KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF HUMANITIES AND SOCIAL SCIENCES

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF ECONOMICS

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ENERGY EFFICIENCY AND MANAGEMENT IN INDUSTRIES – A CASE STUDY OF KAASE INDUSTRIAL AREA IN KUMASI

THIS DISSERTATION IS PRESENTED TO THE DEPARTMENT OF ECONOMICS IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN ECONOMICS (ENERGY AND RESOURCE ECONOMICS OPTION)

BY

OPOKU CURTIS WAYLON

MAY, 2016

DECLARATION

a) I declare that we have wholly undertaken the study reported herein under the supervision of Dr. (Sr) Eugenia Amporfu and that except portions where reference have been duly cited, this dissertation is the outcome of my research.

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……. ……..

DATE **SIGNATURE**

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(STUDENT)

b) I declare that I have supervised the student who has undertaken the study reported herein and confirm that the student has my permission to present it for assessment

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DEDICATION

This work is dedicated to the Lord Almighty who has seen me through my year of studying at Kwame Nkrumah University of Science and Technology. Also, not forgetting my General Overseer Rev. Victor Kusi Boateng and Power Chapel Worldwide for their prayers and financial support during my year of studying. God bless you all.

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ACKNOWLEDGEMENT

I owe my deepest gratitude to God for his unceasing grace which has seen me through this research project.

I am heartily thankful to all my lecturers especially my supervisor, Dr. (Sr) Eugenia Amporfu whose encouragement, guidance and support from the initial to the final level enabled me to develop an understanding of the research.

A special thanks goes to all interviewed personnel of Department of Factory Inspectorate Kumasi, Ghana Chamber of Commerce & Industry and industrial respondents (especially Mr. Fosu Yeboah and Mr. Stephen Oppong-Koduah)

Lastly, I offer my regards and blessings to Rev. Victor Kusi Boateng, the pastoral board and the Administrative office of Power Chapel Worldwide. My family and friends can never be left out without thanking them for their support and encouragement in any respect during the completion of the project.

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ABSTRACT

Energy is and has always been the backbone of the industrial sector of every economy in the world. The sustainability of the industrial sector of every economy depends on how strong that economy or country is willing to make maximum and efficient use of its energy for national development. The efficient use and management of energy enables industries to save cost (make profits) and thus reduce wastage and carbon dioxide emissions. However, industries are finding it difficult (especially in developing countries) to implement energy efficiency and management measures due to factors such as financial constraints, energy price hikes, lack of technical expertise, just to mention a few.

The purpose of this study is to throw more light on the current level of energy efficiency and management measures adopted by industries within the Kaase Industrial area in Kumasi. The study also investigates the existing barriers which mitigates the implementation of energy efficiency and management measures in the industrial area. Another aspect that was also looked at was the driving forces that propelled industries to implement energy efficiency and management measures. To make this study more realistic, questionnaires were administered to both medium and large scale companies in the industrial area. In the questionnaire, respondents were asked to fill in various sections which covered the study area such as the energy management profile, energy information sources, energy efficiency opportunities, etc.

The final results of the study revealed that efficiency gap was in existence since there was low implementation of energy efficiency measures. This was due to the barriers which mitigates the implementation of these measures. In addition, more than half of the industries did not have energy management policies implemented in their companies. Energy audits was also on the low side as industries rarely engaged the services of energy consultants in helping them review their energy

efficiency and management structures. On the high side, majority of the industries did implement the use of efficient machinery and office equipment and the use of energy saving bulbs at their workplace which are cost-effective and profitable. Factors such as “expectation of rise in energy prices” and “statutory requirement for energy efficiency” were the major drivers for implementing energy efficiency measures.

At the end of the study, it was recommended that government should pay much more attention to improve energy efficiency in the Kaase industrial area by empowering the Energy Commission so as to allow them to provide more technical services to these companies.

Also, it was recommended that, industries in the area should adopt a comprehensive energy audit system. The services of energy auditors can be taken advantage of in order to create a data bank for energy and its related issues in the industries.

Another policy which was recommended to industries in the area was the implementation of a comprehensive energy policy. This will help provide a basic framework within which the overall goal of energy can be achieved. This can be done through the upgrading of the skills of the energy managers in the companies to equip them with the requisite skills to manage energy issues better.

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ACRONYMS

ATK	Aviation Turbine Kerosene
BPA	Bui Power Authority
BPSD	Barrels per Stream Day
CFL	Compact Fluorescent Lamp
EC	Energy Commission
ECG	Electricity Company of Ghana
EnMSs	Energy Management Systems
FMEA	Failure Mode and Effects Analysis
GHG	Green House Gases
GNPC	Ghana National Petroleum Corporation
GRIDCO	Ghana Grid Company
GWH	Gigawatt per Hour
IEA	International Energy Agency
IPP	Independent Power Producers
ISO	International Organization for standardization
KMA	Kumasi Metropolitan Assembly
LPG	Liquefied Petroleum Gas
Mmscfd	Million standard cubic feet per day
MOE	Ministry of Energy
MW	Megawatt
NBSSI	National Board for Small Scale Industries
NED	Northern Electricity Department
NG	Natural Gas
NITS	National Interconnected Transmission System
NPA	National Petroleum Authority

PURC	Public Utilities Regulatory Commission
RFO	Residual Fuel Oil
TAPCO	Takoradi Power Company
TICO	Takoradi International Power Company
TOR	Tema Oil Refinery
Tscf	Trillion standard cubic feet
VALCO	Volta Aluminium Company
VRA	Volta River Authority
WAGP	West Africa Gas Pipeline

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CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Background to the Study

Energy is vital for everyday activities and thus a necessity for the growth of every economy. The abundance of energy resources within a nation or economy is an indication that such economy has greater prospects of achieving its development goals. Ghana is endowed with some basic energy resources, which include crude oil and natural gas. Energy is mostly used for residential, non-residential and industrial purposes. In Ghana, the industrial sector consumes chunk of the nation‟s energy due to the growing and vast number of industries springing up in the country. However as the country develops coupled with increasing population, consistent and maintainable energy provision becomes a challenge for the government. This becomes a difficulty because of the ecological and fiscal influence of energy creation and usage. (Energy Commission, 2006).

Electricity is the chief energy source used by Ghanaian industries accounting for about 70% of energy usage. Currently, the country is in power crisis and experiencing load shedding. These power crises has affected many industries and thus making it difficult for them to operate at full capacity and as such are not able to break-even. This therefore has affected the profit margins of many industries in the country. The supply of energy has severe repercussions on the environment and finances of the nation and for this reason controlling energy consumption should be taken seriously. (Energy Commission, 2006).

Worldwide, energy processes have been recognized to have significant effects on the environment as compared to other divisions of an economy. For instance, huge hydropower projects usually destroy fertile farmlands and also have adverse effects on human dwellings. Issues of global

warming and emission of poisonous fumes in the atmosphere as a result of energy operations have all become important topics at the local and international levels. (Energy Commission, 2006)

Energy efficiency is very important to most governments in recent times due to its numerous implications. Governments have therefore prioritized the task of energy efficiency; pursuing a reduction in both domestic and industrial energy consumption to promote sustainability. Referred to as the "hidden" or "first fuel," improved efficiency seems an obvious policy choice since it usually pays back on the investment and is readily available. However, actions do not always follow intentions, and despite the strong consensus behind energy efficiency, numbers show that the impact of energy efficiency on demand has fallen by half over the last 20 years compared with the previous 20 years. (IEA, 2014).

According to the United Nations Industrial Development Organization (UNIDO), energy use in industries is perceived to mature between 1.8% and 3.1% annually over the next twenty-five (25) years. In countries with transitional economies, supply of energy can increase up to fifty percent (50%) that is, not including transport (UNIDO, 2011a). From these two statements, it can be said that high energy demand without a commensurate energy efficient facility and management strategies by industries can lead to a fall in production and proceeds from returns.

Energy Efficiency can be said to be a vital tool to conserve the environment in that, decreased energy consumption reduces discharges and may positively affect economic performance of a country. Economic performance may improve, as the various technologies aimed to ensure energy efficiency are beneficial and may increase profits of industries thereby leading to general economic growth. (UNIDO, 2011b). With this, one of the ways through which most industries can get on track in production and break-even is through technological advancement where firms adopt the most energy efficient resources or facilities to help in further production. However, in developing

countries such as Ghana, industries are having tough times breaking even due to the ongoing energy crisis (notably electricity) which has existed intermittently over the past few years. Aside the lack of technological advancement, there are other barriers such as difficulty is accessing capital, imperfect information on energy efficiency and management strategies, market failure (related to energy-efficient goods and service), risk involved in energy efficiency investments as well as countless unseen costs (UNIDO, 2011c).

The above mentioned barriers show how important it is for government institutions and policy makers to intervene in bridging the current energy efficiency gap. This can be done by enhancing the energy market through the preparation of wide-ranging and groundbreaking policies. However the success of every policy depends on an in-depth knowledge of the obstructions and how it can be dealt with as well as an accurate examination of the expected effects of the policy. (Golove & Eto, 1996).

Energy price increments have caused huge economic risks to most industries, which in turn has led to low productivity in those firms. According to a survey by the Centre for Policy Analysis (CEPA) in partnership with Energy Commission Ghana to assess industrial intensity, disclosed that energy intensive manufacturing processes in industries in Ghana are high in relation to related procedures in some developed countries like USA and Germany. This disparity has been credited to energy efficiency practices and technologies, which are deemed to be poor in Ghana, which shows how necessary it is to ensure an improvement in the area.

Currently, the industrial sector in the country has a power factor not up to approximately ninety percent (90%) at present. Moreover, there are no pollution charges in place so there is little or no motivation for industries to continually progress in the energy use efficiency area. (Energy

Commission, 2006).

1.2 Problem Statement

In this era of energy crisis, which the country is facing, many firms and industries are not able to operate at full capacity. This makes it difficult for most industries to realize maximum profit. The continuous operation of firms depends on the energy efficiency and management policies been adopted by these firms in order to remain in business. No research work has been done on energy efficiency and management policies in industries in the Kaase industrial area to know how these industries are faring in times of power fluctuations. This research work was being conducted to find out how these industries were able to remain in business in period of power fluctuations in relation to the energy efficiency and management policies been adopted by them.

1.3 Research questions

This study aimed at providing responses to these questions, which follow;

- What are the current energy efficiency and industrial energy management practices adopted by industries located in the Kaase area and how effective these strategies are?
- What are the obstacles that hinder the execution of energy efficiency actions by industries in Kaase industrial area?
- What are some of the measures that can ensure efficient use of energy?

1.4 Research objectives

The main objective of this thesis was to find out how firms are able to use energy efficiently in order to remain in business.

Specifically, this thesis attempted:

- To explore the current energy efficiency and industrial energy management practices adopted by industries located in the Kaase area and how effective these strategies are
- To Study the obstacles that hinder the execution of energy efficiency actions by industries in

Kaase

- Make recommendations to ensure efficient energy use

1.5 Methodology

The methodology that was adopted in this thesis was based on primary data which was used to gather relevant information connected to energy productivity and management practices in the Kaase industrial area. Secondary data from books, articles, publications and the Internet were also used. Questionnaires were also administered to respondents to fill in order to solicit their views. Short interviews were also conducted where appropriate.

1.5.1 Data Analysis

Data gathered were analyzed both qualitatively and quantitatively. Charts such as graphs and tables were also used. All estimations that were gathered were analyzed using specific statistical software (SPSS).

1.6 Scope of Study

The scope of the study covered industries within the Kaase Industrial area. It included medium and large-scale industries within the Kaase environs. This research work looked at the current state of how industries were faring in the period of energy crisis that the country is facing.

1.7 Justification of Study

With the continuous and increased power rationing that the country is facing, industries definitely cut their production quota which has led to many employees been laid off. This was as a result of company profits been minimized since industries were finding it difficult to meet the demands of their staff.

This study answered the questions as to what energy efficiency and energy management measures that were put in place in the period of power rationing. It also answered the major barriers which hindered the implementation of these energy efficiency and management strategies. It again

answered the implication of these barriers and the driving forces behind them. Finally, recommendations were made as to how industries can efficiently utilize energy in order to remain in business most especially in periods of power rationing.

Kaase was chosen as the study area because it is the most industrialized place in Kumasi. It houses most of the big industries in Kumasi. The industries span from wood processing, food and beverages, cement factory, oil depots among others. Due to the size of these industries and the equipment they use, energy is greatly consumed. Industries in this area are however been affected by the power crisis the country is facing. There was the need to study how these industries are able to cope with this power crisis

1.8 Organization of Study

The study was structured into five divisions:

The first chapter covered general outline and background to the entire work.

The next chapter also focused on the appraisal of collected works and definition of the thesis.

This was the review of other people‟s investigations on industrial energy efficiency and management.

Chapter three threw more light on and expanded the methodology that was used in the thesis.

Chapter four covered the presentation and analysis of findings.

Chapter five was about conclusion of the study and suggested recommendations for policy consideration.

1.9 Limitations of the Study

A total of 45 companies (45 questionnaires administered) were visited with 15 declining. This was due to the long chain of command that existed in those companies. There were also unwillingness on most companies to give vital information concerning their annual turnover though they were

assured of the confidentiality of their information. There were portions of the questionnaire that were not responded to as a result of restricted understanding of the respondent, moreover some of them required the assistance of another department. There were also difficulty in retrieving information from energy service bodies and energy regulatory bodies due to their bureaucratic systems. Notwithstanding these limitations, efforts were made to gather data from all the 30 companies in the study area and the results showed a true reflection of how industries are faring in the Kaase industrial area in Kumasi.

CHAPTER 2

LITERATURE AND THEORETICAL REVIEW

2.1 Definition of Energy

Generally, energy can been described as the capability to perform a particular work or produce heat. Mostly heat is produced when fuel is burnt; for instance it is generated when an element with inner energy is burnt or through the trapping of the sun rays or from beneath the earth surface through rocks. Likewise, the capability to perform work depends on abilities often referred to as

potential energy which is likened to water stored in a dam or its expression with regards to transforming to motive power often identified as kinetic energy which is also compared to tidal waves (Subhes, 2011).

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2.2 Law of thermodynamics

There are two fundamental laws of thermodynamics governing the flow of energy in physical science. The first states that energy cannot be created or destroyed but it can only be converted or changed which is referred to as a statement of material balance. This shows that energy is totally balanced at all periods. Similarly, the other law talks about energy quality. It advocates that any conversion of energy entails the production of low energy grade, which might not be suitable for work, and it is not possible to disregard this in totality. This therefore executes physical limitations on energy consumption.

2.3 Classification of Energy

Energy can be classified into the following four main categories; it consist of primary and secondary forms; renewable and non-renewable energy; Commercial and non-commercial energy; and finally Conventional and non-conventional forms of energy.

2.3.1 Primary and Secondary Energy

This is referred to as energy that is obtained from natural resources, that is they do not go through any form of alterations except separation and cleaning. Nuclear power, solar energy, crude oil and coal are all natural energy forms.

In contrast, the secondary energy types are the primary ones that have undergone transformational procedures. For this reason products from oil and electricity can be tagged as secondary forms of energy. These types need machines to produce and refine them.

2.3.2 Renewable and Non-Renewable Energy

As their names suggest, renewable energy is a type that is continuously available for present and future generations. They are usually obtained from natural sources which replenishes itself through natural means and it includes wind and solar. Alternatively, non-renewable energy reduces as consumption takes place. It is usually primary energy which is obtained from a fixed stock of resources. This means the use of this kind of energy lessens the stock available for future generations; examples include crude oil and coal.

2.3.3 Commercial and Non-Commercial Energy

Energy that have market prices are known as commercial energy; they are mostly traded entirely or partly in the market and non-commercial energy on the other hand do not have a price and hence do not go through a market.

2.3.4 Conventional and Non-Conventional Energy

This categorization is basically centered on the forms of technology used to acquire various energy sources. Conventional energy acquired though ordinary technologies and the nonconventional form is obtained by the use of very sophisticated technology and expertise.

2.4 Summary of the use of energy in Ghana

2.4.1. Energy subsectors in Ghana

According to the Ministry of Energy (2010) under its National Energy Policy drafted in February, 2010, Ghana‟s energy sector is divided into the following eight (8) subsectors:

(i) Power Sub-sector;

(ii) Petroleum Sub-sector;

(iii) Renewable Energy Sub-sector;

(iv) Waste – to - Energy;

(v) Energy Efficiency and Conservation;

(vi) Energy and Environment;

(vii) Energy and Gender

(viii) Managing the future of the sector

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An overview of the various sub-sectors is given below

2.4.1.1 Power Sub-sector

Electricity is the current principal form of energy used in industries and service sectors in the country. Energy consumption in both sectors constitutes sixty-nine (69) percent of the entire consumption nationwide. Employment has been generated for many Ghanaians through the production and supply of electricity. Another important benefit is that it fetches foreign exchange for the country through exporting electricity to bordering countries.

The Volta River Authority (VRA) is the main body that embarks on energy generation in the country. The Akosombo Power Station, the Takoradi Thermal Power Plant and the Kpong Hydro Powerr Stations are all managed by VRA. It also partners with other private companies like TAQA; this private company owns and controls all activities of the thermal power plant at Aboadze. Another state owned company is the Bui Power Authority which is in charge of the Bui hydro power project. GRIDCO and both ECG and the Northern Electricity Command (a subordinate of the VRA) are also state owned which are in charge of the National Interconnected Transmission Systems for electricity and the distribution of electricity respectively. Moreover, there are also Independent Power Producers, which have been authorized to build and operate, power plants.

Other establishments such as the Ministry of Energy (MOE), Energy Commission (EC) and the Public Utilities and Regulatory Commission (PURC) are in charge of the articulation, supervision and assessing energy related policies and programs.

2.4.1.2 Petroleum Sub-sector

The petroleum sub-sector is further split into upstream, midstream and downstream which includes investigations, manufacturing of petroleum and distribution to the purchasing points. In Ghana the Tano Basin, Saltpond Basin, Accra/Keta Basin, Cape Three Points Basin are believed to have prospects for the production of oil and gas; these sedimentary basins are all off shore and properly discovered; the Volta basin is on-shore and has not been extensively explored.

A study by GNPC in 2007 proved that oil could be tapped in commercial capacities at the Jubilee field in the offshore Tano/Cape Three Points Basin of the continental shelf of the country. Evaluations undertaken on that field values oil reserves at approximately eight hundred (800) million with an upside estimation of three (3) billion barrels. It was concluded that the natural gas reserves was extensive.

Additionally, there have been other detections in the Mahogany Deep, Odum, Tweneboa and Sankofa. Surveys are being strengthened to discover more resources on-shore and off-shores.

The petroleum products marketed in Ghana are; Premium Gasoline; Kerosene; Gas oil; Residual Fuel Oil; Liquefied Petroleum Gas (LPG); and Premix. The Tema Oil Refinery (TOR), a stateowned company produces 70% of the petroleum products leaving imports with about 30%.

Crude oil necessities are usually imported to Ghana and later TOR refines it. TOR‟s production ability is however 45,000 Barrels-Per-Stream-Day (BSPD).

2.4.1.3 Renewable Energy Sub-sector

Ghana‟s renewable energy resource is made of solar energy, wind and biomass. Ghana‟s security with regards to energy and the ability to reduce adverse effects of energy use on climate greatly

depends on the evolution and usage of renewable energy and waste-to-energy resources. Biomass is the leading energy resource in Ghana with regards to existence and usage. Out of the twenty-three (23) million hectares of land mass in the country, biomass resources take up approximately twenty (20) million and also constitute sixty (60) percent of the energy supplied in the country. Moreover, previously destroyed lands can be used to cultivate some crops which can be transformed into biofuels.

There is the availability of solar resources in Ghana as a result of where it is located. These solar resources can be tapped to generate electricity for domestic and industrial consumption. However, it can be seen that solar energy exploitation is limited due to its relative high cost; the government is therefore making dedicated efforts to ensure that it is cost effective. This is ensured by critically reviewing the technologies involved and its challenges, institutional factors and market factors that hinder its cost effectiveness

2.4.1.4 Waste-to-Energy

Waste-to-Energy projects are increasingly developing into a very vital instrument for managing the current sanitation challenges in urban areas and also helping to increase energy supply and sustainability. Waste products from homes, industries, agricultural activities are both liquid and solid and are transformed into fuel using various technologies. Some of the technological methods used are; combustion, gasification, pyrolysis, anaerobic digestion, fermentation, esterification.

2.4.1.5 Energy Efficiency and Conservation

There has been an increasing demand for fuel wood, charcoal, electricity and petroleum products. Fuel wood and charcoal are growing at about 3% per annum, electricity is between 6%-7% annually, petroleum products consumption are projected to increase at about 5% per annum. These estimations show that energy efficiency and conservation is very important since it can suppress

the growth rates. Some losses are also made during the processes from energy production to usage; these losses are about 25% percent for electricity distribution whilst the end use waste is pinned at about 30%. Efforts should therefore be made to reduce the losses of energy supply in order to reduce demand to promote efficiency. Agencies like the Energy ministry have made tremendous efforts to encourage domestic and industrial energy efficiency as well as conservation of energy. These efforts have however not achieved its entire purpose due to some identified challenges from financial to institutional. Also, the prices of energy have a way of persuading consumers to embrace actions that can help reduce consumption. Achievement of energy efficiency and conservation therefore demands groundbreaking intrusions.

2.4.1.6 Energy and Environment

The processes in energy generation and supply obviously have considerable effects on the environment. These impacts vary from air pollution to land degradation. The utilization of biomass leads to the cutting down of trees, which has adverse effects on different environmental resources. Exploitation of other forms of energy results in emission of poisonous substances to the atmosphere, destruction of farmlands and human habitats. The above mentioned impacts cannot be underestimated.

2.4.1.7 Energy and Gender

Energy has a relationship with gender issues, as women are very important players in the energy sector because they often come into contact with energy. Wood fuel is a dominant form of energy used for domestic and commercial activities. Women in Ghana are therefore seen to be more prone to the adverse effects of energy consumptions which are usually emissions.

According to statistics approximately 57% of people are living in the rural areas of the country. Women constitute the largest percentage of the rural population and some of these areas are known

to lack access to electricity and mostly depend on biomass for cooking. The adverse effects on health from indoor pollution from the use of biomass cannot be undermined in Ghana‟s energy development.

2.4.1.8 Managing the future of the sector

In order to increase sustainability of the development of the energy sector management, effective management practices should be undertaken. There is the need for a clear supervisory system coupled with strong institutional and financial capacities.

Acts of parliament establishes three (3) regulatory organizations to ensure accurate interaction of all the actors in the energy sector and to establish the appropriate atmosphere for private investment protection in the sector. The agencies are; National Petroleum Authority, PURC and the Energy Commission.

The Energy Commission (EC) has responsibilities for the licensing of operators and setting technical standards for power sector and natural gas transportation. The EC also advises the Minister for Energy on energy sector policy and planning issues.

The Public Utilities Regulatory Commission (PURC) is responsible for electricity tariffs approval, monitoring quality of service and consumer protection.

The Ministry of Energy has the mandate to regulate upstream petroleum activities including the granting of licenses for petroleum exploration, development and production.

National Petroleum Authority (NPA) combines the responsibilities of the licensing of operators in the downstream petroleum sector and setting of technical standards and enforcement as well as pricing of petroleum products.

2.4.2 Energy use in Ghana

As mentioned earlier, the primary energy sources in Ghana are biomass, fossil fuels and electricity. Locally, these re-produces from biomass sources, the sun, thermal electric plants and hydroelectric

dams. Demand for energy is gradually being affected by the ever increasing population therefore energy is imported to supplement the local production. Crude oil is imported and refined by the Tema oil Refinery and it was about six hundred and ninety-three (693) thousand tonnes in 2014 which was seen to have increased comparing it to 1.3 million tonnes in 2013. Total crude oil products used in 2013 was about 3.3 million tonnes, which was less than the 2012 figure. Electricity creation constitutes about 90% of the consumption of crude oil whereas other refinery procedures take up the residual 10% in 2013. Gasoline and premix fuel however has not increased much as the figure supplied in 2014 was less than in 2013. In 2013, the highest supplied were RFO, gasoline and diesel whereas in 2012 they were LPG, gasoline and premix. (Energy Commission, 2015a). Table 2.1 shows the explained information

Table 2.1 Petroleum products supplied to the Economy for 2012-2014

PETROLEUM PRODUCT	2012	2013	2014	CHANGE	
				b/n 2012 & 2013	*b/n 2013 & 2014*
	1000 tonnes			*Percentage*	
LPG	268.5	251.8	241.5	*-6.2*	*-4.1*

Gasoline	992.7	1,080.6	1,102.3	*8.9*	*2.0*
Premix	58.9	53.4	56.2	*-9.3*	*5.2*
Kerosene	45.6	27.8	9.3	*-39.0*	*-66.5*
ATK	141.3	131.9	113.9	*-6.7*	*-13.6*
Gas oil / diesel	1,665	1,722.6	1,713	*3.5*	*-0.6*
RFO	33.5	39.3	26.8	*17.3*	*-31.8*
TOTAL	**3,205.5**	**3,307.40**	**3,263.1**	***3.2***	***-1.3***

Source: National Petroleum Authority, 2015.

In 2008 biomass consumption was 11.7 million tonnes corresponding to 65.6% of the total energy consumed in Ghana. Petroleum products were at 2.01 million tonnes corresponding to 26.0% and electricity was 8,059 GWh which is proportional to 8.4% of the nationwide consumption. (Ministry Of Energy, 2010).

A certain quantity of energy is lost whenever there is conversion of energy from one state to the other. As earlier explained the second law of thermodynamics advocates that any conversion entails the creation of energy with low grade which cannot be utilized for valuable work and this cannot be entirely ignored hence placing a visible restriction on energy use. Between 2000 and 2004 energy losses has increased from 26% to 30%. (Energy Commission, 2006)

From the year 2005 to 2014, transmission losses has risen and fallen steeply. In 2005, the loss as a percentage of net generation was 3.3%. It however rose steeply to 3.5% in 2006 and was stable throughout up to 2008 after which it rose again to 3.8% in 2009 and fell to 3.7% in 2010. Since then it has been rising and falling up to 2014 (Energy Commission, 2015b). Table 3 exhibits the transmission losses of electricity from 2005 to 2014 as presented by the energy commission in its national energy statistics (2005 – 2014) in April 2015.

Table 2.2 Transmission losses

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Transmission losses of net	249.0	318.0	256.0	303.0	343.0	380.0	531.0	522.0	569.7	565.1
Losses as a % Generation	3.3	3.5	3.5	3.5	3.8	3.7	4.7	4.3	4.8	4.3

Source: Energy Commission – National Energy Statistics, 2005 – 2014 (April, 2015)

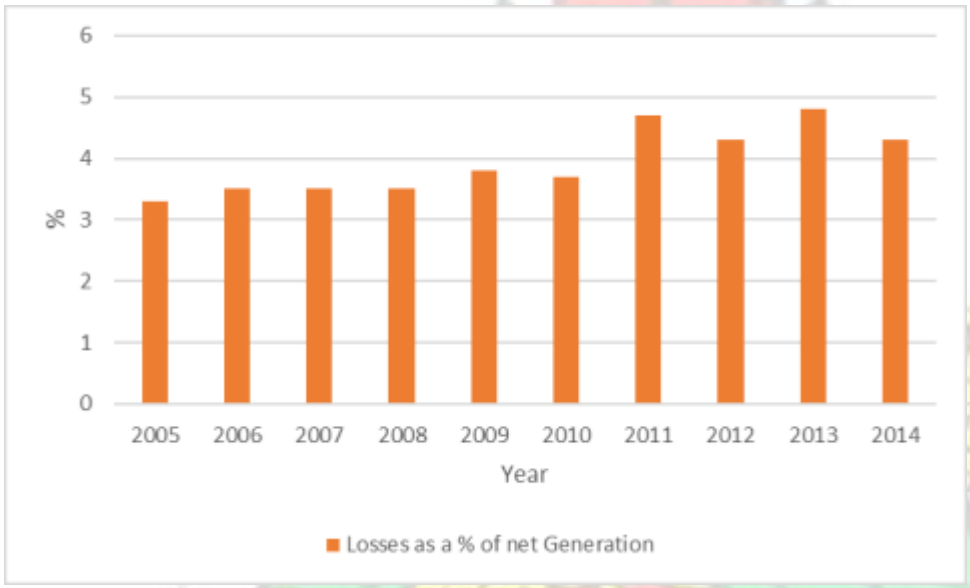

Figure 2.1: Trend in Transmission losses

2.4.3 Energy Market in Ghana

No economy or country can survive without energy been the backbone of such economy since it plays a vital role in economic development. The major driving force in this modern world is energy. Industries need energy to power their plants; households also require energy for cooking, heating and cooling purposes. Ghana, just like any other country cannot be able to achieve its economic development goals without energy been its backbone. The country is expanding in terms of

population and many industries are also springing up due to its middle class status it has achieved over the past few years. However, access to energy is an issue in the country as a result of the shortfalls and incompetence existing in the market. The negative impact of these inadequacies and inefficiencies greatly affects business profits, employment and government revenues goals. The system of centralization is very prevalent in every sector of the economy of Ghana including energy. Energy market activities are mainly in the hands of government institutions. These institutions on behalf of the government monitor, regulate and forecast activities in the energy market.

The cheapest form of energy in the Ghanaian setting is biomass (charcoal, wood fuel). It is mainly found in the rural areas due to proximity to forest areas in the rural area. Most people in these areas cannot afford electricity and other petroleum products and therefore rely on the wood fuel. It‟s production, transportation and sale is mostly operated on private basis. The forces of demand and supply fix wood fuel prices in the country.

On the other hand, in Ghana the primary points of generating electricity are hydropower and imported fossil fuel, which is used to create thermal electricity. Currently, there are three (3) hydro power plants in Ghana, eight (8) thermal plants and one (1) renewable solar panel from the Volta River Authority (VRA). All these provide electricity generation to the people of Ghana. Installed generation capacity obtainable for grid power provision as at the end of 2014 was 2,831 Megawatt (MW) and the generation was 12,963 GWh which comprised 64.7% hydro, 34.75% thermal and 0.05% solar power (Energy Commission, 2015c). In 2014, the quantity of electricity offered for gross transmission was 13,071 GWh as compared to 12,927 GWh in 2013. The 2014 grid electricity transmission comprised 98.74% of generation and 1.26% of it was imported. The peak of the Ghana load on the transmission grid was 1,970 MW and the maximum grid system

was 2,061 MW (Energy Commission, 2015b). Below is Table 3, which shows the electricity generation capacity of installed Grid up to December 2014.

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Table 2.3. Installed Grid Electricity Generation Capacity as of December 2014.

GENERATION PLANT	FUEL TYPE	CAPACITY (MW)				GENERATION	
		Installed name (plate)	% Share	Average Dependable	Average Available	GWh	% Share

HYDRO POWER PLANT							
Akosombo	Hydro	1,020		**900**	**743**	**6,509**	
Bui	Hydro	400		**380**	**84**	**730**	
Kpong	Hydro	160		**140**	**130**	**1,148**	
	Sub-Total	1,580	**55.8**	**1,420**	**956**	**8,387**	**64.70**
Thermal Power Plants							
Takoradi Power Company (TAPCO)	Oil / NG	330		300	102	890	
Takoradi International Company (TICO)	Oil / NG	220		200	82	712	
Sunon–Asogli Power (SAPP)	NG	200		180	144	1,255	
Tema Thermal Plant1 (TT1P)	Oil / NG	110		100	80	697	
Tema Thermal Plant2 (TT2P)	Oil / NG	50		45	26	223	
CENIT Energy Ltd (CEL)	Oil / NG	126		110	58	513	
Takoradi T3	NG	132		125	10	87	
Mines Reserve Plant	Oil / NG	80		70	22	195	
NG is Natural Gas	*Sub - Total*	1,248	**44.1**	**1,130**	**521**	**4,635**	**34.75**
Renewables							
VRA Solar	**Solar**	**2.5**		**2**	**1**	**4**	
	Sub – Total	2.5	**0.1**				**0.05**
TOTAL		**2,831**		**2,552**	**1,482**	**12,963**	

From the table above, it could be seen that most thermal plants are driven both by crude oil and natural gas. Crude oil supplies are all imported from other countries. TOR"s production capability is however 45,000 Barrels-Per-Stream-Day (BSPD) (Ministry of Energy, 2010a). Crude oil production from the Jubilee field hopped to 38.7 million barrels in 2014 from 30.4 million barrels

in 2013. Resultant daily production was averagely 105,935 barrels in 2014 and 91,000 barrels in 2013. Approximately, 22.5 trillion standard cubic feet (Tscf) of gas was provided by the West Africa Gas Pipeline (WAGP) for thermal generation in 2014. This was virtually a double of 2013 converting into an annual mean of just about 62 million standard cubic feet per day (mmscfd) nonetheless it was lower than the contract capacity of about 45 Tscf which is interpreted as 123 mmscfd anticipated from Nigeria. Besides, the stock in 2014 was very inconsistent as matched with 2013 (Energy Commission 2015a).

The Ministry of Energy is in control of the preparation of policies and the execution of certain facets of it. Distinctively for Ghana, supervisory oversight of the power sector is carried out by two distinct organizations, the Public Utilities Regulatory Commission (PURC) and the Energy Commission (EC), often they are regarded as the „economic regulator" and the „technical regulator". State owned bodies rule the Ghanaian energy market; Volta River Authority (VRA), Ghana Grid Company (GridCo) and the Electricity Company of Ghana (ECG), however many private entities have entered the market as well. The VRA does not only generate power, in addition undertake some restricted delivery through its Northern Electricity Department division, the roles of GridCo and ECG have been explained earlier in the study (Ministry of Energy, 2010). Figure 2.2 depicts the structure of the country"s energy sector;

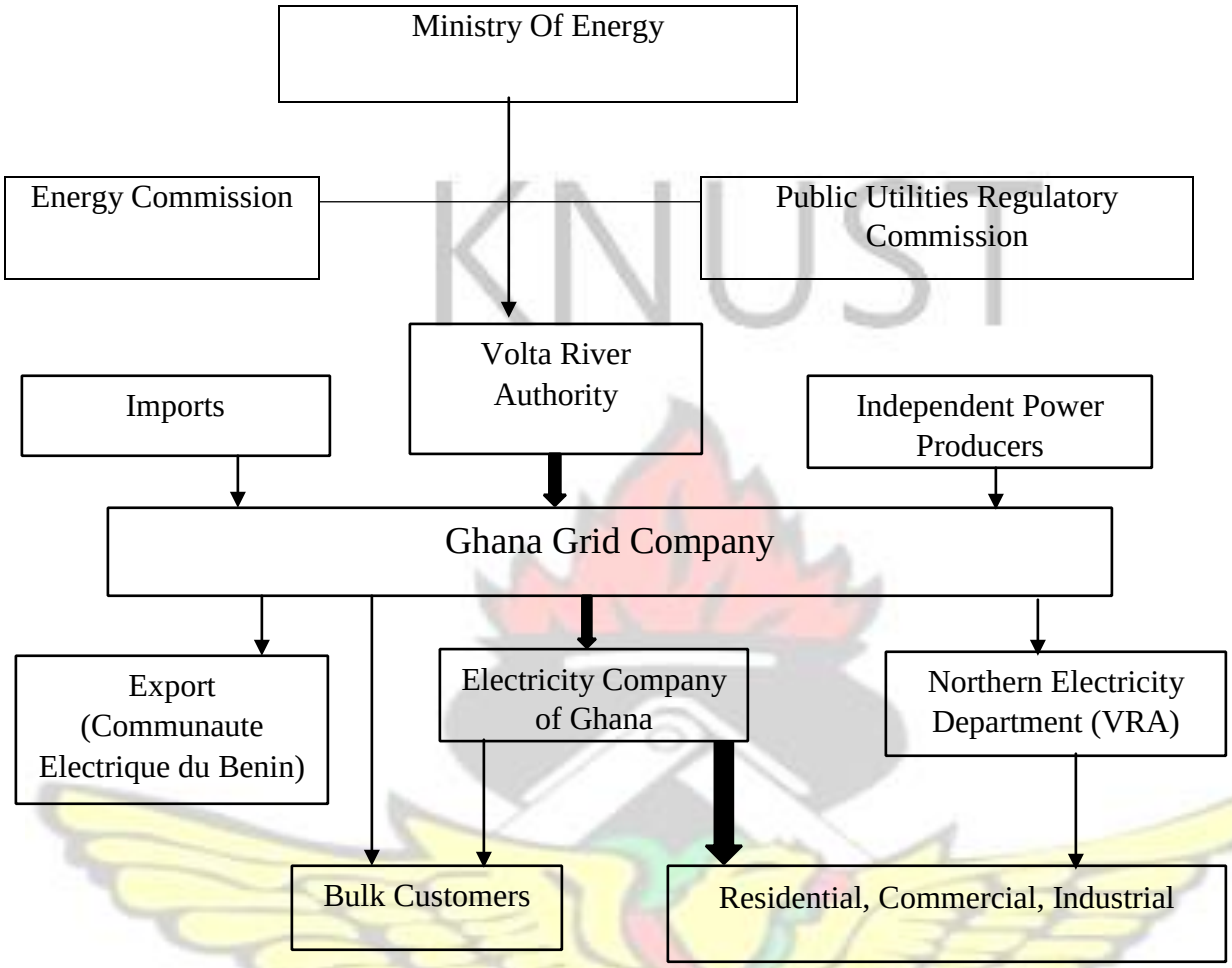

Figure 2.2: The structure of the power sector in Ghana, 2010

2.4.4 Energy use in industries in Ghana

There is a vast industrial sector comprising mainly food manufacturing, lumbering, manufacturing, cement, aluminum production, minor marketable ship building. The industrial sector produce goods and services that are consumed both locally and outside the country as well; exporting these products serves as a source to generate capital. The primary points of supply of energy for these industries are electricity, biomass and petroleum products. The highest proportion of the entire industrial energy consumption is consumed by the mining, manufacturing, construction firms and aluminium smelting companies like VALCO. In Ghana, the industrial sector is the highest consumer of the overall supply of electricity, the residential and commercial sector is the next highest consumer. The Energy Commission confirms that most industries in the country greatly

depend on electricity as the main source of energy for their activities. (Energy Commission, 2015b). Considering how essential electricity is to the industrial sector, price increases and frequent power outages have significant effects on their activities.

Table 2.4 and figure 2.3 show electricity consumption from the year 2005 to 2014 in GWh

Table 2.4: Use of electricity according to sectors (GWh)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Residential	1,956	2,130	2,095	2,269	2,418	2,738	2,761	2,803	3,228	3,223
Non-Residential	676	790	802	927	884	966	1,041	1,153	1,525	1,522
Industrial	2,542	3,593	2,687	2,963	2,921	3,156	3,900	4,153	4,224	5,055
Street Lighting	85	144	137	171	184	264	274	315	377	382
Total	5,259	6,657	5,721	6,330	6,407	7,124	7,976	8,424	9,355	10,182

Source: Energy Commission, (April, 2015b) – National Energy Statistics, 2005 – 2014

Figure 2.3: Developments in electricity use by the sectors of the economy (Source: Energy Commission)

Furthermore, the commonest forms of petroleum products utilized by industries in the country are residual fuel oil and diesel. Petroleum products were identified as the next largest form of energy consumed after electricity. From 2000 to 2004, its proportion has been between 38% and 42% of the total energy use. These companies use the diesel to drive engines during production and other procedures; residual oil on the other hand is usually used for heating. Also it was identified that gasoline was used to power some electricity generating plants in certain industries, used as an alternative power source.

2.5 Challenges facing the energy sector in Ghana

Every economy or nation one way or the other encounter issues related to energy matters. These issues differ between economies. Whereas some economies have issues with technical knowhow, others think of how to raise capital. Ghana, as a developing country cannot be left out and is finding it difficult to tackle its energy issues. Most challenges that the country faces comes from the supply side of the energy sector and this makes it difficult to access, afford and rely on energy supply. High economic growth as a result of emergence of industries coupled with population growth is also a challenge as it makes energy access difficult in the country.

There is also the danger of the fact that the country greatly depends on imports to supplement local production of fuel. These shortfalls affect the security of the country‟s supply and as a result of this Ghana becomes vulnerable to external pressures. The country imports crude oil and refines them at TOR to meet local demand. A chunk of the nation‟s financial resources is used in the importation of crude oil and this affects the nation‟s international trade balances. The importation of crude oil has made the country susceptible to international fuel prices. Any adjustment in international fuel prices affects the country either positively or negatively.

However, the great dependence on imports to supplement local stock of fuels makes the country susceptible to energy supply insecurity rendering it helpless when external pressures arise.

Consequently, expansion in the industrial sector and population growth has increased the demand for energy in Ghana and therefore makes the country more vulnerable to international crude oil prices.

Also, lack of capital is an additional problem inhibiting the operation of the energy sector in the country. Investments in the energy sector require huge sums of money to implement. Expansion of projects in the energy sector has been impeded due to lack of funds. Most turbines, which operate at the Akosombo dam, are no longer in good condition and hence are not fully generating as expected. This is because the government is not in a good financial position to get gas supplied to the dam to run these turbines. Again, in this time of power fluctuations that the country is currently facing, the best option is to adopt renewable energy such as solar energy.

However, these kinds of renewables are expensive and require huge funds to exploit them. Another issue is disorganized valuing of energy services, which has caused a huge financial problem for the providers of energy. There are also little to motivate towards energy conservation thus energy is not used efficiently.

Furthermore, the inadequacies in operation of the services have led to increased damages and subsequently swelling the cost incurred during supply and distribution. There is always a loss anytime energy is transformed from one state to another. In Ghana, the equipment used by the energy service providers are obsolete and not in good condition. The culture of maintenance is not an ideal thing practiced in the country as such when these equipment are old and/or not functioning properly, they are made to lie idle without been fixed or repaired. This leads to a significant loss of energy stocks affecting supply. There exist a low level of technical knowhow to commendably undertake the transformation and delivery of energy in the country. Again, the appliances used domestically are not efficient which consumes a lot of energy. These also contribute to energy loss. Due to this, the government and the Energy Commission have embarked on actions to reduce these

inefficiencies. There has been the introduction of compact fluorescent lamp (CFL) bulbs to be used in various homes. There has also been a ban on the imports of unproductive used electrical piece of equipment (most especially refrigerators) to Ghana. Again, the Energy Commission periodically organizes sensitization programs for different sections of the population to encourage efficient energy use. They also make efforts to encourage the adoption of energy efficient strategies in industries. The collected outcomes of these activities by the government have led to substantial energy saving nevertheless there is still an energy efficiency gap in the sector.

In addition, the extreme dependence on fuel wood is also a challenge that affects the forest of the country. Wood fuel is mostly used in the rural areas for cooking resulting from a restricted access to particular energy forms. The felling of trees in the forest areas therefore leads to deforestation in the country. Due to lack of education in these areas, afforestation is therefore not practiced leaving the land degradable.

Lastly, the most widely used source of energy in Ghana is electricity. The hydroelectric dams generate about 70% of electricity in Ghana. Pressure is therefore mounted whenever the water levels in these dams are low especially during periods of drought. When this happens the country enters into a period of load shedding and this greatly affects the activities and operations of firms in the country.

Table 2.5 below shows the Akosombo dam month end elevation (feet) from 2005 to 2014.

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014

January	252.3	248.0	241.5	253.1	261.7	266.1	273.8	269.8	266.3	256.1
February	250.4	246.1	239.4	251.4	259.9	264.5	272.4	268.0	264.3	254.1
March	248.7	243.8	237.4	249.2	258.1	262.6	270.8	265.9	262.2	251.8
April	247.0	241.5	236.3	247.5	256.9	260.7	269.1	264.1	260.3	249.5
May	245.3	239.8	235.9	246.0	255.0	259.0	267.4	262.6	258.7	247.6
June	244.4	238.5	235.5	245.0	254.0	258.0	266.4	261.4	257.0	245.5
July	244.7	237.0	235.2	246.4	254.1	257.7	266.7	263.2	256.2	244.5
August	246.2	236.7	239.5	252.9	258.8	259.7	267.6	264.0	255.1	243.3
September	250.0	240.9	252.5	261.4	266.3	269.8	271.7	267.6	258.1	247.7
October	253.4	246.0	256.4	266.4	270.4	277.0	274.7	270.8	260.8	250.5
November	252.1	245.7	255.8	265.1	270.3	276.7	273.7	270.0	259.4	249.1
December	250.1	243.8	254.7	263.6	268.2	275.4	271.9	268.4	257.7	247.1

Source: GRIDCO and VRA

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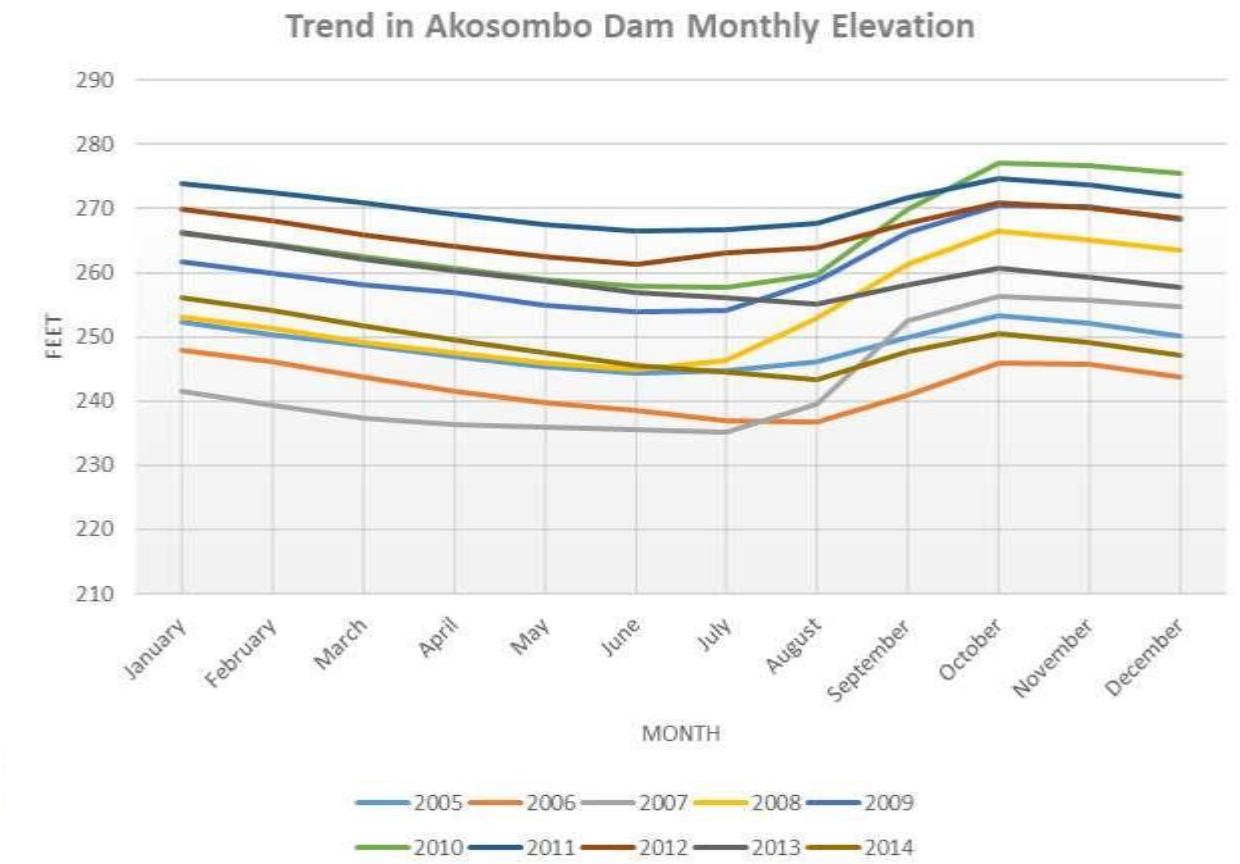

Figure 2.4 Monthly Elevation of the Akosombo Dam

The minimum operating level of the Akosombo dam is 240.0 feet. The first six (6) months of the year 2007 experienced a season of drought and as such was below the minimum operating level. It however rose after the seventh month and became a little bit flatter getting to the end of the year. During this period, the country experienced load shedding and this greatly affects many businesses in the country.

2.6 Energy Efficiency

Energy efficiency is a very important emergent strategy for many countries worldwide. It is exceedingly considered as the best worthwhile and readily accessible approach to deal with the several issues related to energy, which includes energy security, high energy prices and have significant impact of both social and economic on the environment. Similarly, energy efficiency warrants keenness and encourages consumer welfare. Energy efficiency has the exceptional capability to concurrently ensure economic growth, sustainable energy security, as well as enhanced health and general well being; it also aids in controlling emissions of greenhouse gas. By controlling demand for energy, energy efficiency actions can support the resistance of numerous risks, which are increases in energy prices and its instability, strains on energy infrastructure, and interferences to energy supply systems. The IEA defines Energy Efficiency as "a way of managing and restraining the growth in energy consumption (IEA, 2015). It can be said that efficiency is ensured when energy use delivers much more services for its corresponding energy input or the same services for even a smaller amount of input. For instance, the compact florescent light is deemed to be more energy efficient as compared to an incandescent bulb as it uses one third to one fifth less amount of energy yet both produces the same amount of light (International Energy Agency, 2015).

Energy Efficiency, otherwise referred to as efficient energy use, can be explained as consuming less energy to deliver a matching level of performance, compact and expediency (myenergysolution.com, 2015)

It can also be described as the relation of useful outputs to energy inputs for a system, where the latter may be an individual energy conversion device (e.g., a boiler), a building, an industrial process, a firm, a sector or an entire economy. According to Patterson, the amount of energy

efficiency will be contingent on how „useful"it is defined and how inputs and outputs are valued (Patterson, 1996). The options include:

- *Thermodynamic measures*: where the outputs are defined in terms of either heat content or the capacity to perform useful work;
- *Physical measures*: where the outputs are defined in physical terms, such as vehicle kilometers or tonnes of steel; or
- *Economic measures*: where the outputs (and sometimes also the inputs) are defined in economic terms, such as value-added or GDP.

The general viewpoint of the macroeconomic aggregated perspective on the conservative market driven economy, energy efficiency is either symbolized as energy intensity or (shared) as energy productivity. In this manner, energy input is associated with fiscal yield considerations. For instance, the energy intensity can be detailed as primary energy usage for every unit of the gross domestic product (real GDP) or primary energy consumption for every citizen. Similarly, energy intensity can be on the sectoral level indicated as primary energy consumption per unit gross value added segregated by industry sectors. Energy yield is commonly indicated as (real) GDP per primary energy input (Wolfgang, Thomas, Böhler & Spitzner, 2008). Furthermore, energy intensity parameters can be valued on the accumulated level as ratios to certain physical parameters. Probable illustrations are inter alia, the energy consumption per m^2 living space altered by ambient temperature, the electric power consumption for every refrigerator or the fuel consumption per 100km driving performance. In the caring economy, it refers to the specific energy efforts of the supply of household production output (e.g. production of recreational or caring benefits, reachability benefits and freedom of movement benefits) (Wolfgang, Thomas, Böhler & Spitzner, 2008).

Efficient energy use is attained predominantly by means of additional efficient technology or practice. Energy efficient edifices, manufacturing procedures and conveyance could lessen the energy needs of the world by one third by 2050, and aid monitoring global emissions of greenhouse gases. Enabling energy efficiency in homes, automobiles and trades is perceived as a fundamentally unexploited answer to deal with global warming, energy security, and the depletion of fossil fuel (British Geographical survey, 2015).

There is always a big difference between energy efficiency and energy intensity. Energy intensity on the other hand is explained as the volume of energy consumed for every activity or output for sub-sectors and its end use. Largely energy intensity is determined as energy used divided by an economic indicator. Energy intensity is defined by many factors other than energy efficiency alone. These factors can include the economic structure of the country, the kind of industries, the size of the country, its population, the price of energy services, exchange rate, its climate and basic behavior. (IEA, 2014).

2.7 Theoretical framework

Energy efficiency and management could be said to be influenced by the rational choice theory which is a framework for understanding and modeling social and economic behaviour. This theory draws the principle that aggregate social behaviour results from individual actions. It is based on the grounds that human beings base their behaviour on rational calculations, they act with rationality when making choices and that human choices are aimed at maximizing their pleasure or profit. (Bicchieri, 1993)

Another description of rationality involves seeking the most cost-effective means to achieve a specific goal without reflecting on the value of that goal. The theory does not describe the choice process but rather it predicts the outcomes and pattern of choices. Consequently, it focuses on the

determinants of individual choices. It assumes that every individual has preferences among alternative choices of action and that individual takes account of available information, probability of events and the potential costs and benefits of that choice. (Fernandez-Huerga, 2008)

It is worth noting that human beings are the end users of energy and the task of ensuring energy efficiency and management greatly depends on them. The decision to adopt certain strategies to ensure effective management of energy, the decision to use energy efficient appliances and the cultivation of habits that ensure energy efficiency are the responsibility of human beings. This is not different in the industrial setting where human beings are the controllers and managers of the entire systems. The above mentioned conclusions are believed to be influenced by the individual‟s or the industry‟s ability to make prudent choices that are cost effective as well. (Kenneth, 1987)

Furthermore, it can be said that energy efficiency and management is best achieved through a sustained efforts of the various actors involved in ensuring its success. The rational choice theory establishes that the aggregate behaviour is as a result of individual actions hence in the industrial setting this can only be achieved when the entire staff cultivate positive habits to energy issues. For instance, an operator in an industry‟s decision to switch off equipment or machine when not in use will contribute to the combined effect on energy efficiency.

The underlying assumption of the theory emphasizes the importance of information to rational decision making. It proposes that individual preferences are usually based on available information and the potential cost and benefits of that action. (Fernandez-Huerga, 2008) In this case industrial energy efficiency can be effectively achieved when actors have the requisite knowledge on the products, equipment etc as well as the cost and benefit associated with a particular strategy to ensure efficiency.

2.8 Energy efficiency improvement

There exist several opportunities for energy efficiency improvement available to industries, some are purposely tailored to manage specific industries and others are general for all kinds of industries. To ensure efficiency, some industries adopt different strategies from a strategic management program which requires strong organizational skills, and the establishment of energy teams, energy monitoring and control systems.

2.8.1 Purchasing energy efficient office equipment

Purchasing energy efficient computers, photocopiers, and lighting systems improve energy efficiency in industries. For instance where color rendition is critical mercury or fluorescent light bulbs can be replaced by metal halide bulbs which have close to 50% of savings on energy. Where color delivery is not serious, pressured sodium bulbs bargain energy from 50% to 60% on energy savings when matched with mercury lamps (Kramer et al, 2009).

2.8.2 Use of Boiler measures

Energy efficiency which uses boiler measures basically concentrates on controlling processes, reducing heat loss and improving heat recovery.

2.8.3 Dealing with Motor systems

Motor driven systems are considered to consume a higher percentage of industrial energy and hence much attention should be paid to it when aiming at instituting energy efficiency measures. In the US, machines and equipment that are driven by motors constitute approximately 90% of the entire energy consumption within the pulp and paper industry in 2002 (Kramer et al, 2009).

Kramer et al (2009) also identified some efficiency measures for motor systems in industries. They stated that the systems approach was the best way to tackle this. The systems approach basically considers together the energy demand and supply margins of the systems driven by motors as well as how they intermingle to augment overall system performance. The various steps involved in this approach is to first identify all motor driven systems in the industry, noting the specifications and the current conditions of the motors, assessing the needs and the real use of the motors, gathering information on potential repairs and upgrades taking into consideration economic costs and benefits. Lastly, upgrading should be done and from there monitoring should be done frequently to evaluate actual cost savings.

2.8.4 Conducting energy audits

Energy audit can simply be defined as an assessment and scrutiny of energy movements for energy protection in a structure, a procedure otherwise a system to regulate the volume of energy use without significantly affecting outcomes or outputs. Conducting energy audits is very vital for assessing energy efficiency and management because it encourages many ways of saving money. A well implemented energy audit is a foundation for an efficient upgrade of energy management system which is a sustained process of increasing efficiency and cost reduction.

With this, energy cost savings are recorded periodically to assess the level of fluctuation

2.8.5 Power Factor Corrections

Power factor has an inverse relationship with energy consumption and expenditure such that lower power factor increases energy consumption and expenditure. It can be corrected by turning off motors when not in use and the use of efficient motors.

2.8.6 Compressors

Cultivating a habit of cooling compressor motors and changing compressor lubricants helps to reduce energy consumption. Old compressor systems can be managed and reconfigured to improve efficiency. Moreover inadequate maintenance can lower compressor efficiency and increase operating temperatures and poor moisture control. Improved maintenance is said to deal with these problems and that it may include frequent filter inspection, frequent cleaning and lubrication of motors, checkup of water pumps and fans, examination of drain traps, compressor belt inspection among others (Kramer et al, 2009).

2.9 Obstructions to Energy Efficiency

Ensuring the efficient use of energy comes with its own challenges or hindrances. Barriers in any case make it difficult to adopt new technologies in helping to promote the efficient use of energy. Sorrell *et al* (2004), defines an *obstruction* to energy efficiency as "a hypothesized apparatus that hinders a result or behaviour that seems to be both energy efficient and economically effective."

One of the main barriers to energy efficiency is lack of access to capital. Energy projects or activities are capital intensive and thus involves huge sums of money to run or implement. In a situation where a country or organization is not able to raise internal funds or having difficulty in assessing additional funds through borrowing, investments in energy efficiency hinders and becomes stagnant. One main reason why firms are not able to secure loans from external sources

(banks and financial institutions) to invest in energy efficiency is due to market failures. These financial institutions believe that firms have a restricted technical knowledge to implement energy efficiency tasks.

Another barrier to energy efficiency is imperfect information. Information is vital in every sphere of economic life most especially in making cost-effective decisions. Opportunities that can lead to the execution of cost effective measures can be lost when there is lack of information. Similarly, flawed information can also result in the driving out of efficient products from the market by the inefficient ones.

Three (3) forms of imperfect information were described by Golove & Eto (1996) and they include;

- Unavailability of information: This is linked to investment cost and cost of operation. These cost sometimes causes consumers in making irrational decisions.
- The cost associated with obtaining information: Customers may be deterred from gathering all relevant information on the energy performance of various technologies due to the inherent cost it may involve. They therefore make decisions with the little information they have.
- Exactness of information: Accuracy of information acquired is just as important as searching and acquiring it. Precision of information on the energy market can sometimes be difficult because producers of goods may embellish the performance of various technologies. This can affect the expectation and returns of investment.

Furthermore, split incentive is also another barrier to energy efficiency. Energy efficiency prospects maybe overlooked whenever players are unable to appropriate the reimbursements of the venture. Under this form of barrier, one party gains at the expense of another due to the discrepancies in advantages of energy efficiency investment. For instance, incentives to managing

energy efficiently can help make departments in an organization more responsible for their energy usage.

Moreover, risks involved in energy efficiency investments hinder its implementation. Risks directly or indirectly affect energy market. They can be in the form of external, business and technical risk. External risks can be in the form of electricity price hikes, tight government policies and economic trends. Business risks are mostly found in the financial or economic sector and are directly related to businesses. These risks deter investors from investing in energy efficiency projects. Technical risks depends on the type of technology been adopted in ensuring efficient use of energy.

In addition, the principles of an institution also serve as an obstruction to energy efficiency. The values, norms and principles in one organization can be different from another organization. These cultures can make an organization adopt the implementation of an energy efficient project or not. For example, organizations which find it prudent to consider environmental factors are mostly conscious of the implications of energy use on the environment and they find it easier to adopt measures that can promote energy efficiency as compared to companies with less environmental sensitivity. This show how important the principles and culture of an entity affects the actions of energy efficiency.

Lastly, disparities in available information levels between two parties undertaking a transaction is a type of asymmetric information referred to as adverse selection. This situation occurs when one party is very knowledgeable about a particular technology before entering a transaction. (SPRU, 2000), the cost of transaction can have an effect on the benefits of efficiency. Adverse selection is established when the manufacturer of a product has an enhanced knowledge or unshared information on the performance of the product than the prospective purchaser. This alters the

decision of the consumer to purchase the product because accessible information is not enough to take a rational decision.

2.10 Energy Security

There is no way you can talk of energy efficiency without mentioning of energy security. The growth in the world‟s population and also the use of energy by industries for various activities makes energy security very paramount in the world today. The IEA explains energy security as the incessant obtainability of energy resources at reasonable prices. (IEA, 2015). This uninterrupted supply could be long term or even short term. In the long term well-timed investments to energy provision coordinated with economic expansions and environmental requirements are ensured. On the other hand, the short term deals with the promptness of the energy system to respond to unexpected changes in supply and demand (IEA, 2015).

The World Bank explains energy security as the techniques a country adopts for the production and utilization of energy in a sustainable routine and at a very affordable cost so as to improve economic growth. This goes a long way to reduce poverty among the populace and improves people‟s lives by way of increased access to energy services. (World Bank Group, 2005). Nonetheless, it is worth noting that the concept of energy security differs from country to country in that it is affected by the institutional factors, geographical, geological factors among others. (Sovacool & Brown, 2010). This has caused in a variety of explanations and insights, for example the World Bank meaning of energy security is grounded on three features, which are energy efficiency, broadening of supply, and reduction of price instability (World Bank Group, 2005). Considering the viewpoint of the final consumer, energy security involves the supply of energy service without interferences (Sovacool & Brown, 2010). For the producers of energy, it is the skill of protecting a stretched period of time and attractive markets for their natural resources that often

buttress their economies (World Bank Group, 2005). Overall, energy security entails four interrelated benchmarks or measurements: availability, affordability, efficiency, and environmental stewardship (Sovacool & Brown, 2009).

Availability dimension of energy security talks about attaining adequate volume of energy to warrant a continuous supply and lessen dependency importation of fuel (Sovacool & Brown, 2010). Moreover, it also encompasses the broadening of energy service which has the potential to reduce the risk of energy of an individual. Diversification embraces three scopes namely (ibid):

- Source diversification necessitates employing a blend of diverse energy sources, fuel varieties, and fuel phases.
- Supplier diversification raises the development of several points of energy creation in that there is no sole provider who has total power over it in the market
- Spatial diversification means scattering the places of specific facilities so that in case of an attack or failure, not all locations will be affected to interrupt supply.

Access to reasonably priced and impartial energy supply is an imperative characteristic of any country,,s energy security. Essentially, the affordability dimension expresses the delivery of energy and energy services at a reasonable price to every citizen in a particular country. Unpredictable energy prices can interrupt the energy security of a nation; consequently, the stability of energy prices is as important as its affordability (Sovacool & Brown, 2010).

Efficiency is an economical approach to guarantee energy security by reducing the component reserve input for every unit output. Efficiency can be sectioned into economic and energy efficiency. Considering the economic aspect, efficiency is the degree of performance enhancement or improved disposition of much more energy efficiency equipment and preservation (Sovacool &

Brown, 2010). Whereas, energy efficiency refers to refining the performance of energy equipment and changing consumer approaches (Sovacool & Brown, 2009).

Recently, there has been a heightened awareness and concentration on environmental protection as a key enhancer for issues on energy security. Globally, stakeholders are making efforts to discover innovative ways to conserve the environment by reducing the negative effects of utilizing energy from carbon exhaustive and sources that cannot be replenished. The Environmental Stewardship highlights the significance of environmental sustainability, which comprises shielding the natural surroundings, societies and forthcoming generations (Sovacool & Brown, 2010; Sovacool & Brown, 2009).

2.11 Industrial energy management

The proportion of energy consumption by industrial activities is about one third of the world‟s total energy consumption and gradually this proportion is increasing. Even though energy efficiency in industries have been enhanced and CO_2 concentration has dropped in many manufacturing firms over modern times, this advancement has been further balanced by growing industrial production universally (IEA, 2010).

The commendable execution of energy controlling in industries can go a long way in saving energy so as to avoid wastage. Refining energy efficiency activities in various industries play a very important role in a company as well as the entire economy. Industries can help improve energy efficiency by adopting better energy management systems. These energy management systems must be systematic in order to address barriers relating to energy efficiency.

Industries cannot only pursue energy management systems without the support of governments.

Governments can contribute their quota of energy management through legislation, incentives and guidance. Energy management programmes can help governments in making long term strategies in parts of energy efficiency, energy safekeeping and the moderation of climate change.

Energy Management is explained as the prudent and effectual use of energy to get the best of profits, to reduce cost and augment competitive situations (Capehart et al, 1997).

Energy Management (EM) is measured as a blend of energy efficiency actions, procedures and supervision of interrelated procedures which causes a reduced cost of energy and emission of gases into the atmosphere. Handling energy consumption in an appropriate fashion has been a considerable mark for a maintainable improvement worldwide (Seyithan & Numan, 2011).

Energy management involves the methodical tracing, inquiry and forecasting of energy usage. Energy management systems (EnMSs) consist of energy management activities, practices and procedures (IEA, 2012). These systems are a way through which establishments institute the schemes and processes needed to accomplish effective control and constant upgrading of energy performance. It is also a means by which industries focuses on reducing energy end-use in companies. It helps in reducing industrial energy costs and negative environmental impacts.

Industries require a device to succeed in energy and environmental management drives by recognizing energy efficiency targets and CO_2 emission cuts. Such complementary schemes presented to maintain these actions are: principles, eminent management practices, which include lean six sigma, benchmarking, Failure Mode and Effects Analysis (FMEA) Methodic, voluntary agreements, labeling and standardizations such as EN 16001 and ISO 50001.

Benchmarking in energy management is when industries assess their own performance and make comparison with other industries. It helps industries to compare its energy use (especially with plants) with other facilities which produce comparable products or to nationwide or global paramount practice energy consumption altitudes. Procedures, systems and plants are being

compared using a benchmark. However, the shortfall in this energy management technique is to how to detect or identify similar industry or organization which consumes the same amount of energy.

The failure mode and effects analysis (FMEA) is also an energy management method in which there is an orderly and comprehensive recognition of prospective complications and dangers and also their influence in advance. The dangers, which occur, must be cautiously considered, thoroughly evaluated and measured in order to develop precautionary actions. The objective of FMEA is a prompt revealing of acute constituents or weak points. Cost of counteractive actions may increase depending on the time of the cycle of product development, weak points are revealed.

2.11.1 Energy Management Strategy

Most management systems are grounded on a philosophy of Plan-Do-Check-Act (PDCA). This incorporates energy management in the daily organizational practices for continuous improvement in energy efficiency. In the energy controlling context, the outline of the continual improvement framework (PDCA) is:

- **Plan phase:** This is the starting phase of an energy management strategy. Here, organizational energy policies, energy performance pointers, goals, marks and action plans are set to accomplish outcomes that can advance energy performance. Cautious innovative design of an EnMSs guarantees that all the essential components can be unified at the outset, escaping interruptions, repetition of hard work or misunderstanding. Forecasting should be transparent and must involve stakeholders from the beginning and through that it will help to identify future implementation issues or difficulties. One important feature at this stage is Energy audit where historical data on energy consumption trends are gathered. They are carried out during the commencement of a platform to institute the past and present energy consumption patterns of a facility; centered on these facts important

spots of energy can be acknowledged and benchmarks can be fixed for weighing improvements.

- **Do phase:** The next phase after planning objectives and targets is the do or implementation phase. These targets and objectives are implemented or executed at this phase. There should be an institutional assistance at this phase, which will be a fundamental point of exchange for contributors in the EnMSs, and this is going to have the responsibility for motivating the materializing the action plan. Institutional support must be a nationwide harmonizing group, such as the energy agency of the country or other bodies of the government. All assets for institutions that undertake training programs, tools, support systems, authentication/endorsement systems and persuasive supplies must be safeguarded at this phase.
- **Check phase**: This phase has to do with monitoring and measuring processes of the implemented actions. An indispensable fragment of the process of monitoring encompasses collection of data and appraisal, which delivers a quantifiable means for governments to quantify compliance and authenticate improvement in the direction of achieving energy efficiency objectives and operative acceptance of EnMSs and EnMS constituents. Data collection needs to gather appropriate facts to permit an evaluation of policies (Tanaka, 2009). To grasp the whole meaning of the level of adoption of EnMSs by a particular company, indicators need to be looked. The usefulness of the systems with regards to achieving other energy related targets; how the system has affected the performance of energy in the company in totality. Moreover, indicators help to track other advancements to production yield.
- **Act phase:** This is the final phase of the energy management strategy. This is also known as the evaluation phase. It is based on the monitoring and reviewed actions taken to

continually improve energy performance, correct any deviations or abnormalities and improve the energy management system to meet the established targets. The main objective of evaluations is to analyze the extensive importance to companies and the general public. It helps measure cost-effectiveness; invite new partakers; review yearly plans and programs; prioritize amongst diverse categories of courses of action; fix or amend budgets; and enlighten a promising exit strategy.

2.11.2 Energy management and the Environment

The preservation of the environment is very keen to human existence. An environment which is devoid of hazards and pollution makes it cleaner to live in. Utilization of fossil fuel is highest in the industrial sector resulting in high level of emissions of greenhouse gas resulting in climate change globally. There have been a lot of calls and conferences as to how to reduce and if possible eradicate industrial emission of poisonous gases. In December, 1997 The Kyoto Protocol adopted in Kyoto, Japan arrived at a force on February 16th, 2005 admonished the parties involved by fixing targets that aim to reduce emissions on the global level. However, little has been done in helping to reduce these greenhouse gas emissions.

Increased global warming is posing a major threat to global environment. Industries emits large amount of carbon dioxide emissions, the major greenhouse gas, and this accounts for about 78% of the annual consumption of coal in the world, 41% of total electricity consumption worldwide, 35% of total natural gas usage globally, and 9% of global oil consumption. The best solution way through which increased global warming can be reduced is through industrial energy efficiency (Hrustic, Sommarin, Thollander & Söderström, 2011).

Ensuring efficient energy use in industries is an essential way of controlling greenhouse gas emissions. Nevertheless, there are some factors that hinder the realization of an effective energy efficiency culture. It can therefore be said that, the ultimate goal can only be achieved

when particular attention is given to mitigate the effects of these barriers. (Johansson, Thollander & Moshegh).

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CHAPTER THREE

METHODOLOGY

3.1 Introduction

This section deals with the approaches that were used in gathering and analyzing data for the purpose of this dissertation. It identifies the sources of data, sample size and techniques used. It also throws more light on the questionnaires that were administered, data analysis and also profile of the study area.

3.2 Study area

3.2.1 Profile of study area (Kumasi)

Kumasi is located in the Ashanti Region and it is its capital and it is included in the metropolitan areas, which are considered as large in Ghana. Kumasi covers about 254 square kilometers (25,415 hectares) of the land area in the country. Kumasi lies in latitude 6º 41‟ 0” N and longitude 1º 37‟ 0” W. The city can be found within the transitional forest zone and is approximately 270 kilometers north of Accra, which is the national capital. It is also seen as the commercial, industrial and cultural capital of Asanteman.

The total population of Kumasi is 2,035,064 consisting of 972,258 males and 1,062,806 females with a current growth rate of 5.4% per annum (2010 Population and Housing Census final results, Ghana Statistical Service). The city encompasses 9 sub-metropolitan areas namely - Bantama, Suame, Manhyia, Tafo, Kwadaso, Nhyiaeso, Subin, Oforikrom and Asokwa (Kumasi Metropolitan Assembly, 2016).

The figure below shows the map of Kumasi and the sub-metro areas.

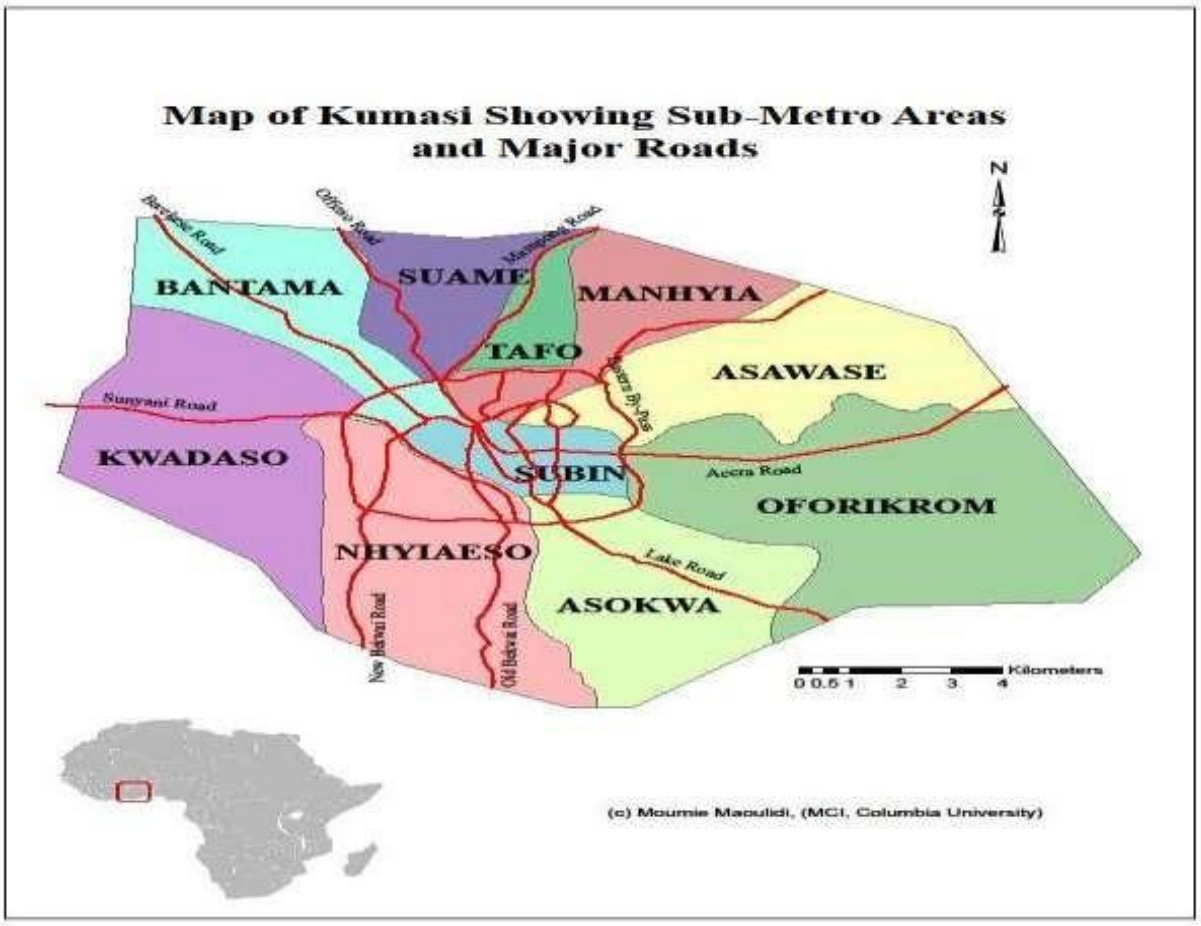

Figure 3.1: Map of Kumasi (Source: Millennium Cities Initiative, Columbia University)

The key subdivisions of the country in Kumasi is put under Trade/Commerce/Services which constitutes approximately 71%, industries which constitutes about 24% and the Primary Production sector also made up of only 5%. The Industrial sector comprises the production firms, which are breweries, beverages, and wood processing among others. Majority of these firms are situated within the industrial area at Asokwa-Ahinsan-Kaase, the pivot of companies producing on large scale. Another industrial area is located at Suame often referred to as Suame magazine. This area specializes in automobile parts production and services and it is the next largest to the aforementioned area within Kumasi. Anloga and Sokoban areas make up the informal industrial sector in the metropolis. The areas are made up of wood processing firms, woodcarving, and furniture production. There are other small-scale entities that use wood for production which are

sparsely distributed in the metropolis. Ahwia, a suburb of Kumasi, also has some petty production of commodities. (Kumasi Metropolitan Assembly, 2011).

The Kumasi Metropolitan Assembly (KMA) is the Administrative seat of the Kumasi Metropolis. The KMA (Kumasi Metropolitan Assembly) together with the Department of Factories Inspectorate are in charge of ensuring that the operations of companies are in line with the safety and regulations of the nation. Another body is the Environmental Protection Agency of Ghana, which confirms that industries in the metropolis are environmentally responsible for their actions.

3.2.2 Profile of Kaase Industrial area

Kaase is a suburb of Kumasi in the Ashanti Region. It is both a residential and industrial area under the Asokwa Sub-Metro with a population of 36,183 (Ghana Statistical Service, 2010). It is about 10 kilometers westwards from center of the regional capital. Kaase is home to many industries in Kumasi, which includes the Kumasi Abattoir, breweries, textile industries, cement factories, oil depots and wood processing companies.

3.3 Data Sources

Secondary and primary data were employed to gather information to achieve the objectives of this thesis.

3.3.1 Secondary data sources

Data gathered here was drawn from books, published articles and other Internet materials. Data was also gathered from both statutory and international institutions, which consist of the Energy Commission, Ministry of Energy and the International Energy Agency. The data, which was gathered here, provided the actual situation on the ground from which primary data was gathered. It gave insight into how industries within the Kaase industrial area were performing during the

period of power cut and load shedding most especially with regards to the energy efficiency and management strategies which have been adopted by these industries.

3.3.2 Primary data sources

Primary data was gathered from industries within the Kaase Industrial area. Questionnaires were distributed to industries within and around the industrial area. These industries were selected because they were the companies that were registered with the Department of factory Inspectorate. The industries selected spanned from wood producing companies, food and beverage companies and construction firms.

3.4 Sample size

The sample size which was taken for the purpose of this thesis was 45 industries and out of the forty-five (45) only thirty (30) agreed to participate in the study. The units of analysis were Managers, Supervisors or staff who were directly in charge of energy related issues. It is from these personnel that the data required for this thesis was gathered for analysis.

3.5 Questionnaire design and Administration

Questionnaires were designed and administered to respondents to fill in order to solicit their views. Few of them were administered in the presence of the respondents, the rest were left at the company and later picked up due to the bureaucratic processes in their companies. The questionnaires were structured into the categories below;

- Basic information of the interviewee
- Profile of the industry
- Monthly energy usage
- Energy management profile of company

- Information systems on energy
- Opportunities present for energy efficiency
- Sources of information for energy efficiency
- The execution of particular technologies
- Obstructions to improving efficiency
- Factors that move industries to improve on energy efficiency

The initial four segment of the questionnaire helped to obtain facts on company‟s outline and facts about the manner in which they use energy. The next two focused on the management culture of the surveyed companies as well as the prospects of efficient use of energy. The subsequent sections delved into how useful various sources of information are to the industries. Respondents were therefore allowed to rate the identified sources in literature. Moreover, information on the execution of specific technologies and practices, the obstructions and the factors that motivates companies to ensure effective energy efficiency were also captured in the eighth to tenth sections.

3.6 Method of Data Analysis

The methods of analysis used were both qualitative and quantitative methods. The Statistical Package for Social Science version 20 (SPSS) was used to derive the descriptive statistics of the quantitative data which included the number of employees, approximate monthly electricity and fuel consumption. The software was then used to derive the frequencies of all the responses, which aided in drawing bar and pie charts to depict the information gathered.

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CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This section shows the data gathered from the various industries that participated in the survey. This section commences with a summary of the categories of industries, structure, trend, energy utilization and expenditure features within Kaase industrial area. It goes further to discuss the

responses of the industries on the energy efficiency practices, energy information systems, energy management systems, energy efficiency opportunities, the various sources of energy information, the driving forces for energy improvement and the barriers to the improvement of energy efficiency.

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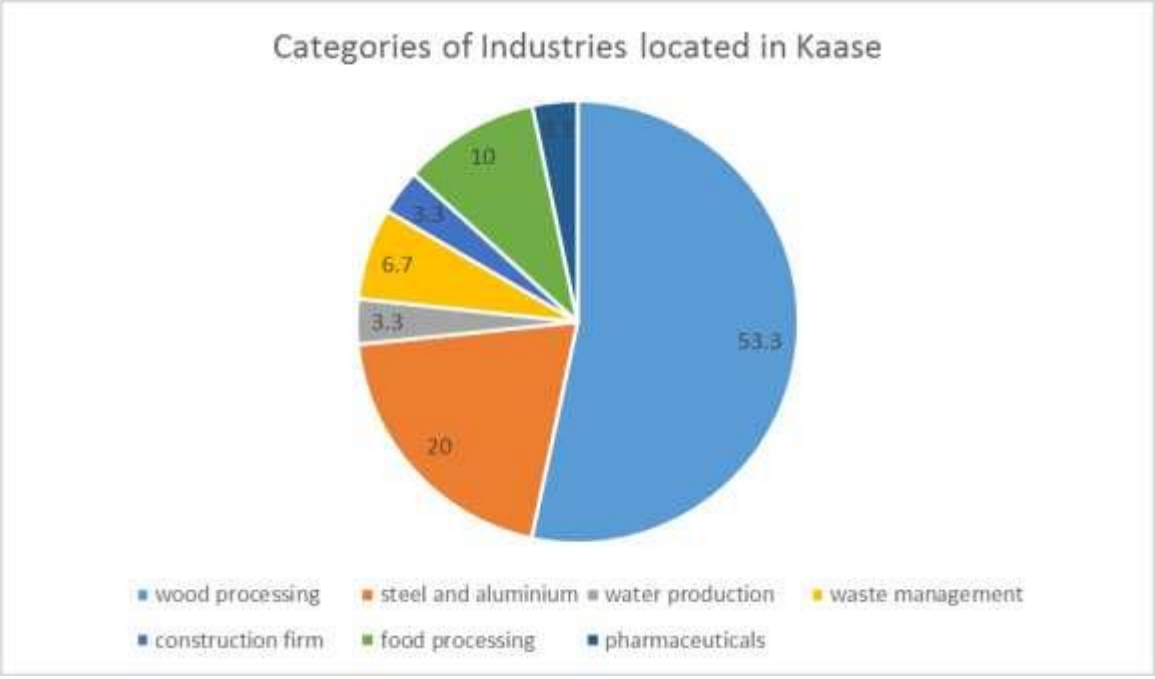
4.2 Overview of the industries

The background of the industries interviewed was important to be discussed because it provided an insight into the categories of industries located in the area and the number of employees. The study further sought to obtain information on the approximate energy consumption levels and expenditure. This created a basis for the discussion in order to achieve the objectives of this study.

4.2.1 Categories of the industries

The categories of companies identified in the study area were wood processing; steel and aluminium industries, water production firms, waste management companies, construction firms, food processing and pharmaceutical industries. Figure 4.1 depicts the percentages of each category



Source: Researcher‟s construct 2016

Figure 4.1 Categories of industries located in Kaase

As shown in the pie chart, Wood processing firms constitute the largest number of industries in the study area representing 53.3% which included timber processing firms and saw dust processing, followed by steel and aluminum industries representing 20%. Food processing companies that participated in the study consisted of a meat factory, brewery among others and it constituted about 10% which is the third highest. Water production, construction and pharmaceutical firms all constituted 3.3% each. Waste management companies identified were mostly into recycling of plastic waste and solid waste and it was just about 6.7%, which is the fourth highest in the area. It can therefore be said that the Kaase industrial area is predominantly made up of wood processing and steel companies.

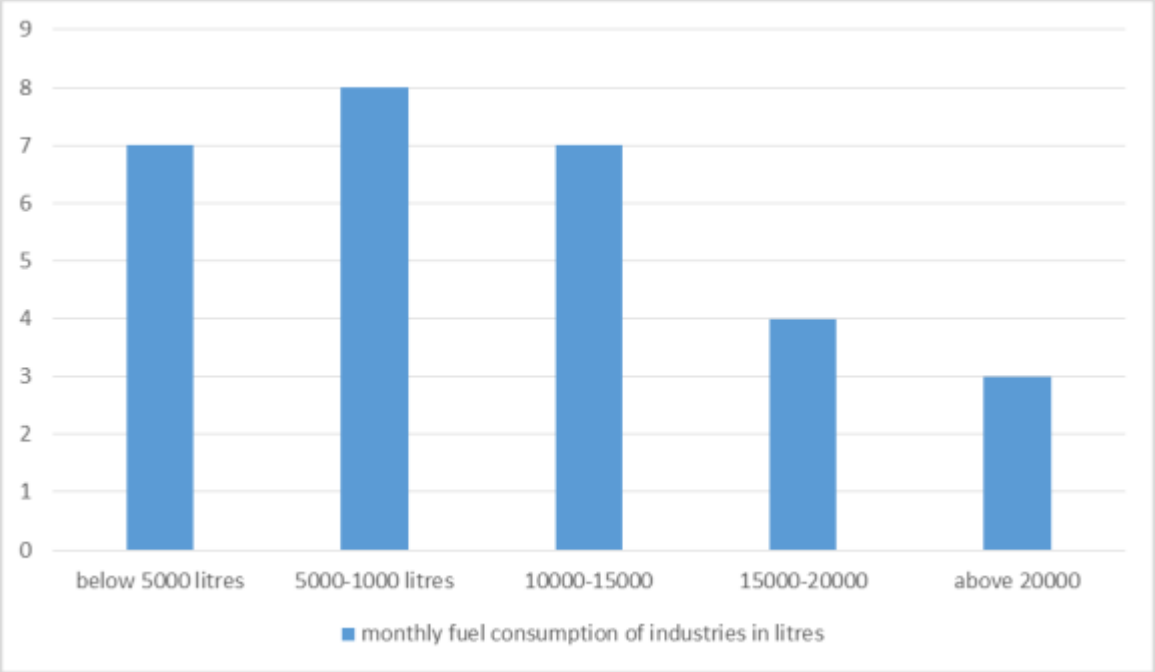
4.2.2 Sizes of the companies

The National Board for Small Scale Industries (NBSSI) determines the size of industries by its fixed assets and/or number of employees. It supports the idea that companies with more than ten (10) employees are classified under medium and large-scale industries. With this classification, all industries in the area can be classified either to be large scale or medium scale.

4.2.3 Energy use in the Kaase industrial area

Expenditure on energy constitutes a large amount of the total operating cost of companies. It was realized that electricity and fuel were used in most activities in the various industries therefore

information was obtained on the approximate monthly consumption and expenditure. Figure 4.2 shows the level of consumption of fuel for the industries that participated.



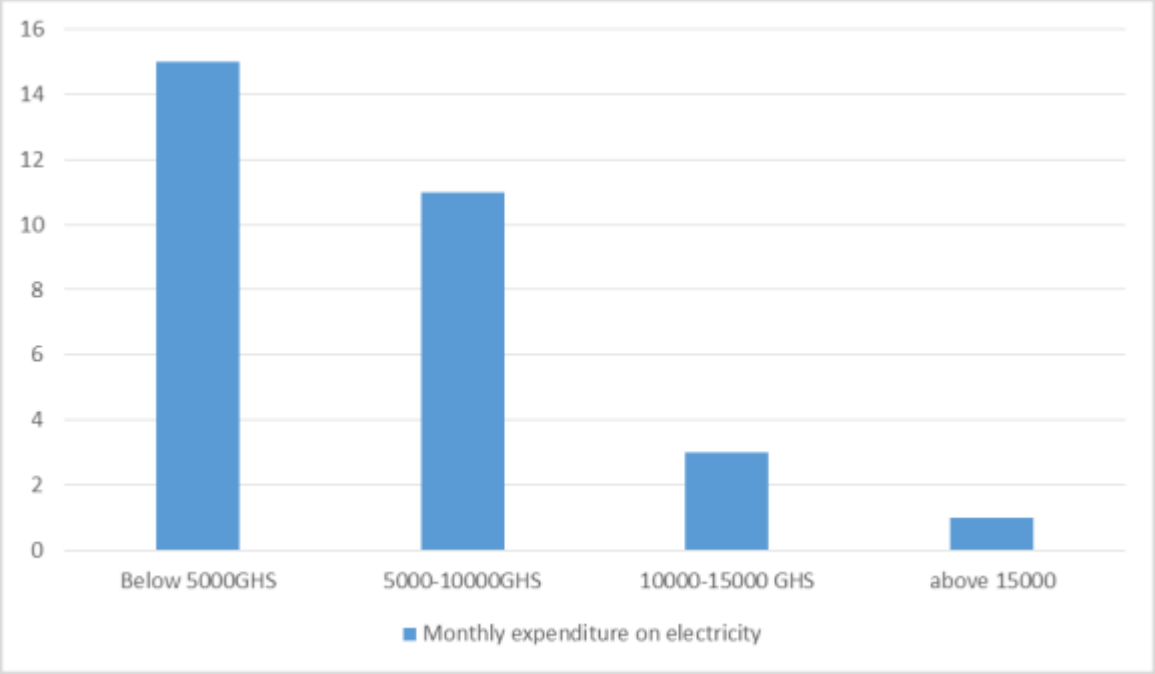
Source: Researcher‟s construct, 2016

Figure 4.2 Fuel consumption of industries in litres

From the bar graph it can be noted that industries in the area consume huge quantities of fuel. The identified uses of fuel included fuel for machines and equipment, vehicles and the highest fuel use was for electricity generating plants which were the main alternative source of energy. There were twenty-nine (29) responses for this particular question, out of the twenty-nine, eight (8) of the industries consumed between 5000 and 10000 litres of fuel every month representing 27.5% of the total responses which is considerably high. The lowest consumption level recorded was for seven (7), which was 5000, and below representing 24.1% of the total responses. However the highest consumption levels of 20000 and above were recorded for three (3) companies constituting 10% of the responses. It is worth nothing that these companies consisted of two food

processing companies and one wood processing company indicating the level of demand for fuel in these industries. From the presentation above, it can be concluded that industries in the study area take note of their fuel consumption which is a basic step to energy efficiency and management.

Furthermore, electricity use was also assessed since it is an integral part of industrial energy use. Respondents did however not give the approximate monthly consumption of electricity but expenditure levels were given. In this case, consumption has a direct effect on expenditure level since the companies‟ pays just for the quantity of units used. Figure 4.3 shows monthly expenditure on electricity in the surveyed industries;



Source: Researcher‟s construct, 2016

Figure 4.3 Monthly expenditure on electricity

Electricity use identified included general lighting and ventilation of offices, printing, scanning, photocopying, equipment and machines among others. Electricity expenditure levels are high as well in the area as shown in the chart, the highest proportion represents 50% of the responses and

the lowest represents 3.3 %. This means that a half of the industries reviewed spend below GHS 5000 on electricity per month and just about 3.3% spending above GHS 15000. The remaining represents 36.6% and 10%, which are for the ranges GHS 5000 to 10000 and GHS 10000 to 15000 respectively. This also shows that electricity is well captured in the area.

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4.3 Energy information systems in Kaase Industrial area

In order to control energy usage and cost to ensure energy efficiency and management, industries require a recent information system grounded on energy consumption quantities and productivity indicators. Usually the kind of energy information systems used is dependent on the scope of a company plus the proportion of expenditure cost on energy use. It was identified that appropriate information systems creates transparency and personal accountability for employees.

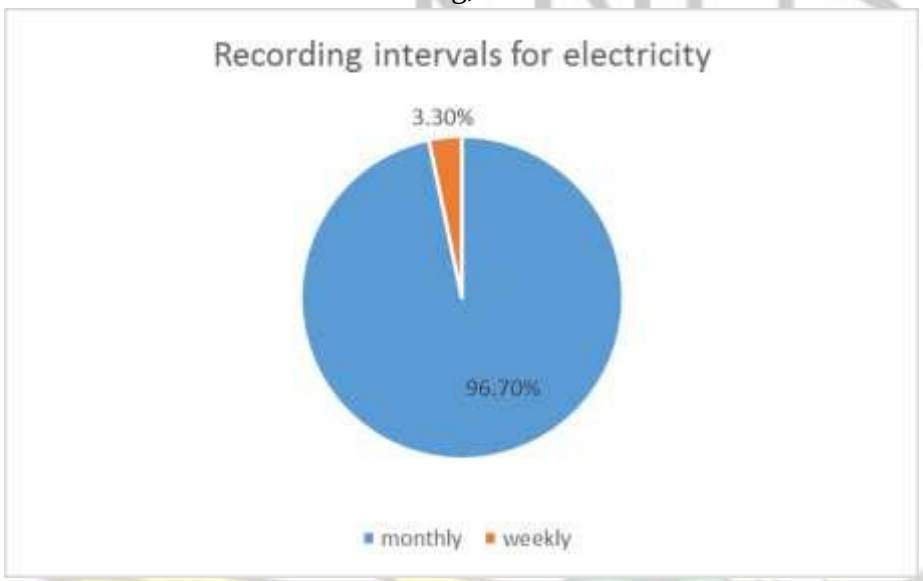
4.3.1 Electricity metering

This involves installing devices that measures the amount of electric current consumed by the industries. These meters measure the maximum use of power in some interval, demands and permits electric degrees to be charged in the day time, it accounts for utilization at periods where cost are very high, off peaks and lesser costs period. In view of this, the respondents were asked to assess the level at which electricity is metered whether the entire site for production is metered or the building or just specific equipment. After the field survey, it was realized that all the thirty (30) companies that participated in the study had electricity metered in the whole site, building level and individual equipment.

4.3.2 Recording

To ensure energy efficiency, industries are advised to ensure electric meters are read and recorded periodically to establish billing cycles and energy used. These recordings may be used to reduce

or postpone certain types of electricity consumption. The respondents were asked to confirm how frequently electricity was recorded whether annually, monthly, weekly, or daily. In the end it was gathered that all the industries did their recording either monthly or weekly. Figure 4.4 shows the intervals for recording;



Source: Researcher"s construct, 2016

Figure 4.4 recording intervals for electricity

The chart shows that most of the companies record electricity monthly representing 96.7% and 3.3% did it on weekly basis. Respondents confirmed that the periodic recording helps the industries to; detect problematic areas at their very early stage; validate utility billing; support in energy procuring; aid in preservation; aid in identifying and monitoring energy projects.

4.3.3 Alternative source of energy

The alternative energy sources used in the industries were mainly electricity generating plants and liquefied petroleum gas. About 93.3% of the companies had alternative sources of energy and the remaining 6.7% had no alternative sources. Approximately 83.3% of the companies that had were

large electricity generating plants, 6.7% used generators and 3.3% used LPG, no responses accounted for 6.7% as well.

Furthermore, the respondents were asked the level at which the alternative sources of energy were metered, twenty-seven (27) responses were recorded which all indicated that the source was metered within the whole site and not just the buildings or particular machinery. Out of the twenty-seven responses, 3.3% recorded on monthly basis; 53.3% did the recording on weekly basis and 36.7% took daily recordings.

4.3.4 Energy Monitoring and steering

Monitoring and steering energy is based on the fact that without measuring you cannot manage. When systems are put in place to monitor energy use, it provides feedback on various management practices and serves as a guide to energy use. Figure 4.5 and 4.6 show the percentage of industries that have these systems in place;

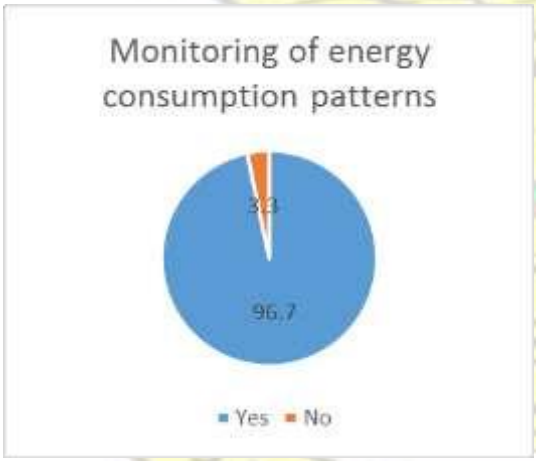
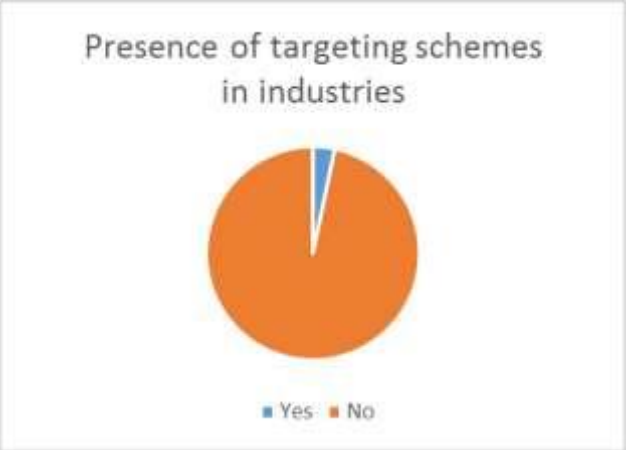


Figure 4.5 Monitoring of energy consumption patterns



Source: Researcher‟s construct, 2016 Figure 4.6 targeting schemes

Figure 4.5 monitoring of energy consumption patterns

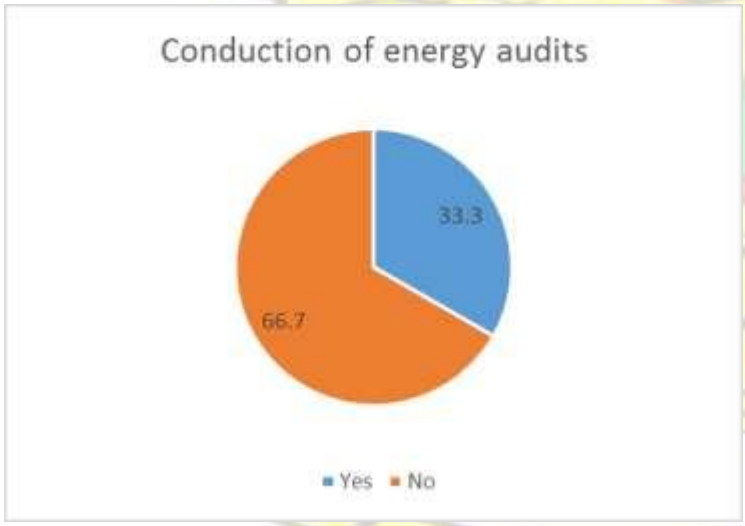
About 96.7% of the companies located in the area use various monitoring systems and the remaining 3.3% do not have. However 60.7% do not have targeting schemes instituted which means there is poor monitoring because the two complement each other. About 39.3% had targeting schemes implemented which is considerably low, looking at the consumption levels of these industries. The identified targeting systems put in place included the identification of areas that use energy excessively; the detection of instances where energy use went unexpectedly low or high; envisaging energy consumption trends and determining future energy use and cost. The target schemes also checked areas where energy was wasted and also the effect of the changes of the driving factors to energy use was studied and finally performance targets were set for energy management programs.

It was also realized that the monitoring of consumption patterns were adjusted to suit energy price changes in most industries. This was deemed very necessary because of the current price hikes in energy; these adjustments were therefore necessary to make energy efficiency and management efforts realistic. At the end of the study, only 16.7% considered price hikes in observing patterns and the remaining 83.3% did not take that into consideration.

The staff of the companies also had adequate information on the energy consumption levels of their companies. This is very important because they have got a vital role to play in achieving efficiency. It was confirmed that 93.3% of the companies communicate this information to its employees and the remaining 6.7% did not, this was however impressive. Approximately 10% used benchmarks to monitor their consumption patterns. This was seen to be poor since about 90% did not use benchmarks.

4.3.5 Energy audits

Conducting energy audits is very vital for assessing energy efficiency and management because it encourages many ways of saving money. A well implemented energy audit is a foundation for an efficient upgrade of energy management system which is a sustained process of increasing efficiency and cost reduction. With this, energy cost savings are recorded periodically to assess the level of fluctuation. Figure 4.7 shows the percentage of industries that conduct audits;



Source: Researcher‟s construct, 2016

Figure 4.7 Conduction of energy audits

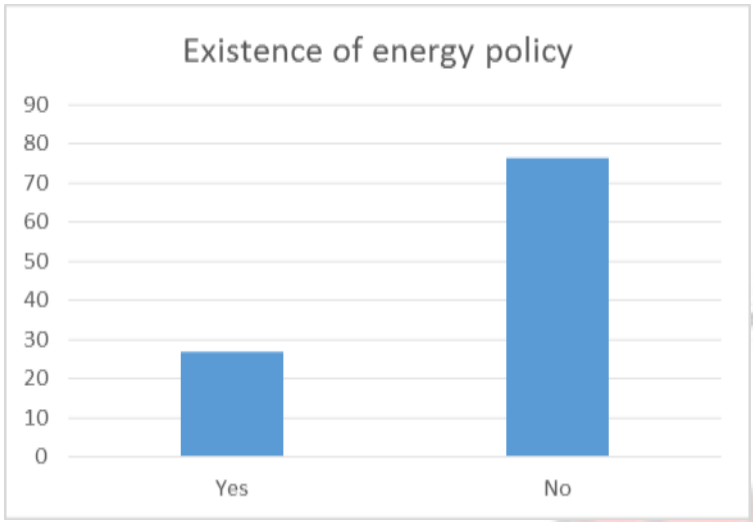
It can be seen from the chart that energy auditing is very low in the Kaase industrial area. This means that there were no sources of realistic information for tracking energy flows in the area. Only 33.3% of the participating industries conducted energy audits and the highest proportion representing 66.7% did not. It can therefore be said that the initial stage in detecting prospects to lessen energy consumption is not evident in most of the companies in the study area.

4.4 Energy Management Systems

Energy efficiency and management in industries greatly depends on the quality of the industries‟ management system which refers to all the activities that affect energy use and its cost. Failure to define clearly energy management systems in a company usually increases energy use and cost because there is no encouragement and commitment to energy efficiency. One point worth noting is that, these management systems should be a continuous process and an effective way to realize that is a sustained commitment from the companies.

4.4.1 Energy Policy

A company‟s energy policy includes the organization‟s guidelines with respect to energy use, the elements of energy planning, procedure for achieving the goals of the policy among others. The existence of an energy policy can be said to be the foundation of an effective energy efficiency and management of an industry since it provides a framework within which energy issues are tackled. However the existence of energy policy in the industries captured were very low as shown by figure 4.8



Source: Researcher‟s construct, 2016 **Figure 4.8 Existence of energy policy**

The existence of energy policies in companies was also identified to be low, as just about 26.7% of the surveyed firms had it in place whereas the remaining 73.3% do not have it. As stated earlier, an industry‟s energy efficiency and management culture stems from the existence or inexistence of an energy policy hence the information in figure 4.8 proves that there will definitely be an efficiency gap in the study area. Comparatively, the industries with the policy have a higher tendency of achieving the goal of efficient energy use.

4.4.2 Effectiveness of the energy policies

The presence of an energy policy is not adequate to ensure energy efficiency but how effective that policy is deemed is as important as its existence. Therefore the effectiveness was evaluated by finding out the commitment level of top management to the policy since they are at the topmost level of the organizational hierarchy, the level of awareness among the entire staff and the level of integration of the policy into the firm‟s daily activities.

Energy policies were absent in 73.3% of the industries indicating that its effectiveness needs not to be assessed. It was then realized that the entire 23.3% which had it, had the top level management officials fully committed to the policy and also had its content fully integrated into

all activities in the firm. There was also a high level of awareness among the staff of those industries as confirmed by the respondents.

4.5 Energy Efficiency Opportunities

Literature proves that there are several energy improvement opportunities available in industries to reduce consumption and expenditure whilst boosting productivity. Energy efficiency can be ensured with respect to the use of equipment and machines; where the company cultivates a good maintenance culture to eliminate older equipment which consume much more energy yet lower efficiency level. It can also be as a safeguard at the production level by regulating and optimizing processes involved in production to maximum efficiency. Feasible process integration can be put in place to minimize general energy use like lighting and ventilation at the facility level. Lastly, at the organizational level, a framework could be designed for monitoring of energy, setting targets and ensuring commitment by the entire workforce. The opportunities available in the Kaase industrial area were then evaluated according to their cost effectiveness.

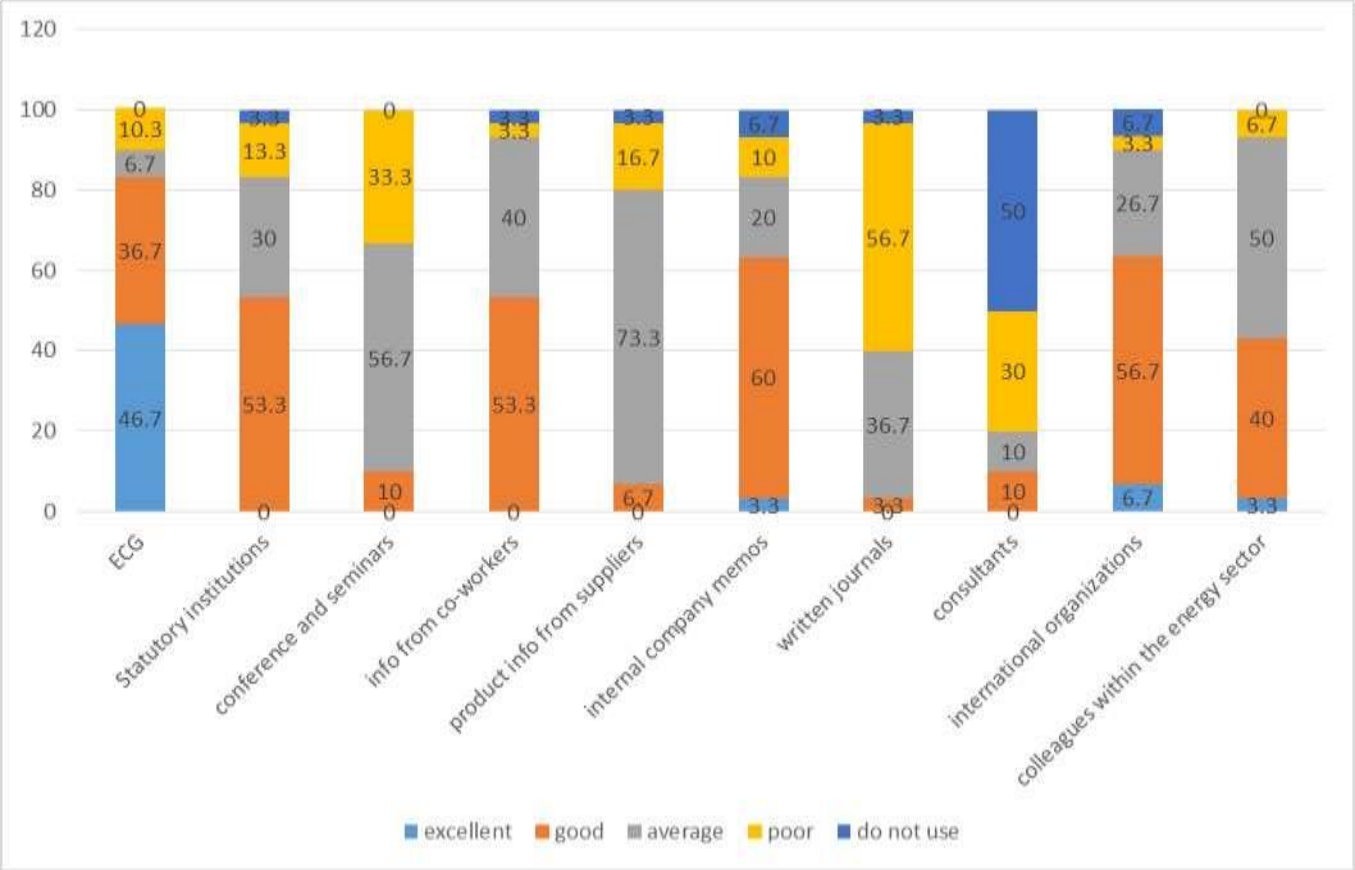
From the field survey, all the industries interviewed confirmed that they had a number of energy efficiency opportunities in place and all confirmed that those measures were cost effective and profitable to their companies. The measures identified included the great attention that was given to motor driven systems; all the respondents stated that motor driven systems constituted a large proportion of their energy consumption hence various activities have been put in place to minimize consumption but improving productivity.

The human factor also was identified to be one key area they paid attention to; the companies communicated extensively on energy issues in such a way that operators and other staff are very sensitive to the impact of various machinery and equipment on energy. Timing was also identified

as an opportunity in the study area where high cost non-essential processes were shifted to off-peak seasons to take advantage of the dynamics it can institute in the pricing of energy utilities.

4.6 Energy Information Sources

It was necessary to identify how useful the various energy information sources in Ghana are to the industries in Kaase. These institutions possess vital information for energy efficiency and management and the credibility of these sources are also very important. The respondents were then asked to rate the usefulness of each of the sources, figure 4.9 rates the responses from excellent to poor;



Source: Researcher‟s construct, 2016

Figure 4.9 Usefulness of Energy Information sources

The Electricity Company of Ghana was rated as an excellent source of information for the industries as 46.7% agreed that they always provided very useful information whenever they were in need of it. About 36.7% rated their usefulness as good, 6.7% believe their usefulness is on the average level. It is worth noting that, the institution was deemed to be a credible source of energy efficiency information and opportunities as all the industries depended on it somehow in that regard. Respondents explained that the ECG organized industrial seminars and workshops for them periodically and the outcomes of those workshops had helped their industries.

Internal company memos was graded the next most useful information source as 60% of the industries rated it as a good source of information for them. They added that the memos within their various companies were made to suit the conditions in that very company and hence was deemed reliable.

It was also realized that international organizations like the World Bank and IEA were another reliable source for them. This was confirmed by 56.7% of the participating companies rating it as good. Conferences and seminars were generally deemed to be on the average level as a little over half of the respondents rated it as such.

The energy commission is the technical regulator of Ghana‟s energy resources. It regulates, manages, develops and utilizes all forms of energy resources in the country. They provide information on energy efficiency initiatives to guide companies in achieving the efficiency goal. Respondents rated the body‟s usefulness as a source of information to them as good as shown in the bar graph where a little over half confirmed it. They made it clear that, they had access to authentic information from them most times.

Product information from suppliers was ranked to be on the average level by most participating companies representing 73.3%. They added that this information source was however not reliable as energy efficient machinery and equipment manufactured in advanced countries sometimes do not auger well for local settings. They admitted that suppliers had some information for them but not always useful.

It is worth noting that, the use of consultants in the study area was very low. Consultants could be a very credible source of energy efficient technologies and opportunities but 50% of the industries did not use the services of these experts. About 10% rated their services as good and 30% rated their source of information as poor.

4.7 Implementation of specific energy efficient technologies

With regards to some technologies to reduce energy consumption identified in literature, the study sought to investigate into the presence or absence of these technologies and the levels of implementation; that is, if it is in existence.

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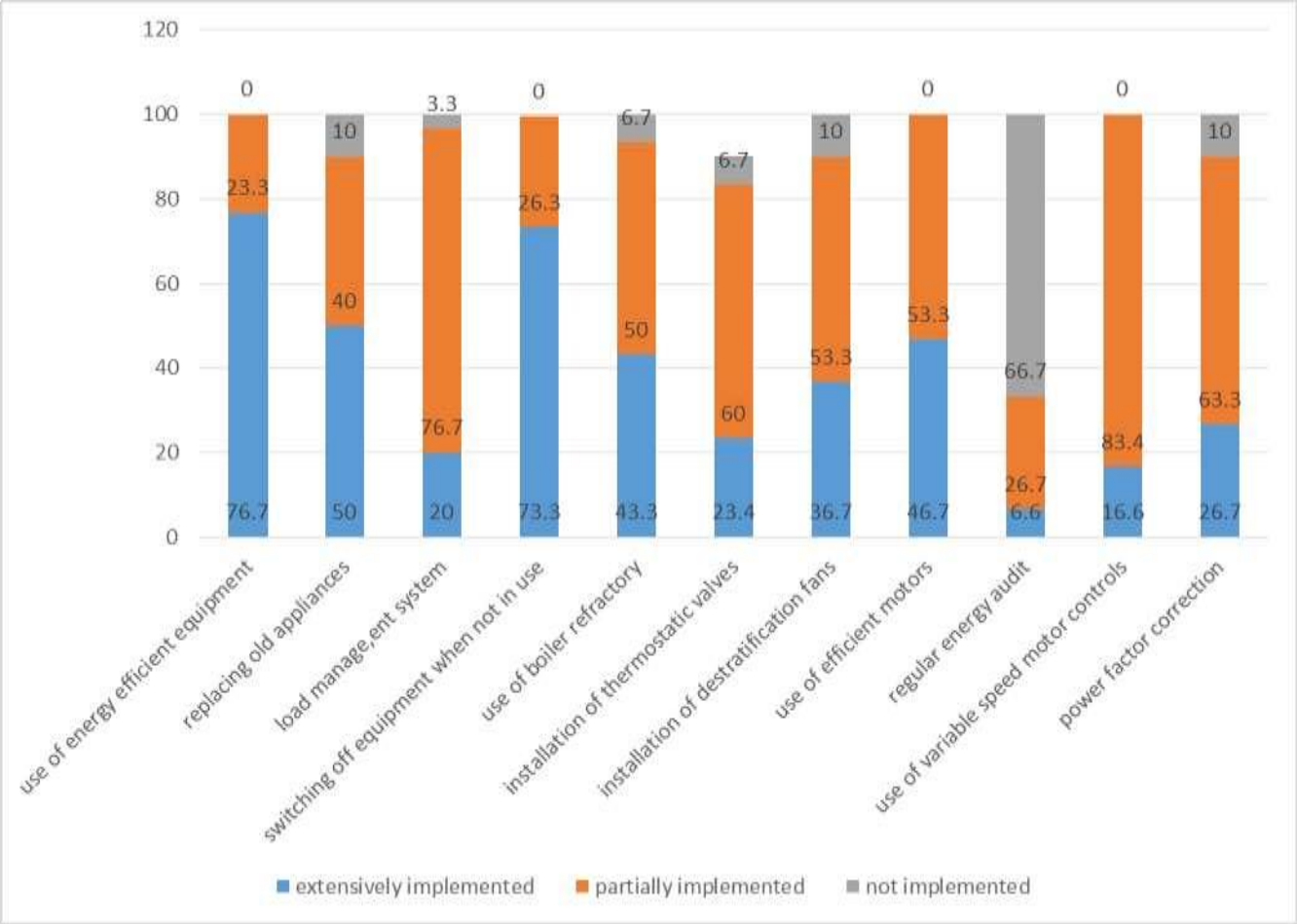


Source: Researcher"s construct, 2016

Figure 4.10 Level of implementation of specific energy efficient technologies

From the bar graph it can be noted that the most extensively developed system was the use of energy efficient equipment where 76.7% of the industries confirmed that they use only energy efficient computers, photocopiers, bulbs and others. The remaining 23.3% indicated that this system was in place but was partially put in place at the time of the survey.

About 73.3% of the industries also confirmed that all their employees have cultivated the routine of putting off of all machines after using them, 26.3% said efforts were ongoing to achieve this aim. Half of the companies have made efforts to replace their old appliances, 40% had done that partially, respondents mentioned that it was a gradual process and in no time old equipment will

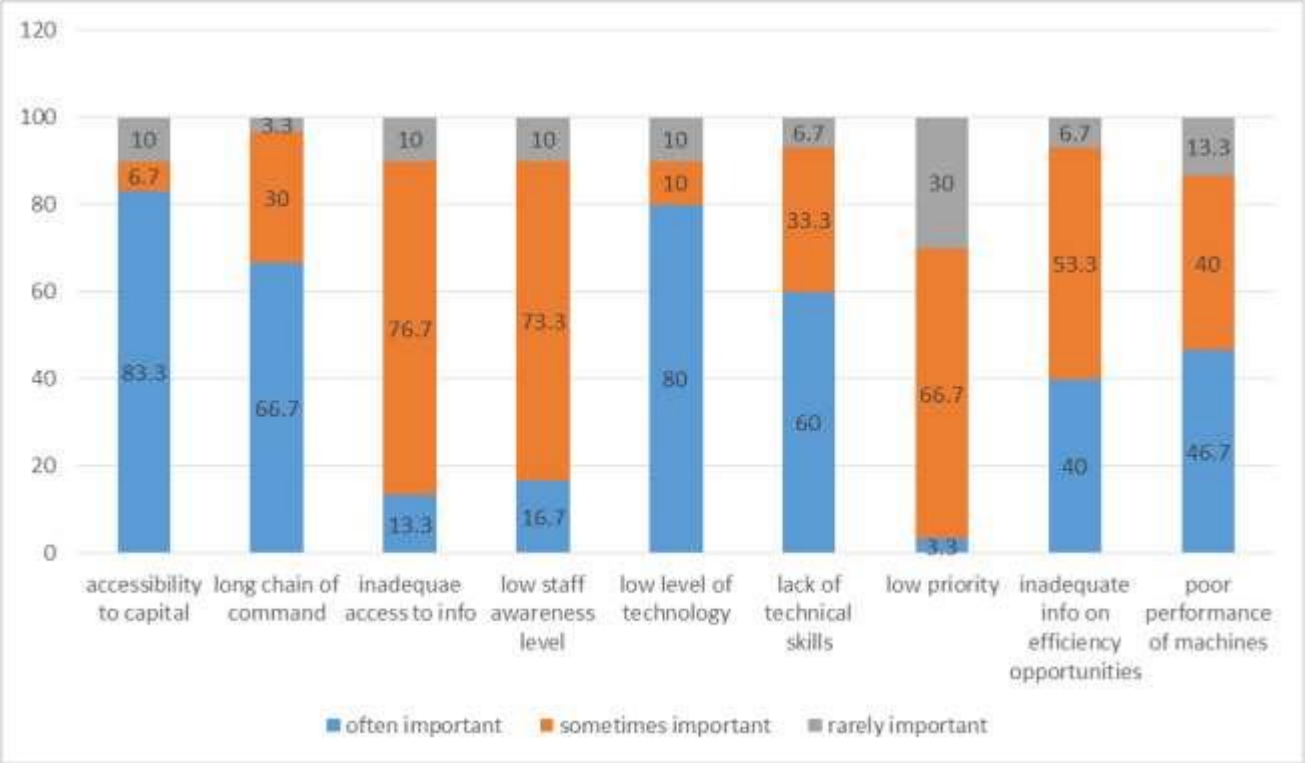
be totally replaced with high efficient ones. However 10% approved that this strategy was not implemented in their industries.

Load management system on site, usage of boiler refractory, fixing of thermostatic valves and installation of destratification fans were all partially implemented in the industries as represented in the graph which shows that 76.6%, 50%, 60% and 53.3% respectively confirmed partial implementation of these technologies in their firms.

Use of variable speed motor controls and power factor correction were also partially implemented in most industries as represented by 83.4% and 63.3% respectively. Lastly energy audit recorded the least implemented strategy in the study area; about 66.7% of the companies did not conduct energy audits whereas 26.7% had implemented it partially. This shows that most technologies available to the industrial area have not been fully exploited.

4.8 Barriers to energy efficiency improvement in Kaase

In every institution there are factors which mitigate the implementation of policies. The energy efficiency issues discussed earlier are believed to have root causes, respondents were therefore asked to value the impact of some identified barriers in the application of cost effective energy efficiency methods in their respective companies. The scale they used was often important, sometimes important and rarely important. Figure 4.11 shows how respondents valued each of the barriers;



Source: Researcher‟s construct, 2016

Figure 4.11 Barriers to energy efficiency improvement

Accessibility to capital was the commonest obstacle inhibiting energy efficiency in the industries. It can be said that implementation of energy efficiency and management policies can be very costly sometimes hence it requires huge capital. Respondents therefore confirmed that there was a problem of low access to capital for implementing these strategies. This problem was as a result of the inadequate of technical capability of the industries and financial institutions to precisely assess the paybacks of energy efficiency investments.

In the second position was, low level of technology at the site which was confirmed by 80% of the respondents as an often important factor which impedes energy efficiency improvement. They confirmed that some forms of technology they use at the sites do not perform up to expectations

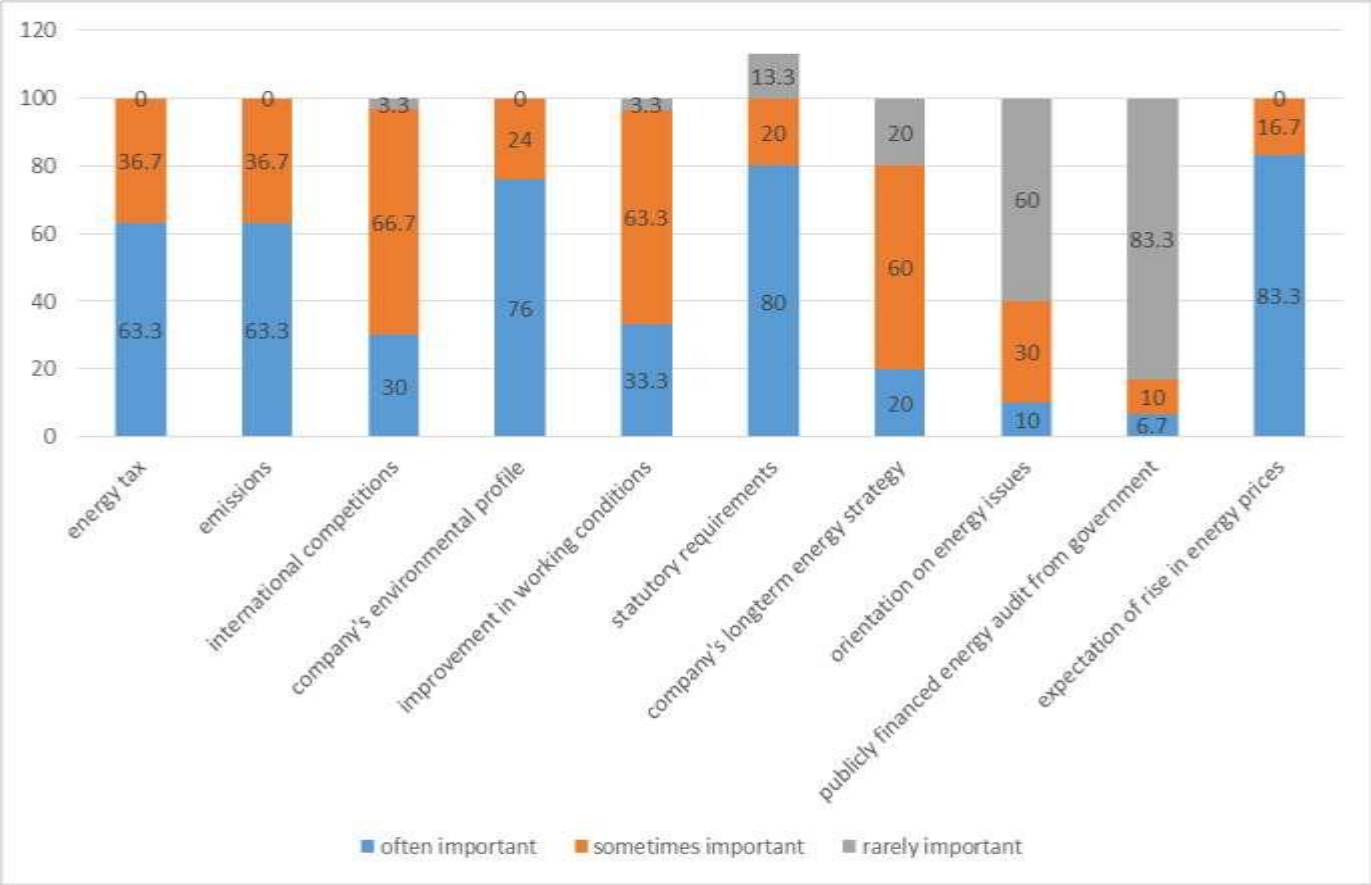
hence undermining the achievement of the ultimate goal. Long chain of command in the companies was deemed to be an often important factor as 66.7% agreed to it. An established chain of command creates efficiency in reporting problems and improves communication at a workplace; it can however have negative effects when it becomes complex. Respondents indicated that the long chain of command had affected their ability to react to changes concerning energy issues.

The fourth important barrier was the low level of technical skills which was established by 60% of the industries as an important factor negatively affecting them. The industries lacked the requisite skills to harness the full energy saving potentials of their respective firms. Approximately, 46.7% said the poor performance of some machines and equipment contributed to their inability to improve efficiency. However 40% of the poor performance of machinery was not always an impeding factor in their companies whereas the remaining 13.3% claimed it was rarely important to them.

Inadequate information on energy efficiency opportunities was the next important barrier identified as 40% deemed it often important however, 53.3 % said it was sometimes important to them. Low priority given to energy management policies, inadequate access to information on energy consumption of equipment and low staff awareness level were all seen to be less important barriers by the industries.

4.9 Driving forces for energy efficiency improvement in Kaase

The study went further to assess the various factors that motivate industries to initiate cost effective energy efficiency measures. This was vital because it informs decision makers on how to deal with energy issues effectively. To achieve these, respondents were asked to value the importance of each identified barrier using often important, sometimes important and rarely important. Figure 4.12 shows the responses obtained;



Source: Researcher"s construct, 2016

Figure 4.12 Driving forces for energy efficiency improvement

The highest factor that motivated the industries was the expectations of rise in energy prices, which was confirmed by 83.3% of the respondents. The industries had recorded a steadily increase in cost involved in energy use as a result of constant increase in prices hence anticipations of future increases pushed them to take energy efficiency improvement seriously in order to reduce cost and maximize profit. The second highest factor identified was the requirements set by the government; they explained that there were no rigid rules set by the statutory institutions but they valued it as a very important factor that pushes them to achieve the goal. The third highest motivator was the company"s environmental profile, which was also seen as a very effective driver. Emissions and

energy tax was ranked on fourth positions; this shows that some of the industries have concerns for environmental issues. International competitions, improvement in working conditions, company‟s long term energy strategy, orientation on energy issues from seminars and publicly financed energy audit by government were ranked less important to motivate energy efficiency improvement.

CHAPTER FIVE

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

The final chapter of this thesis comprises the overview of the findings founded on the aims of the study including the current energy efficiency and management strategies adopted in the Kaase industrial area and the factors that inhibit its smooth operation. Recommendations were further made as proposed solutions to mitigate the barriers identified; a conclusion was then drawn on the entire study.

5.2 Summary of Findings

The Kaase industrial area is mostly made up of wood processing firms which constitute about 53.3% of the industries located in the area. Fuel and electricity were the main forms of energy used in manufacturing.

With respect to energy information systems, it was concluded that all the industries surveyed had meter systems to monitor energy use at the whole site, building and equipment levels. Recordings were mostly done on monthly basis as 96.7% stated. The alternative sources of energy found were electricity generating plants and LPG which were also metered and recorded at specific intervals.

Approximately, 39.3% used targeting schemes which was considered to be very low and 96.7% monitored energy use patterns and only a few representing 16.7% adjusted those patterns to price hikes. Furthermore, it was discovered that only 10% used benchmarks in assessing their performance which was very low. Similarly, energy audit was very low among the industries as 33.3% of the participating industries undertook it. Energy policy was also inexistent in most of the industries constituting 73.3% however those who had it in place confirmed that there was a commitment to it by top level officials, high awareness level among staff and a full integration of it in their respective firms.

The most useful sources of information on energy efficiency issues consisted of the Electricity Company of Ghana, which organized periodic seminars and workshops for the industries. This was followed by internal memos on energy, international organizations and the energy commission.

The most important driving force of energy efficiency improvement identified in Kaase was the anticipation of energy price increase. The others included the statutory requirements set by the government, a particular company‟s environmental profile, energy taxes, emissions and

international competitions.

The most extensively implemented technology or strategies were the use of energy efficient equipment like bulbs, photocopiers and other equipment. This was followed by the companies cultivating the routine of putting off all machinery after using them. The next was replacing old appliance and the use of boiler refractory and use of efficient motors, which were partially implemented in most industries. Implementation of strategies such as regular energy appraisals, power factor correction, installation of de-stratification fans were comparatively on the lower side

Considering the barriers to the implementation of the above explained strategies, access to capital was ranked first on the ladder as 83.3% of the respondents indicated that it was often an important factor. Also the low level of technology on site, long chain of command, inadequate facts regarding energy efficiency prospects and the poor performance of machines were deemed to have significant effects on energy efficiency improvement.

With regards to the motivating factors to energy efficiency improvement; future expectations of energy price increases was the most important factor that motivates the industries in Kaase to take energy efficiency seriously. Others included the statutory requirements set by the government, the individual company‟s environmental profile, energy tax, emissions, and international competitions among others.

5.3 Conclusion

The analysis of this study gives a broad indication of the energy management profile, practices, systems and barriers within the Kaase industrial area. Generally, it can be concluded that efforts to achieve the goal of industrial energy efficiency and management is moderate and needs to be reconsidered to ensure effectiveness.

Effective energy management can only be achieved through an integrated system approach consisting of the presence of energy policies for various companies, frequent conduction of energy audits, frequent recording of energy consumption and the use of benchmarks to monitor performance which helps industries to be cautious. This can also be achieved with the full commitment of the entire human body in the institutions through frequent extensive communication of energy issues to the staff. Furthermore, the identified opportunities should be harnessed by using the services of the experts in the subject matter.

5.4 Recommendations

The industries are entreated to prepare comprehensive energy policies in order to provide a basic framework within which the overall goal of energy can be achieved. This can be done through the upgrading of the skills of the energy managers in the companies to equip them with the requisite skills to manage energy issues better.

Industries in the area should review relevant energy use based on a comprehensive energy audit. It was concluded that the efficiency measures put in place were ineffective due to the absence of energy audit in most of the companies. The services of energy auditors can be taken advantage of in order to create a data bank for energy and its related issues in the industries.

Construction of energy information systems which include the establishment of a measuring system based on analysis of energy use as well as the determination and valuation of efficient indicators.

The government is entreated to pay much more attention to improve energy efficiency in the industries by empowering the Energy Commission so as to allow them to provide technical services to these companies.

Awareness level should be increased among both top management officials and staff through training and capacity building programs. These programs could be organized in the respective companies periodically and they should thoroughly educate them on the benefits of efficient energy use.

The government and even financial institutions can develop innovative financing schemes for these industries so as to deal with the issue of low access to capital. These schemes could have very flexible terms and incentives which will attract the various industries

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DEPARTMENT OF ECONOMICS

Questionnaire for thesis work on energy efficiency and management in industries – a case study of Kaase industrial area in Kumasi.

1. Identification

Name of company…….

2. The company

Number of employees (approximate) ……..

Annual turnover (approximation)…….

3. Monthly energy use

Please indicate your company„s approximate monthly consumption of:

Fuel ……

Electricity…… (Please indicate units)

Please indicate your company„s approximate monthly expenditure on:

Fuel……

Electricity……..

4. **Energy information systems**

i. At what level is electricity generally metered?

Whole site [ ] Building [ ] Individual equipment [ ] ii. How frequently is electricity recorded?

Annually [ ] Monthly [ ] Weekly [ ] Daily [ ] iii. Aside electricity, does your company have any alternative source of energy use?

Yes [ ] No [ ]

iv. If yes, please state the energy source…….

……

v. At what level is the alternative energy source also metered?

Whole site [ ] Building [ ] Individual equipment [ ] vi. How frequently is the alternative energy source recorded?

Annually [ ] Monthly [ ] Weekly [ ] Daily [ ] vii. Does your company monitor energy consumption patterns?

Yes [ ] No [ ]

viii. Are consumption patterns adjusted to energy price hikes and changes?

Yes [ ] No [ ]

ix. Does your company have a monitoring or targeting scheme instituted?

Yes [ ] No [ ]

x. Is energy consumption advised to staff?

Yes [ ] No [ ]

xi. Are there benchmarks with which consumption patterns are compared?

Yes [ ] No [ ]

xii. Does your company conduct energy audits?

Yes [ ] No [ ]

5. **Energy Management Profile?**

i. Does your company have an energy policy?

Yes [ ] No [ ]

ii. If yes, is the top management of your firm fully committed to the energy policy?

Yes [ ] No [ ]

iii. If yes, is the energy policy fully integrated into your firms operations?

Yes [ ] No [ ]

iv. If yes, what is the level of the policy awareness among staff in the firm?

High [ ] Low [ ]

v. Does your firm have any energy management system (EnMS) instituted?

Yes [ ] No [ ]

vi. If yes, please state and comment on the features of the EnMS

……

……

……...

6. **Energy efficiency opportunities**

i. Does your company have any energy efficiency measures implemented?

Yes [ ] No [ ] ii. Are the energy efficiency measures cost-effective and profitable to your company? Yes [ ] No [ ]

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7. **Energy information sources**

With a scale of 0 to 1, how useful do you consider the following sources to be as regards to information on energy efficiency measures?

	Excellent (1)	Good (0.75)	Average (0.5)	Poor (0.25)	Don"t use (0)
Electricity Company of Ghana					
Statutory Institutions (Energy Commission, Ministry of Energy)					
Conference and Seminars					
Information from co – workers					
Product information from suppliers					
Internal company memos					
Written journals and newsletters					
Consultants performing energy audits					
International organizations (IEA, World Bank)					
Colleagues within the energy sector					

8. **Implementation of specific energy efficient technologies**

With regards to some of the following measures for reducing energy consumption. **Please indicate the extent to which your company has implemented each measure by assigning it a number on a scale from 0 (not implemented) to 1 (extensively implemented).**

	0	**0.25**	**0.5**	**0.75**	**1**
Purchase of energy efficient computers, photocopiers & other office equipment?					
Use of energy saving bulbs in offices and production site (Compact fluorescent lamp)					
Replacing old appliances with high efficient type					
Load management system at production site					
Switching off of conveyors and other equipment when not in use					
Use of boiler refractory?					
Insulation of boilers, water tanks					
Installation of thermostatic radiator valves?					

Installation of de-stratification fans					
Use of efficient motors for compressors (Reluctance motors)					
Regular energy appraisals/audits					
Use of variable speed motor controls					
Allow for power factor correction					

Aside these measures, please list any other energy efficiency measures implemented by your company:……

……

……

9. **Barriers to energy efficiency improvement**

In every institution, there are factors which mitigate the implementation of policies. In your own experience, how do you value the impact of the following barriers in the implementation of cost -effective energy efficiency measures at your company.

	Often important (1)	Sometimes important (0.5)	Rarely important (0)
Accessibility to capital			
Long chain of command			
Lack of access to information on energy consumption of equipment			
Ignorance of staff awareness on energy issues			
Low level of technology at the site			
Lack of technical skills			
Low priority given to energy management policies			
Lack of information regarding energy efficiency			
opportunities			
Poor performance of machines or equipment			
Risks associated with production disruptions			

Aside these factors, do you have any comments on barriers to energy efficiency improvement?

……

……

……

10. **Driving forces for energy efficiency improvement**

There exists forces which drives companies to initiate successful energy efficiency improvement. In your own experience, how do you value the impact of the following barriers in the implementation of cost –effective energy efficiency measures at your company?

	Often important (1)	Sometimes important (0.5)	Rarely important (0)	
Energy tax				
Emissions / Pollution tax (CO_2)				
International competitions				
Expectation of rise in energy prices				
Company‟s environmental profile				
Improvement in working conditions				
Statutory requirement for energy efficiency				
Company‟s long-term energy strategy				
Orientation on energy issues from seminars				
Publicly financed energy audit by government				

Do you have any further comments on driving forces for energy efficiency improvement?

……
……
……

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE