replaced with solid flush wooden panels, whilst the old louvre frames which did not allow for firm closure of windows must either be repaired or replaced. Louver blade decorative windows should be replaced with glazed flush windows or solid wood flush panels to reduce air leakage

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APPENDIX A:

Approved Special Load Tariff, Effective October 01, 2013

Special Load Tariff (SLT) Customers	Existing Tariff (GHp / kWh)	Approved Tariff (GHp / kWh)	Percentage Increase
SLT - Low Voltage			
Capacity Charge (GHp / KVA / Month)	1,542.9400	2,760.3197	78.9%
Energy Charge (GHp / kWh)	26.3402	47.1226	78.9%
Service Charge (GHp / Month)	1,102.1000	1,971.6569	78.9%
SLT - Medium Voltage			
Capacity Charge (GHp / KVA / Month)	1,322.5200	2,365.9883	78.9%
Energy Charge (GHp / kWh)	20.3889	36.4757	78.9%
Service Charge (GHp / Month)	1,542.9400	2,760.3197	78.9%
SLT - High Voltage			
Capacity Charge (GHp / KVA / Month)	1,322.5200	2,365.9883	78.9%
Energy Charge (GHp / kWh)	18.7357	33.5182	78.9%
Service Charge (GHp / Month)	1,542.9400	2,760.3197	78.9%
SLT - High Voltage – Mines			
Capacity Charge (GHp / KVA / Month)	1,542.9400	2,760.3197	78.9%
Energy Charge (GHp / kWh)	29.7567	53.2347	78.9%
Service Charge (GHp / Month)	1,542.9400	2,760.3197	78.9%

PUBLIC UTILITIES REGULATORY COMMISSION

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PUBLIC UTILITIES REGULATORY COMMISSION PRESS RELEASE
APPROVED ELECTRICITY TARIFFS EFFECTIVE 1st OCTOBER 2013

The Public Utilities Regulatory Commission in the later part of the year 2012 received proposals from the Utility Service Providers in the electricity and water sectors, namely the Volta River Authority (VRA), Ghana Grid Company Ltd (GRIDCO), the Electricity Company of Ghana (ECG), the Northern Electricity Distribution Company (NEDCO) and Ghana Water Company Limited (GWCL).

The proposals were a request for an upward adjustment in electricity and water tariffs. The proposed increase as requested was meant to enable the Utility Service Providers to cover their operational and maintenance costs. Together, the Electricity Utilities requested an average increase of 166% whilst the water utility requested for a 112% increase.

It should be noted that there has not been any major adjustment in water and electricity Tariffs since 1st June 2010. However, the Automatic Adjustment Formula was implemented.

As mandated by law and the Commission's decision making processes , extensive stakeholder consultations were held to solicit views and gather input for the final determination of upward adjustments in electricity and water Tariffs.

Subsequent to a careful investigation of the proposals submitted by the Utility Service Providers for
Utility Tariff Adjustments, and considering concerns of consumers and inputs from Stakeholders the Commission at its meeting today approved Utility Tariff Increases for various customer categories.

In arriving at a decision the Commission was guided by its Rate Setting Guidelines and considered factors which balance consumer and investor interests, the economic development of the country , optimal generation mix and growth in demand.

To satisfy the above requirements the following considerations were taken into account:

- Fair apportionment of total cost of supply to various classes of consumers and a certain minimum level of service (Lifeline Supply) at an affordable price to residential consumers who may not be able to pay full cost.

- Appropriate rate of return on investments to satisfy the interests of investors in the National Interconnected system.

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- Setting of Bulk Supply Tariff (BST) to ensure that distribution utilities procure electricity for distribution at least-cost from wholesale power suppliers and retail to regulated customers.

- Setting of Transmission and Distribution Service Charge to ensure economically efficient, reliable and secure operation of the Transmission System by the Electricity Transmission and Distribution Utilities.

- Provision of adequate revenue to ensure the financial viability of the utilities.

- Allowance for a tariff structure which incorporates uniform rates for all customers within a particular category of customers regardless of geographical location.

In adjusting electricity and water Tariffs the Commission took into consideration the social impact on certain categories of consumers who need to be supported through a lifeline Tariff Intervention Mechanism which seeks to ensure that such consumers are not overburdened.

According to the Commission's Rate Setting Guidelines in calculating the Tariffs for Lifeline Consumers there is the need to take into consideration the price of kerosene and the incomes of consumers in the lifeline category. In all there are about 937,632 customers on lifeline within the ECG and NEDCo Networks. The Commission also took into consideration the effect of Cedi depreciation against the US Dollar.

The Commission also wishes to indicate that the cost of producing electricity has increased due to the shift in the generation mix of using more thermal electricity (Natural Gas and Crude Oil) as against Hydro (Water from Akosombo, Kpong and Bui).

A growth in demand of 10% per annum in electricity has also contributed to the need for more resources and increased cost to enable the utility service providers to meet the needed expansion.

The energy situation over the past one year has not helped due to the unavailability of Natural Gas through the West African Gas Pipeline (WAGP) for electricity generation which resulted in an acute load shedding situation in the country.

There is no doubt that this situation has adversely contributed to the decline in the economic development and growth of the country because industry depended largely on alternative sources which are more expensive than electricity through the grid.

Currently, supplies of Natural Gas through the WAGP are not adequate thus forcing the VRA to largely depend on expensive imported light crude oil for generation.

It should be noted that any increase in electricity tariffs is based on a projected generation mix for hydro and thermal.

The Commission wishes to remind all consumers and stakeholders that tariffs alone cannot raise the needed capital for the utilities to operate efficiently and effectively. In this regard, the Commission is urging government to continue sourcing funds to supplement the Tariff income to enable the Utility Service Providers to maintain, replace, repair utility equipment and add on the needed investments that would bring about the required improvements in the sector.

IMPROVEMENT IN QUALITY OF SERVICE

Following a marine accident on the West African Gas Pipeline(WAGP) resulting in the disruption in the flow of Gas from Nigeria in the past year, the sector has faced challenges in achieving the required standards of quality of service delivery to consumers due to the impact of the load shedding exercise that have been experienced by the country.

Notwithstanding this unfortunate crisis situation that the country experienced , the Commission has been committed to ensuring that the required benchmarks under relevant Regulations are adhered to by the Utility Service Providers. Any breach of the Quality of Service Regulations would result in stiffer penalties and sanctions for Utility Service Providers.

The Utility Service Providers should reposition themselves to deliver quality of service and respond adequately to the needs of the consumer by implementing appropriate mechanisms ensuring to minimize the response time to faults that occur in the distribution network .

It is the strong view of the Commission that an increase in tariffs should correspond to an improvement in quality of service and the Commission would ensure that the following key benchmarks for the attainment of the acceptable and attainable levels of quality of service are strictly adhered to.

- Reduction in Technical and Commercial losses to meet the Commissions benchmark of 21% for the Distribution Companies(ECG & NEDCO)
- Reduction in Transmission losses to meet the Benchmark of 3.5% for GRIDCO
- Generation Plant Availability of 92% benchmark for Thermal Plants .
- Hydro Plant Availability at 95%.
- Voltage stabilization at the consumer end to reduce the incidence of suppressed demand.
- An efficient billing and revenue collection effort to meet regulatory benchmark of a 95% collection Ratio.

- Develop and carry out orderly annual capital investments and preventive maintenance programs to avoid a rapid deterioration of the system.

- Carry out extensive Public Education and Awareness Programs on their activities and also communicate effectively to the Public in dealing with challenges of reliability of the service.

• Develop a human face in Customer Relations .

- ECG and NEDCO to address challenges associated with Pre-Paid Meters being used by consumers.

- The installation of Multiple meters by ECG and NEDCo in compound houses so that consumers in such dwellings can take advantage of the life line Tariff.

The Utility Service Providers MUST comply with the following to ensure efficiency and maximization of Resources :

- Institutionalization of effective and prudent cost control measures to ensure a fair return on Investment

• Effective Billing and Revenue Collection

- Continue vigorously the installation of Pre- Paid Meters for Public and Private Buildings and Institutions

- Internal restructuring to provide the necessary guidance and supervision to ensure effective and efficient operations

APPROVED ELECTRICITY TARIFFS

Subsequent to a careful investigation of the proposals submitted by the Utility Service Providers for Utility Tariff Adjustments , and considering concerns of consumers and inputs from Stakeholders the Commission at its meeting today has approved Utility Tariff Increases for various customer categories.

Approved Residential End User Electricity Tariff Effective October 01, 2013

Residential Customer Class	Existing Tariff (GHp / kWh)	Approved Tariff (GHp/kWh)	Percentage Increase
0 - 50	9.5000	15.6750	65.0%
51-150	17.5785	31.4479	78.9%
151-300	17.5785	31.4479	78.9%
301-600	22.8135	40 .8134	78.9%

601+	25.3483	45.3481	78.9%

Not e: Refer to Appendix I & 2 for approved rates for Non Residential and Special Load (SLT) Customers.

In arriving at a decision on the tariff increases the actual increases averaged 150%, but the Commission took into consideration concerns of Stakeholders regarding a one time quantum mcrease.

In this regard the Commission has agreed to stagger the Tariff increase over a period using the Automatic Adjustment Formula. This is also in consonance with suggestions by key Stakeholders during extensive consultations on the matter.

APPROVED WATER TARIFFS EFFECTIVE 1st OCTOBER 2013

The Public utilities Regulatory Commission following consultative process adjusted water Tariffs effective 1st October 2013. It should be noted that the last Major Water Tariff adjustment was done in June 1st 2010.

The current Tariff adjustment is meant to assist the GWCL meet key operational costs which include cost of electricity, cost of chemicals for the treatment of Raw Water, and operation and maintenance costs. The electricity cost which is a pass through cost forms about one third of the cost of water production & supply.

Customer Class	**Existing Tariff (GHp / cubic metre)**	**Approved Tariff (GHp / cubic metre)**	**Percentage Increase**
Residential			
0-20	85.2600	129.5952	52.0%
20+	127.8100	194.2712	52.0%
Non Residential			
Commercial / Industrial	181.6800	276.1536	52.0%
Public Institutions / Government Departments	163.9600	249.2192	52.0%
Unmetered Premises Flat Rate per House per Month	554.9300	843.4936	52.0%
Premises without connection (Public Stand Pipes) per 1,000 litres	84.2900	128.1208	52.0%
Special Commercial	516.6400	785.2928	52.0%

A,pproved Water Rates Ef£ecf1ve 0ctober 01' 2013

CONCLUSION

It is the hope of the Commission that this Tariff Adjustment is going to assist the Utility Service Providers to undertake critical investments that impact and ensure the availability of adequate and reliable supply in electricity

The Commission is very much concerned about lapses in quality of service especially in the area of Response Time to faults, Communication with the general public on system reliability and the activities of the Utility Service Providers, delays in the acquisition of water and electricity meters, improvements in monthly average efficiency, reduction in forced outages, communicate effectively on planned outages and observance of planned maintenance schedules.

The Commission is grateful to the general public and stakeholders who made contributions and submitted inputs during our extensive stakeholders.

The Commission wishes to assure consumers that it is committed to an improvement in the delivery of quality of service and would not hesitate to apply the necessary sanctions as stipulated in our various Regulations.

APPENDIX B:
Breakdown of Installed Capacity of VRA, IPPs and other Plants in Ghana

Plants	Installed Capacity (MW)	Type	Fuel Type
Akosombo	1,020	Hydro	Water
Kpong	160	Hydro	Water
TAPCO (T1)	330	Thermal	LCO/Gas
TICO (T2)	220	Thermal	LCO/Gas
T3	132	Thermal	LCO/Gas
TT1PP	126	Thermal	LCO/Gas
TT2PP	50	Thermal	DFO/Gas
MRP	80	Thermal	DFO
Solar	2.5	Renewable	Solar
A. Sub-total	**2,120.50**		
Private Plants	**Installed Capacity (MW)**	**Type**	**Fuel Type**
Sunon Asogli	200	Thermal	Gas
CENIT	126	Thermal	LCO/Gas
Bui HEP	400	Hydro	Water
B. Sub-total	**726**		
GHANA'S TOTAL INSTALLED CAPACITY: 2,846.5			

*LCO - Light Crude Oil | *DFO - Distillate Fuel Oil. (Source, VRA, 2014).

APPENDIX C:
SPECIMEN DATA COLLECTION SHEET

The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

Date: 31 May 2002 Auditor: SD Comments:		insulation good	insulation average	insulation Poor	Flanges insulated	no leaks	some leaks	Many leaks	automatic Controls	standard operating Procedure	steam Meter	Fuel Meter	Make-up water Meter	Preventive Maintenance	Fix as required	Energy recovery	Economizer Controls	total Points
	Location/Points	2	1	0	2	2	1	0	1	1	1	1	1	1	0	3	2	
	Maximum Score	2			2	2			1	1	1	1	1	1		3	2	17
1	Main Boiler Room		1				1		1		1	1		1		3		9
2	West Plant Boiler		1					0						1				2
total Points for section																		**11**
Rating for Boiler Plant Systems = (100 × Total Points) = (100 × 11) Number of Items × Maximum Score (2 × 17)																		**32%**

After each checklist is completed, a score is calculated [i.e. according to the formula given in the above example].

This score is then used to indicate the urgency of corrective action, based on the following scale:

range of score	action required
0 – 20	Immediate corrective action required
20 – 40	Urgent corrective action required
40 – 60	Corrective action required
60 – 80	Evaluation for potential improvement required
80–100	No corrective action required

Checklists in "Part C: Technical Supplement" address the following:

1. Windows
2. Exterior Doors
3. Ceilings
4. Exterior Walls
5. Roofs
6. Storage Areas
7. Shipping and Receiving Areas
8. Lighting
9. Food Areas
10. Heating and Boiler Plant
11. Heat Distribution
12. Cooling Plant
13. Cooling Distribution
14. Electrical Power Distribution
15. Hot Water Service
16. Water Service
17. Compressed Air
18. Process Heating

In each case, only the template headings are shown, along with the scoring structure. At the end of the section, there is a blank template that can be customized to specific systems in your facility and others not included in the above list. In the latter case, consider using a scoring structure similar to the one shown above.

Table 6: Results from Electrical Power Distribution assessment: Accra East

The Condition Survey: ACCRA EAST

System: Electrical Power Distribution

Date:

Auditor: HK

No.	Location / Points	Recording Meter	Usage Pattern	Power Co. Coordination	Power Peak Warning	Power Demand Limited	Standard Op. Procedures	Preventive Maintenance	Fix as Required	% Power Factor									Total Points	Rating for Location
No.	Location / Points	2	1	1	1	1	1	1	0	2										
Maximum Points		2	1	1	1	1	1	1	0	2									10	100%
1	CSD	2	1	1	1	1	1	1		2									10	0%
2	M&T	2	1	1	1	1	1	1		2									10	0%
3	Finance	2	1	1	1	1	1		0	2									9	0%
4	CSD_1	2	1	1	1	1	1	1		2									10	0%
5	HR	2	1	1	1	1	1		0	2									9	0%
6	Finance_1	2	1	1	1	1	1		0	2									9	0%
7	Operations	2	1	1	1	1	1	1		2									10	0%
8	Engineering	2	1	1	1	1	1			2									9	0%
9	ICT	2	1	1	1	1	1		0	2									9	0%
10	Audit	2	1	1	1	1	1			2									9	0%

11	CSD_2	2	1	1	1	1	1	1		2									10	**0%**
	Total Points and Overall Rati Distributi																		**104**	**95%**

Source: Authors's field work (2013).

The Condition Survey

ACCRA WEST

System:	**Exterior Walls System**																			
Date:																				
Auditor:	HK	Recording Meter	Usage Pattern	Power Co. Coordination	Power Peak Warning	Power Demand Limited	Standard Op. Procedures	Preventive Maintenance	Fix as Required	% Power Factor									**Total Points**	**Rating for Location**
No.	**Location / Points**	2	1	1	1	1	1	1	0	2										
Maximum Points		2	1	1	1	1	1	1	0	2									10	**100%**
1	CSD	2	1	1	1	1	1	1		1									9	**0%**
2	M&T	2	1	1	1	1	1	1		1									9	**0%**
3	HR	2	1	1	1	1	1	1		1									9	**0%**
4	Finance	2	1	1	1	1	1	1		1									9	**0%**
5	Audit	2	1	1	1	1	1	1		1									9	**0%**
6	Engineering	2	1	1	1	1	1	1		1									9	**0%**
7	Operations	2	1	1	1	1	1	1		1									9	**0%**
8	ICT	2	1	1	1	1	1	1		1									9	**0%**

Total Points and Overall Rating for Exterior Walls System	**72**	**90%**

Table 7: Results from Electrical Power Distribution assessment: Accra West Source: Authors's field work (2013).

APPENDIX E

The electricity use diagram below shows the difference between ***energy (kWh)*** and ***demand (kW)***:

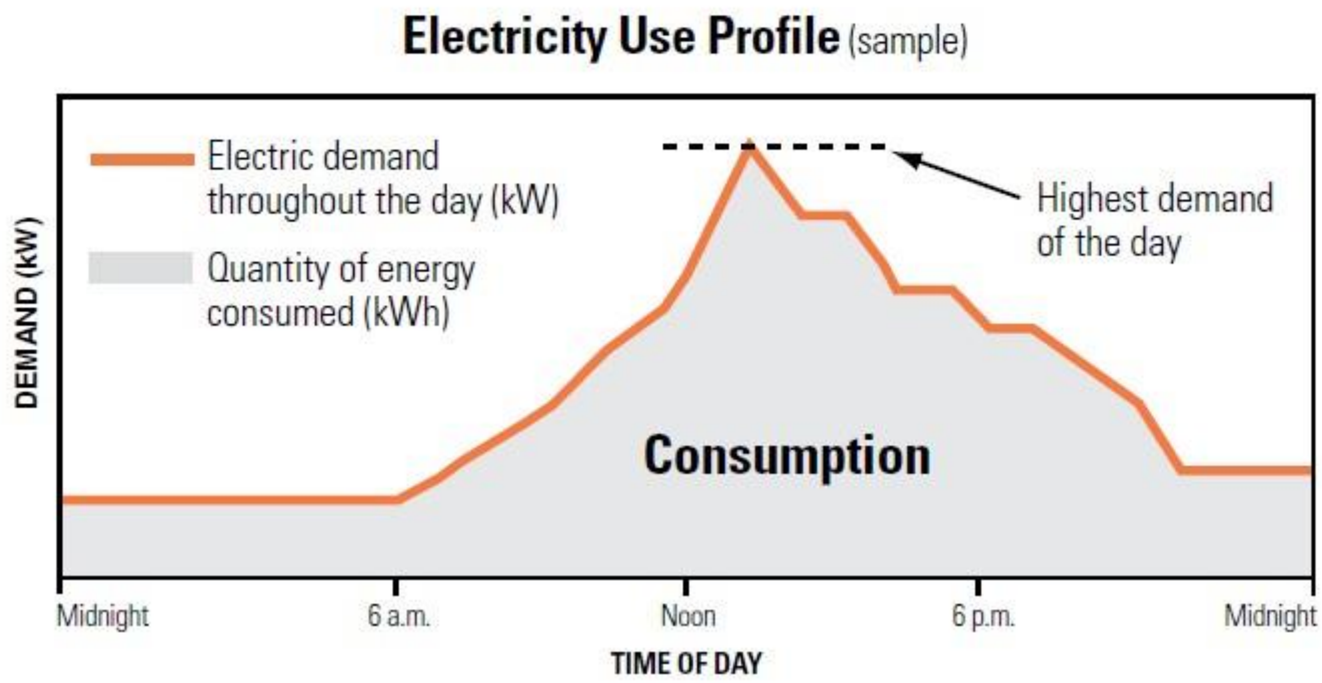

Figure 11: Difference Between Energy Consumption and Demand.
Source: Western Electric (2010).

The Condition Survey

1. ACCRA EAST

System:	Lighting System
Date:	
Auditor:	HK

Comments

These are sample comments for the lighting systems condition survey.

No.	Location / Points	No Decorative Lighting	Light Work Area	Light Entire Room	Diffusers Good	Diffusers Average	Diffusers Poor	Reflection Good	Reflection Average	Reflection Poor	Source Appropriate	Source Not Appropriate	Lights Vented	Lights Turned Off	Illumination Adequate	Excessive Illumination			Total Points	Rating for Location
No.	Location / Points	1	1	0	2	1	0	2	1	0	1	0	1	1	1	0				
Maximum Points		1	1		2			2			1		1	1	1				10	100%
1	CSD			0	2			2			1		1	1	1				8	0%
2	M&T			0	2			2			1		1		1				7	0%
3	Finance			0	2			2			1		1	1	1				8	0%
4	CSD_1			0	2			2			1		1	1	1				8	0%
5	HR			0	2			2			1		1	1	1				8	0%
6	Finance_1			0	2			2			1		1	1	1				8	0%
7	Operations			0	2			2			1		1	1	1				8	0%
8	Engineering			0	2			2			1		1	1	1				8	0%
9	ICT			0	2			2			1		1	1	1				8	0%
10	Audit			0	2			2			1		1	1	1				8	0%
11	CSD_2			0	2			2			1		1	1	1				8	0%
																			0	0%

Total Points and Overall Rating for Lighting System	87	79%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

1 NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

LIGHTING RATING INS TRU CTIONS

1 point if extensive decorative lighting has been eliminated where used for appearance only (not security, walkway lighting and other necessities). 1 point if lighting has been arranged to illuminate only the work area.

0 points if lighting has been designed to illuminate the entire room to a working level. 2 points if light fixture diffuser is clean and clear.

1 point if diffuser is slightly yellowed or dirty.

0 points if diffuser is noticeably yellowed or dust is visible. This restriction can amount to 10% or more of the light flux being transmitted. 2 points if fixture internal reflective surface is in good condition (the paint is reflective and clean). 1 point if the fixture internal reflective surface gives dirt indication on clean white cloth. 0 points if the reflective surface is yellowed and dull.

1 point if the light source (T8, HPS, MH, LED ‘’Exit’’ lamps) are appropriate for the application. 0 points if an inappropriate light source is used.

1 point if lights are properly vented the heat can escape to ceiling space, providing that ceiling space is ventilated to prevent heat build-up. 1 point if lights are turned off when area is not occupied. 1 point if illumination level is adequate for designed usage. 0 points if area is “overilluminated” for designed use.

0 points if two or more lamps have blackened ends or are glowing without lighting.

The Condition Survey ACCRA EAST

System: Windows System

Date:

Auditor: HK

Comments:

No.	Location / Points	Storms	Solar Protection	Tight Fit	Minor Infiltration	Major Infiltration	Cannot Be Opened	Can Be Opened	Weatherstripped										Total Points	Rating for Location
		2	2	2	1	0	3	0	1											
Maximum Points		2	2	2	1		3												10	100%
1	CSD	2	2	2	1			0	1										8	80%
2	M&T	2	2	2	1			0	1										8	80%
3	Finance	2	2	2	1			0	1										8	80%
4	CSD_1	2	2	2	1			0	1										8	80%
5	HR	2	2	2	1			0	1										8	80%
6	Finance_1	2	2	2	1			0	1										8	80%
7	Operations	2	2	2	1			0	1										8	80%
8	Engineering	2	2	2	1			0	1										8	80%

9	ICT	2	2	2	1			0	1										8	80%
10	Audit	2	2	2	1			0	1										8	80%
11	CSD_2	2	2	2	1			0	1										8	80%
Total Points and Overall Rating for Windows System																			88	80%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

WINDOW RATING INSTRUCTIONS

2 points: if the window has storm windows adequate for cold weather protection. The storm windows must fit tightly and block the wind from entering around the window.

2 points: if the window has protection from the direct sun during warm weather. Solar protection can be part of the building design such as overhang, awnings or physical shields. Protection can also be a tinted or reflective film applied to the windows, double-glazed windows, solar screening or trees blocking out direct sunlight.

2 points: for a tight-fitting window. A window is tight-fitting if the infiltration will not be detected around the window during a windy day. The window must fit well and all caulking must be in place. Weatherstripping will contribute to a tight fit.

1 point: if the wind has some infiltration around the window. The window should fit fairly well and not be loose and rattle.

0 points: if infiltration can be felt to a large degree. The window is loose in the frame and caulking is missing or in poor condition.

3 points: if the window is designed, so physically it cannot be opened.

0 points: if it can be opened. It will be opened to "regulate" room temperature.

1 point: if window is weatherstripped all around and the weatherstripping is in good condition.

The Condition Survey

System:	Ceiling System																				
Date:																					
Auditor:	HK																				
Comments:																					
These are sample comments for the lighting systems condition survey.		Drop Ceiling	Insulated Drop Ceiling	Insulated Regular Ceiling	Space Not Mech. Vented	All Panels in Place	Panels Broken	Panels Missing												Total Points	Rating for Location
No.	Location / Points	1	1	1	1	2	1	0													

Maximum Points		1	1	1	1	2		0											6	100%
1	CSD	1	1	1	1	1													5	83%
2	M&T	1	1	1		2													5	83%
3	Finance	1	1	1		2													5	83%
4	CSD_1	1	1	1	1	1													5	83%
5	HR	1	1	1	1	1													5	83%
6	Finance_1	1	1	1		2													5	83%
7	Operations	1	1	1	1	1													5	83%
8	Engineering	1	1	1	1	1													5	83%
9	ICT	1	1	1	1	1													5	83%
10	Audit	1	1	1	1	1													5	83%
11	CSD_2	1	1	1	1	1													5	83%
																			0	0%
Total Points and Overall Rating for Ceiling System																			55	83%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

CEILING RA TING INS TRU CTIONS

1 point if a drop ceiling exists.
1 point if insulation exists above ceiling on top floor below roof or mechanical space. 1 point if there is no insulated regular ceiling.
1 point if space above drop ceiling is mechanically vented. Natural draft is not considered mechanical venting.
2 points if all panels are in place and in good condition and no broken or missing panels are present.

1 point if panels are broken or in poor condition.
0 points if panels are missing or removed and out of place.

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and

2. # ACCRA EAST

The Condition Survey

System:	Air Conditioning System																			
Date:		Standard Op. Procedures	Control Good	Control Average	Control Poor	Preventive Maintenance	Fix as Required	Condition as Required	Constant Conditioning	Zone Control Good	Zone Control Average	Zone Control Poor							Total Points	Rating for Location
Auditor:	HK																			
Comments These are sample comments for the lighting systems condition survey.																				
No.	Location / Points	1	2	1	0	1	0	1	0	2	1	0								
Maximum Points		1	2			1		1		2									7	100%
1	CSD	1	2			1		1			1								6	0%
2	M&T	1	2			1		1			1								6	0%
3	Finance	1	2			1		1			1								6	0%
4	CSD_1	1	2			1		1			1								6	0%

5	HR	1	2			1		1			1								6	0%
6	Finance_1	1	2			1		1			1								6	0%
7	Operations	1	2			1		1			1								6	0%
8	Engineering	1	2			1		1			1								6	0%
9	ICT	1	2			1		1			1								6	0%
10	Audit	1	2			1		1			1								6	0%
11	CSD_2	1	2			1		1			1								6	0%
																			0	0%
Total Points and Overall Rating for Air Conditioning System																			66	86%

adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

AIR CONDITIONING RATING INSTRU CTIONS

1 point if definite standard operating procedures are used. These should be written and posted near the control panel.

2 points if the control system for each area is adequate. The control system maintains the temperature in each room close to the thermostat setting.

1 point if the control system for each area is only a general control without the ability to control each room. 0 points if the control system has little or no control over the area temperature. Also included here is a control system that allows the heating and cooling systems to oppose each other in the same

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and general areas. 1 point if a definite preventive maintenance schedule is followed.

0 points if equipment is maintained or repaired only when it breaks down.

1 point if the area is conditioned only when occupied. This will apply especially to auditoriums, work rooms, hobby shops, TV rooms, etc. 0 points if the area is conditioned all the time regardless of occupancy.

2 points if the zone control is good and certain areas can be secured when not in use or require less temperature conditioning. 1 point if the zone control allows only general areas to be secured when conditions dictate.

0 points if zone control cannot be secured without securing a large general area

3. ACCRA EAST

The Condition Survey

System: Exterior Walls System

Date:

Auditor: HK

Comments

These are sample comments for the lighting systems condition survey.

No.	Location / Points	Recording Meter	Usage Pattern	Power Co. Coordination	Power Peak Warning	Power Demand Limited	Standard Op. Procedures	Preventive Maintenance	Fix as Required	8% Power Factor									Total Points	Rating for Location
		2	1	1	1	1	1	1	0	2										

Maximum Points		2	1	1	1	1	1	1	0	2									10	100%
1	CSD	2	1	1	1	1	1	1		2									10	0%
2	M&T	2	1	1	1	1	1	1		2									10	0%
3	Finance	2	1	1	1	1	1		0	2									9	0%
4	CSD_1	2	1	1	1	1	1	1		2									10	0%
5	HR	2	1	1	1	1	1		0	2									9	0%
6	Finance_1	2	1	1	1	1	1		0	2									9	0%
7	Operations	2	1	1	1	1	1	1		2									10	0%
8	Engineering	2	1	1	1	1	1			2									9	0%
9	ICT	2	1	1	1	1	1		0	2									9	0%
10	Audit	2	1	1	1	1	1			2									9	0%
11	CSD_2	2	1	1	1	1	1	1		2									10	0%
																			0	0%
Total Points and Overall Rating for Exterior Walls System																			104	95%

adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

ELECTRICAL POWER RATING INSTRU CTIONS

2 points for operation of a recording ammeter.
1 point
for
hourly

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and electrical usage pattern of building being determined. 1 point for study of electrical requirements with power company staff. 1 point for insta

llationofapowerpeakwarningsystem.1po

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and intforanalysistoeliminatepowerpeakd

emands.

1 point if definite standard operating procedures are used. These must be written and posted near the control panel.

1 point if a definite preventive maintenance schedule is followed.

0 points if equipment is maintained or repaired only when it breaks down. 2 points for overall system power factor of 90% or above at main service

The Condition Survey

ACCRA EAST

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and

System:	Food Areas System																			
Date:		Equipment Turned Off	Equipment Left On	Refrigeration Doors Closed	Refrigeration Doors Ajar	Faucets Not Leaking	Faucets Leaking	Access Doors Closed	Good Vent Hoods	Average Vent Hood	Poor Vent Hood	Adequate Ventilation	Refrigeration Equip. Good	Refrigeration Equip. Average	Refrigeration Equip. Poor	Heat Recovery System			Total Poin ts	Rating for Location
Auditor:	HK																			
Commen :s:																				
No.	Location / Points	2	0	1	0	1	0	3	2	1	0	1	2	1	0	3				
Maximum Points		2		1		1		3	2			1	2			3			15	100%
1	CSD	2		1		1		3		1		1	2			3			14	0%
2	M&T	2		1		1		3	2		0		2			3			14	0%
3	Finance	2		1		1		3	2			1	2			3			15	0%
4	CSD_1	2		1		1		3	2			1		1		3			14	0%
5	HR	2		1		1		3	2			1	2			3			15	0%
6	Finance_1	2		1		1		3	2			1	2			3			15	0%
7	Operations	2		1		1		3	2			1	2			3			15	0%
8	Engineering		0	1		1		3	2			1	2			3			13	0%
9	ICT	2			0	1		3	2			1	2			3			14	0%

10	Audit	2		1		1		3	2			1	2			3			15	0%
11	CSD_2	2		1		1		3	2			1	2			3			15	0%
																			0	0%
Total Points and Overall Rating for Food Areas System																			159	96%

adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

FOOD AREAS RATING INSTRUCTIONS

2 points if the food preparation equipment is only energized when actually needed. This includes, but is not limited to, ovens, warmers, steam tables, delivery equipment and coffee urns.

0 points if equipment is turned on and left on all day.

1 point if refrigerator and freezer doors are kept tightly closed. 0 points if refrigerator and freezer doors can be left ajar.

1 point if faucets and valves are in good condition and not leaking.

0 points if faucets and valves are

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and leaking. Leaks may be outside or inside the system. 3 points if doors between kitchen area and other areas are kept closed.

2 points if adequate vent hoods are used over heat-producing equipment.

1 point if some vent hoods are used over heat-producing equipment.

0 points if no or inadequate vent hoods are used.

1 point if ventilation air supply is adequate to remove most of the heat produced by the kitchen equipment. 2 points if refrigerator equipment is in good repair, seals are good, condenser is clean, and air passage over condenser is clear.

1 point if refrigeration equipment is in average condition, dust and dirt exist on condensers but the airflow is not restricted, and door gaskets seal all around although they may have lost some resiliency.

0 points if refrigeration equipment is in poor condition, a large collection of dust and dirt on the condenser or the fins may be bent to restrict airflow, and door gaskets do not seal all around, are brittle, broken or missing.

3 points if heat recovery systems are utilized. These can be applied to the exhaust air, the hot wastewater or the refrigeration equipment.

The Condition Survey ACCRA EAST

System: Exterior Doors System

Date:

Auditor: HK

Comments:

These are sample comments for the lighting systems condition survey.

No.	Location / Points	Air Lock	Door Has Closer	Closer Has No Hold-Open	Closer Has a Hold-Open	Snug Fit	Average Fit	Loose Fit	Weatherstrip 4 Edges	Weatherstrip Jamb Head	No Weatherstrip	Wind Screens or Other							Total Points	Rating for Location
		2	1	1	0	2	1	0	2	1	0	1								
Maximum Points		2	1	1		2			2	1		1							10	100%
1	CSD				0	2			2										4	40%
2	M&T				0	2			2										4	40%
3	Finance				0	2			2										4	40%
4	CSD_1				0	2			2										4	40%
5	HR				0	2			2										4	40%
6	Finance_1				0	2			2										4	40%
7	Operations				0	2			2										4	40%
8	Engineering				0	2			2										4	40%
9	ICT				0	2			2										4	40%
10	Audit				0	2			2										4	40%

11	CSD_2				0	2			2										4	40%
																			0	0%
Total Points and Overall Rating for Exterior Doors System																			44	40%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

DOOR RATING INSTRUCTIONS

This section applies to all doors that open to the outside and all doors that open to an unconditioned space such as warehouses and storerooms.

2 points if door is part of an air-lock system.

1 point if door has a closer, which may be spring, air or hydraulic. 1 point if door closer does not have a hold-open feature.

0 points if door closer has a hold-open feature.

2 points if door fits snugly into the door-frame with no loose condition and where no infiltration exists around the edges.

1 point if door is an average fit and can be slightly rattled in the frame and has a slight infiltration around the edges.

0 points if door is loose in the frame and infiltration exists.

2 points if weatherstripping exists on all four edges and is in good condition. (Thresholds with elastic or fibre to close the space and astragals on double doors are considered weatherstripping.)

1 point if weatherstripping exists on jambs and head only.

0 points if no weatherstripping exists or if it exists and is in poor condition.

1 point if door is protected from outside wind. This can be building design, windscreen or shrubbery.

4. ACCRA EAST

The Condition Survey

System:	Exterior Walls System																			
Date:		Insulated	Not Insulated	Solar Protection	Watertight	Cracked or Broken	Open to Unconditioned Space												Total Points	Rating for Location
Auditor:	HK																			
Comments These are sample comments for the lighting systems condition survey.																				
No.	Location / Points	3	0	2	2	1	0													
Maximum Points		3		2	2														7	100%
1	CSD	3		2	2		0												7	0%
2	M&T	3		2	2		0												7	0%
3	Finance	3		2	2		0												7	0%
4	CSD_1	3		2	2														7	0%
5	HR	3		2	2														7	0%
6	Finance_1	3		2	2														7	0%
7	Operations	3		2	2														7	0%

8	Engineering	3		2	2														7	0%
9	ICT	3		2	2		0												7	0%
10	Audit	3		2	2														7	0%
11	CSD_2	3		2	2														7	0%
																			0	0%
Total Points and Overall Rating for Exterior Walls System																			77	100%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

WALL RATING INSTRU CTIONS

3 points if wall is designed to resist outside temperature differential. Insulation is present to substantially change heat transfer time. 0 points if wall is merely a physical separation without adequate insulating qualities.

2 points if outside wall surface has solar protection such as light finish, is heavily shaded or has physical sunscreens. 2 points if surfaces of walls are in good repair and not damaged.

1 point if inside is in average condition with a few small cracks in the surface and smaller plaster sections missing. 0 points if wall has openings to unconditioned space, i.e. plumbing or duct openings not closed.

The Condition Survey

5. ACCRA EAST

System: Roofs System

Date:

Auditor: HK

Comments

These are sample comments for the lighting systems condition survey.

No.	Location / Points	Dry Insulation	Wet Insulation	Reflective Surface	Ventilation Under Roof	No Leaks	Small Leaks	Many Leaks											Total Points	Rating for Location
		2	0	1	1	2	1	0												
Maximum Points		2		1	1	2													6	100%
1	CSD	2		1	1	2													6	0%
2	M&T	2		1	1	2													6	0%
3	Finance	2		1	1	2													6	0%
4	CSD_1	2		1	1	2													6	0%
5	HR	2		1	1	2													6	0%
6	Finance_1	2		1	1	2													6	0%
7	Operations	2		1	1	2													6	0%
8	Engineering	2		1	1	2													6	0%
9	ICT	1	0	1	1	0	1												4	0%
10	Audit	2		1	1	2													6	0%
11	CSD_2	2		1	1	2													6	0%
																			0	0%

Total Points and Overall Rating for Roofs System	64	97%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

The Condition Survey

System:	Lighting System
Date:	
Auditor:	HK

Comments

These are sample comments for the lighting systems condition survey.

No.	Location / Points	No Decorative Lighting	Light Work Area	Light Entire Room	Diffusers Good	Diffusers Average	Diffusers Poor	Reflection Good	Reflection Average	Reflection Poor	Source Appropriate	Source Not Appropriate	Lights Vented	Lights Turned Off	Illumination Adequate	Excessive Illumination			Total Points	Rating for Location
No.	Location / Points	1	1	0	2	1	0	2	1	0	1	0	1	1	1	0				
Maximum Points		1	1		2			2			1		1	1	1				10	100%
1	CSD			0	2			2			1		1	1	1				8	0%
2	M&T			0	2			2			1		1	1	1				8	0%
3	HR			0	2			2			1		1	1	1				8	0%
4	Finance			0	2			2			1		1	1	1				8	0%
5	Audit			0	2			2			1		1	1	1				8	0%
6	Engineering			0	2			2			1		1	1	1				8	0%
7	Operations			0	2			2			1		1	1	1				8	0%

8	ICT			0	2			2			1		1	1	1				8	0%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Lighting System																			64	80%

ACCRA WEST

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

LIGHTING RATING INS TRU CTIONS

1 point if extensive decorative lighting has been eliminated where used for appearance only (not security, walkway lighting and other necessities). 1 point if lighting has been arranged to illuminate only the work area.

0 points if lighting has been designed to illuminate the entire room to a working level. 2 points if light fixture diffuser is clean and clear.

1 point if diffuser is slightly yellowed or dirty.

0 points if diffuser is noticeably yellowed or dust is visible. This restriction can amount to 10% or more of the light flux being transmitted. 2 points if fixture internal reflective surface is in good condition (the paint is reflective and clean). 1 point if the fixture internal reflective surface gives dirt indication on clean white cloth. 0 points if the reflective surface is yellowed and dull.

1 point if the light source (T8, HPS, MH, LED ‘’Exit’’ lamps) are appropriate for the application. 0 points if an inappropriate light source is used.

1 point if lights are properly vented the heat can escape to ceiling space, providing that ceiling space is ventilated to prevent heat build-up. 1 point if lights are turned off when area is not occupied. 1 point if illumination level is adequate for designed usage. 0 points if area is “overilluminated” for designed use.

0 points if two or more lamps have blackened ends or are glowing without lighting.

The Condition Survey

ACCRA WEST

System:	Windows System																		
Date:		Storms	Solar Protection	Tight Fit	Minor Infiltration	Major Infiltration	Cannot Be Opened	Can Be Opened	Weatherstripped									Total Points	Rating for Location
Auditor:	HK																		
Comments:																			

No.	Location / Points	2	2	2	1	0	3	0	1											
Maximum Points		2	2	2	1		3												10	100%
1	CSD	2	2	2	1			0	1										8	80%
2	M&T	2	2	2	1			0	1										8	80%
3	HR	2	2	2	1			0	1										8	80%
4	Finance	2	2	2	1			0	1										8	80%
5	Audit	2	2	2	1			0	1										8	80%
6	Engineering	2	2	2	1			0	1										8	80%
7	Operations	2	2	2	1			0	1										8	80%
8	ICT	2	2	2	1			0	1										8	80%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Windows System																			64	80%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

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2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

WINDOW RATING INSTRUCTIONS

2 points: if the window has storm windows adequate for cold weather protection. The storm windows must fit tightly and block the wind from entering around the window.

2 points: if the window has protection from the direct sun during warm weather. Solar protection can be part of the building design such as overhang, awnings or physical shields. Protection can also be a tinted or reflective film applied to the windows, double-glazed windows, solar screening or trees blocking out direct sunlight.

2 points: for a tight-fitting window. A window is tight-fitting if the infiltration will not be detected around the window during a windy day. The window must fit well and all caulking must be in place. Weatherstripping will contribute to a tight fit.

1 point: if the wind has some infiltration around the window. The window should fit fairly well and not be loose and rattle.

0 points: if infiltration can be felt to a large degree. The window is loose in the frame and caulking is missing or in poor condition.

3 points: if the window is designed, so physically it cannot be opened.

0 points: if it can be opened. It will be opened to “regulate” room temperature.

1 point: if window is weatherstripped all around and the weatherstripping is in good condition.

The Condition Survey

1

System:	Air Conditioning System																			
Date:																				
Auditor:	HK																			

Comments

These are sample comments for the lighting systems condition survey.

No.	Location / Points	Standard Op. Procedures	Control Good	Control Average	Control Poor	Preventive Maintenance	Fix as Required	Condition as Required	Constant Conditioning	Zone Control Good	Zone Control Average	Zone Control Poor							Total Points	Rating for Location
		1	2	1	0	1	0	1	0	2	1	0								
Maximum Points		1	2			1		1		2									7	100%
1	CSD	1	2			1		1			1								6	0%
2	M&T	1	2			1		1			1								6	0%
3	HR	1	2			1		1			1								6	0%
4	Finance	1	2			1		1			1								6	0%
5	Audit	1	2			1		1			1								6	0%
6	Engineering	1	2			1		1			1								6	0%
7	Operations	1	2			1		1			1								6	0%
8	ICT	1	2			1		1			1								6	0%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Air Conditioning System																			48	86%

ACCRA WEST

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

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2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

AIR CONDITIONING RATING INSTRU CTIONS

1 point if definite standard operating procedures are used. These should be written and posted near the control panel.

2 points if the control system for each area is adequate. The control system maintains the temperature in each room close to the thermostat setting.

1 point if the control system for each area is only a general control without the ability to control each room. 0 points if the control system has little or no control over the area temperature. Also included here is a control system that allows the heating and cooling systems to oppose each other in the same general areas. 1 point if a definite preventive maintenance schedule is followed.

0 points if equipment is maintained or repaired only when it breaks down.

1 point if the area is conditioned only when occupied. This will apply especially to auditoriums, work rooms, hobby shops, TV rooms, etc. 0 points if the area is conditioned all the time regardless of occupancy.

2 points if the zone control is good and certain areas can be secured when not in use or require less temperature conditioning. 1 point if the zone control allows only general areas to be secured when conditions dictate.

0 points if zone control cannot be secured without securing a large general area

The Condition Survey

ACCRA WEST

System: Ceiling System

Date:

Auditor: HK

Comments:

These are sample comments for the lighting systems condition survey.

No.	Location / Points	Drop Ceiling	Insulated Drop Ceiling	Insulated Regular Ceiling	Space Not Mech. Vented	All Panels in Place	Panels Broken	Panels Missing											Total Poin ts	Rating for Location
		1	1	1	1	2	1	0												
Maximum Points		1	1	1	1	2		0											6	100%
1	CSD	1	1	1	1	2													6	100%
2	M&T	1	1	1	1	2													6	100%
3	HR	1	1	1	1	2													6	100%
4	Finance	1	1	1	1	2													6	100%
5	Audit	1	1	1	1	2													6	100%
6	Engineering	1	1	1	1	2													6	100%
7	Operations	1	1	1	1	2													6	100%
8	ICT	1	1	1	1	2													6	100%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Ceiling System																			48	100%

Validation of Data	An "X" these cells indicated that there is an error in that column.

Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

1. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

CEILING RA TING INS TRU CTIONS

1 point if a drop ceiling exists.

1 point if insulation exists above ceiling on top floor below roof or mechanical space. 1 point if there is no insulated regular ceiling.

2 point if space above drop ceiling is mechanically vented. Natural draft is not considered mechanical venting.

3 points if all panels are in place and in good condition and no broken or missing panels are present.

1 point if panels are broken or in poor condition.

0 points if panels are missing or removed and out of place.

The Condition Survey

4

System: Exterior Walls System

Date:

Auditor: HK

Comments

These are sample comments for the lighting systems condition survey.

		Recording Meter	Usage Pattern	Power Co. Coordination	Power Peak Warning	Power Demand Limited	Standard Op. Procedures	Preventive Maintenance	Fix as Required	8 % Power F actor									Total Poin ts	Rating for Location
No.	Location / Points	2	1	1	1	1	1	1	0	2										
Maximum Points		2	1	1	1	1	1	1	0	2									10	100%
1	CSD	2	1	1	1	1	1	1		1									9	0%
2	M&T	2	1	1	1	1	1	1		1									9	0%
3	HR	2	1	1	1	1	1	1		1									9	0%
4	Finance	2	1	1	1	1	1	1		1									9	0%
5	Audit	2	1	1	1	1	1	1		1									9	0%
6	Engineering	2	1	1	1	1	1	1		1									9	0%
7	Operations	2	1	1	1	1	1	1		1									9	0%
8	ICT	2	1	1	1	1	1	1		1									9	0%
																			0	0%
																			0	0%
																			0	0%
																			0	0%

Total Points and Overall Rating for Exterior Walls System	72	90%

ACCRA WEST

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

6. Below is a checklist template for collecting information. It includes a point rating system. The checklist template can be readily modified and adapted to your facility; for example, in a survey of lighting, a line can be created for each room or distinct area in your facility.

7. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

ELECTRICAL POWER RATING INSTRU CTIONS

2 points for operation of a recording ammeter.
1 point for hourly electrical usage pattern of building being determined. 1 point for study of electrical requirements with power company staff.
1 point for installation of a power peak warning system. 1 point for analysis to eliminate power peak demands.
1 point if definite standard operating procedures are used. These must be written and posted near the control panel.

1 point if a definite preventive maintenance schedule is followed.
0 points if equipment is maintained or repaired only when it breaks down. 2 points for overall system power factor of 90% or above at main service

The Condition Survey

ACCRA WEST

System:	Food Areas System																			
Date:		Equipment Turned Off	Equipment Left On	Refrigeration Doors Closed	Refrigeration Doors Ajar	Faucets Not Leaking	Faucets Leaking	Access Doors Closed	Good Vent Hoods	Average Vent Hood	Poor Vent Hood	Adequate Ventilation	Refrigeration Equip. Good	Refrigeration Equip. Average	Refrigeration Equip. Poor	Heat Recovery System			Total Points	Rating for Location
Auditor:	HK																			
Commen :s:																				
No.	Location / Points	2	0	1	0	1	0	3	2	1	0	1	2	1	0	3				
Maximum Points		2		1		1		3	2			1	2			3			15	100%
1	CSD	2		1		1		3	2			1	2			3			15	0%
2	M&T	2		1		1		3	2			1	2			3			15	0%
3	HR	2		1		1		3	2			1	2			3			15	0%
4	Finance	2		1		1		3	2			1	2			3			15	0%
5	Audit	2		1		1		3	2			1	2			3			15	0%
6	Engineering	2		1		1		3	2			1	2			3			15	0%

7	Operations	2		1		1		3	2			1	2			3			15	0%
8	ICT	2		1		1		3	2			1	2			3			15	0%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Food Areas System																			120	100%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

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2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

FOOD AREAS RATING INSTRUCTIONS

2 points if the food preparation equipment is only energized when actually needed. This includes, but is not limited to, ovens, warmers, steam tables, delivery equipment and coffee urns.

0 points if equipment is turned on and left on all day.

1 point if refrigerator and freezer doors are kept tightly closed. 0 points if refrigerator and freezer doors can be left ajar.

1 point if faucets and valves are in good condition and not leaking.

0 points if faucets and valves are leaking. Leaks may be outside or inside the system. 3 points if doors between kitchen area and other areas are kept closed.

2 points if adequate vent hoods are used over heat-producing equipment.

1 point if some vent hoods are used over heat-producing equipment.

0 points if no or inadequate vent hoods are used.

1 point if ventilation air supply is adequate to remove most of the heat produced by the kitchen equipment. 2 points if refrigerator equipment is in good repair, seals are good, condenser is clean, and air passage over condenser is clear.

1 point if refrigeration equipment is in average condition, dust and dirt exist on condensers but the airflow is not restricted, and door gaskets seal all around although they may have lost some resiliency.

0 points if refrigeration equipment is in poor condition, a large collection of dust and dirt on the condenser or the fins may be bent to restrict airflow, and door gaskets do not seal all around, are brittle, broken or missing.

3 points if heat recovery systems are utilized. These can be applied to the exhaust air, the hot wastewater or the refrigeration equipment.

The Condition Survey

ACCRA WEST

System:	Exterior Doors System
Date:	
Auditor:	HK
Comments:	
These are sample comments for the lighting systems condition survey.	

No.	Location / Points	Air Lock	Door Has Closer	Closer Has No Hold-Open	Closer Has a Hold-Open	Snug Fit	Average Fit	Loose Fit	Weatherstrip 4 Edges	Weatherstrip Jamb Head	No Weatherstrip	Wind Screens or Other							Total Points	Rating for Location
		2	1	1	0	2	1	0	2	1	0	1								
Maximum Points		2	1	1		2			2	1		1							10	100%
1	CSD				0	2			2										4	40%
2	M&T				0	2			2										4	40%

3	HR				0	2			2										4	40%
4	Finance				0	2			2										4	40%
5	Audit				0	2			2										4	40%
6	Engineering				0	2			2										4	40%
7	Operations				0	2			2										4	40%
8	ICT				0	2			2										4	40%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Exterior Doors System																			32	40%

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

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2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

DOOR RATING INSTRUCTIONS

This section applies to all doors that open to the outside and all doors that open to an unconditioned space such as warehouses and storerooms.

2 points if door is part of an air-lock system.

1 point if door has a closer, which may be spring, air or hydraulic. 1 point if door closer does not have a hold-open feature.

0 points if door closer has a hold-open feature.

2 points if door fits snugly into the door-frame with no loose condition and where no infiltration exists around the edges.

1 point if door is an average fit and can be slightly rattled in the frame and has a slight infiltration around the edges.

0 points if door is loose in the frame and infiltration exists.

2 points if weatherstripping exists on all four edges and is in good condition. (Thresholds with elastic or fibre to close the space and astragals on double doors are considered weatherstripping.)

1 point if weatherstripping exists on jambs and head only.

0 points if no weatherstripping exists or if it exists and is in poor condition.

1 point if door is protected from outside wind. This can be building design, windscreen or shrubbery.

The Condition Survey	5
System:	Exterior Walls System
Date:	
Auditor:	HK

Comments These are sample comments for the lighting systems condition survey.		Insulated	Not Insulated	Solar Protection	Watertight	Cracked or Broken	Open to Unconditioned Space												Total Points	Rating for Location
No.	Location / Points	3	0	2	2	1	0													
Maximum Points		3		2	2														7	100%
1	CSD	3		2	2														7	0%
2	M&T	3		2	2														7	0%
3	HR	3		2	2														7	0%
4	Finance	3		2	2														7	0%
5	Audit	3		2	2														7	0%
6	Engineering	3		2	2														7	0%
7	Operations	3		2	2														7	0%
8	ICT	3		2	2														7	0%
																			0	0%
																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Exterior Walls System																			56	100%

ACCRA WEST

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

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WALL RATING INSTRU CTIONS

3 points if wall is designed to resist outside temperature differential. Insulation is present to substantially change heat transfer time. 0 points if wall is merely a physical separation without adequate insulating qualities.

2 points if outside wall surface has solar protection such as light finish, is heavily shaded or has physical sunscreens. 2 points if surfaces of walls are in good repair and not damaged.

1 point if inside is in average condition with a few small cracks in the surface and smaller plaster sections missing.

0 points if wall has openings to unconditioned space, i.e. plumbing or duct openings not closed.

The Condition Survey

6

System: Roofs System

Date:

Auditor: HK

Comments

These are sample comments for the lighting systems condition survey.

		Dry Insulation	Wet Insulation	Reflective Surface	Ventilation Under Roof	No Leaks	Small Leaks	Many Leaks											Total Points	Rating for Location
No.	Location / Points	2	0	1	1	2	1	0												
Maximum Points		2		1	1	2													6	100%
1	CSD	2		1	1	2													6	0%
2	M&T	2		1	1	2													6	0%
3	HR	2		1	1	2													6	0%
4	Finance	2		1	1	2													6	0%
5	Audit	2		1	1	2													6	0%
6	Engineering	2		1	1	2													6	0%
7	Operations	2		1	1	2													6	0%
8	ICT	2		1	1	2													6	0%
																			0	0%

																			0	0%
																			0	0%
																			0	0%
Total Points and Overall Rating for Roofs System																			48	100%

ACCRA WEST

Validation of Data	An "X" these cells indicated that there is an error in that column.																
Error: Maximum Points to Large																	
Error: Invalid Score for a Location																	

NOTE:

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2. The rating is based on a three-point system in which 3 represents a condition reflecting high energy efficiency and 0 represents a condition reflecting low energy efficiency. The rating indicates the urgency of corrective action.

ROOF RATING INS TRU CTIONS

2 points if roof insulation is in dry condition.

0 points if roof insulation is in poor condition, wet, aged, brittle, cracked, etc., or if no insulation exists.

1 point if roof has a reflective surface; this may be the type of material used or the colour and condition of surface (gravel, etc.). 1 point if mechanical ventilation exists between roof and ceiling below. This should be properly sized so adequate airflow exists. 2 points if no leaks exist in the roof.

1 point if minor leaks exist.

0 points if there are many leaks.