UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

INVESTIGATION INTO THE IMPACT OF USING CFL BULBS ON ENERGY CONSUMPTION IN GHANA-A CASE STUDY OF TWIFO HEMANG LOWER DENKYIRA DISTRICT IN THE CENTRAL REGION OF GHANA.

WILSON SOLOMON KWEKU

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A Dissertation in the Department of ELECTRICAL AND ELECTRONICS TECHNOLOGY EDUCATION, Faculty of TECHNICAL EDUCATION, submitted to the school of Graduate Studies, University of Education, Winneba in partial fulfilment of the requirements for the award of Master of Technology Education in Electrical and Electronics Technology degree.

AUGUST, 2016

DECLARATION

STUDENT'S DECLARATION

I, WILSON SOLOMON KWEKU, declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my original work, and it has not been submitted, either in part or whole for another degree elsewhere.

SIGNATURE:……..

DATE: …….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines and supervision laid down by the University of Education Winneba.

Name of Supervisor: **MR. FRANCOIS SEKYERE**

SIGNATURE:……..

DATE: …….

DEDICATION

I dedicate this dissertation to my wife, Ernestina Asuakoh and my children Yaw Addae Wilson, Amanda Akua Nkansah Wilson, Kojo Inkoom Wilson and also to my spiritual father Yao Addison.

ACKNOWLEDGEMENT

I am grateful to Almighty God for His guidance and protection. Secondly, I am grateful to Mr. Francois Sekyere and all the Lecturers at the electrical department at the UEW-K.

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ABSTRACT

The main purpose of the study was to investigate into the impact of using CFL bulbs on energy consumption in Ghana- a case study of Twifo Hemang lower Denkyira district in the central region of Ghana. This study employed quantitative and descriptive methodology to collect data and analyze data. The population for this study comprises individuals who consume electricity in the Twifo Hemang lower Denkyira District in the Central Region of Ghana. The population for the study was nine hundred and seventy (970).The random (probability) sampling technique was used to sample 274 electricity consumers within the study area. The instruments used for the study were structured questionnaires. The introduction of CFL bulbs has impacted in reducing power consumption in households in the Twifo Hemang Lower Denkyira District. The respondents were willing to use CFL bulbs to conserve electrical energy and save money. The study concluded that education, income, age and occupation, played significant role in electrical conservation and consumption. The study recommended that the ECG should organise periodic advertisements and awareness programmes to educate electricity consumers on the importance of using the CFL bulbs to conserve electrical energy.

CHAPTER ONE

INTRODUCTION

This chapter contains the background to the study, statement of the problem, purpose of the study, objectives of the study, significance of the study, scope of the study and overview of the rest of the study.

1.1 Background to the Study

The compact fluorescent lamps as defined by the Electric Power Research Institute are lamps intended to replace the incandescent lamps and have an overall length of 20 cm or less. The CFLs consist of two parts, gas- filled tube (bulb) and magnetic electronic ballast. CFLs require less energy input than incandescent lamps for example, the 27 watts (W) CFL generates approximately 1800 lumens compared to 1750 lumens from 100 watts (W) incandescent. CFLs also have a significantly longer service life, 6000-15000 hrs compared to 750 – 1000 hrs for a standard incandescent lamp (Doe & Asamoah, 2014).

The CFLs produce less heat and consequently reduce the need for cooling with fans and air conditioners which also consume electricity. The compact fluorescent lamp therefore offers a considerable increase in energy efficiency compared to conventional incandescent lamps and has long been recognized as the quickest and surest way of reducing energy consumption particularly among residential consumers (Douglas & William, 2012).

The Ministry of Energy in August launched the National Compact Fluorescent Lamps (CFLs) exchange programme. The Ministry announced that the government had imported six million CFLs for distribution free of charge to all households in the country

in exchange for incandescent bulbs. This was an emergency policy intervention measure to reduce peak electricity supply in order to resolve the power crisis, as a result of low rainfall which had affected hydro-electricity supply. Earlier, in August 2006 the Volta River Authority (VRA) and the Energy Foundation had held a series of meetings and outlined measures to reduce electricity demand. The Foundation presented a report which identified measures that combine technology, administrative measures, education and policy intervention to reduce electricity peak load. In addition to the above measures, a CFLs exchange programme was introduced with the objective to replace six million incandescent lamps with an equivalent number of CFLs. The following outputs were targeted; Peak Electricity demand reduction from 200-220 MW, Stabilization of electricity grid system, Elimination of brownout and transformer overloads, Reduction of diesel and other thermal generators to supplement hydro and other cheaper power generation options It is generally known that, a higher penetration of CFLs for household lighting could reduce growth in electricity demand, reduce fossil fuel use for thermal electricity generation and lessen environmental impacts (Gyamfi, Mawufemo & Sinisa, 2015).

On the Global front a recent publication by Asia-Pacific Economic Cooperation on Energy Inefficient Light Bulbs indicated that nations are moving gradually towards more energy-efficient lighting and phasing out inefficient bulbs in an effort to reduce greenhouse gas emissions. The first country in the world to phase out incandescent lamps is Cuba. Cuba implemented a massive market transformation effort to replace every single incandescent lamp in every socket in the country by a compact fluorescent lamp in 2006 and 2007. Incandescent lamps are banned from sale and production. The country also replaced more than a million inefficient domestic refrigerators over the same period. Oil rich Venezuela has also banned the use of incandescent lamps.

Australia is phasing out incandescent lamps by 2009. Other economies in Asia including China, Thailand and Philippines have introduced measures to promote the use of energy-saving bulbs instead of incandescent lighting. India is following another route to achieve the shift away from incandescent lighting, through a series of large-scale CDM (Clean Development Mechanism) projects under the recently approved programmatic approach. Government and utilities in Egypt, Argentina, Indonesia, South Africa and Vietnam are all considering similar options and strengthening existing major CFL promotional programs. Several other countries including Brazil and Mexico have previously launched successful large scale programmes to promote the use of CFLs. In the USA, California and Nevada have introduced legislation to phase out incandescent lamps and all the states in the USA are expected to phase out incandescent lamps by 2012 (Gyamfi, Mawufemo & Sinisa, 2015). The study therefore seeks to investigate the impact of using CFL bulbs on energy consumption in Ghana; using the Twifo Hemang lower Denkyira District in the Central Region of Ghana as a case study.

1.2 Statement of the Problem

The stated problem of the study is that the most residents in the Twifo Hemang Lower Denkyira District use the onion type bulbs which consumes high electrical energy. Thereby increasing the cost of electrical usage. The introduction of CFL bulbs is low in the district. The report also highlights some of the setbacks of the programme include; Lack of cooperation of major stakeholders in the planning and implementation of the exercise, due to the emergency nature of the intervention, the oversight of environmental issues in the disposal of dead CFLs and the handling of the broken CFLs, Inadequate training for programme implementation team and Inadequate awareness creation on CFLs technology for household beneficiaries. Therefore, the study seeks to

investigate into the impact of using CFL bulbs on energy consumption in Ghana, using the Twifo Hemang Lower Denkyira District as a case study.

1.3 Purpose of the Study

The main purpose of the study is to investigate into the impact of using CFL bulbs on energy consumption in Ghana- a case study of Twifo Hemang lower Denkyira district in the central region of Ghana.

1.4 Specific Objectives of the Study

1. To assess the extent of knowledge and usage of compact fluorescent lamps (CFL) among households in the Twifo Hemang Lower Denkyira District.
2. To investigate the impact of using compact fluorescent lamps (CFLs) on energy consumption in the Twifo Hemang Lower Denkyira District.
3. To assess the factors that influence household's perceptions about electrical energy conservation in the Twifo Hemang Lower Denkyira District.

1.5 Research Questions

The following research questions will be used for the study

1. To assess the extent of knowledge and usage of compact fluorescent lamps (CFL) among households in the TwifoHemang Lower Denkyira District.
2. To investigate the impact of using compact fluorescent lamps (CFLs) on energy consumption in the TwifoHemang Lower Denkyira District.
3. To assess the factors that influence household's perceptions about electrical energy conservation in the Twifo Hemang Lower Denkyira District.

1.6 Scope of the Study

This research is focused on investigating into the impact of using CFL bulbs on energy consumption in Ghana, using Twifo Hemang Lower Denkyira District in the Central Region of Ghana. Thus the study is geographically limited in scope to Twifo Hemang Lower Denkyira District. Moreover, the study is theoretically and empirically limited in scope to the following research objectives, to investigate the impact of using CFL bulbs on energy consumption in the Twifo Hemang Lower Denkyira District, to assess the coverage of the CFLs distribution among households in the Twifo Hemang Lower Denkyira District, to assess the perception of key stakeholders and households on the significance and expectations of the intervention and to assess the importance of using CFL bulbs in the Twifo Hemang Lower Denkyira District.

1.7 Significance of the Study

The study would investigate the impact of using CFL bulbs in the Twifo Hemang Lower Denkyira District. The study would also provide some vital information that may guide the various stakeholders and policy makers in formulating policies that will improve the use of CFL bulbs in their homes, offices and various destinations. Finally the findings of the study would add to the existing literature on the use of CFL bulbs and energy consumption in Ghana.

1.8 Organization of the Research

This project report consists of five chapters, Chapter one deals with the background to the study, the statement of the problem, research questions and objectives of the study, significance and organization of the study. In Chapter two the researcher reviewed related literature whiles chapter three deals with the research methodology used

in the study. Other aspects of chapter three describe the research design, the population, sample and sample procedures, data gathering instruments, data collection procedures and methods of data analysis. Chapter four describes the research findings and the discussion of the main findings and chapter five presents the summary of the findings, conclusions, recommendations and suggestions for further research

CHAPTER TWO

LITERATURE REVIEW

2.1 History of Electrical Power Generation in Ghana

The history of electricity production in modern Ghana dates back during the colonial times in 1914 when the electricity supply sponsored by the government was initiated in Sekondi in the Western part of modern Ghana (ISSER, 2005 and ECG). Since then various reforms and restructuring has taken place. However, it is not the focus of this section of the report to relate the long history and the various transition reforms that took place (i.e. pre independence era). However the historical path of Ghana's electrical power production can be divided into three main phases. **a)** "*Before the hydro years*", this period refers to the time period before the main hydro plant in Akosombo was built in the 1966. **b)***"The hydro years",* refers to the time period from 1966 when the Akosombo hydro plant was completed to the 80s **c)***"thermal complementation years",* the 90s to present when thermal plants were used to supplement the hydro generation (ISSER, 2005). This chapter focuses on the post-independence era especially since the late 70s to the present time. With this in mind, it will be difficult to discuss the electric power production during this time frame without it being dominated by the hydroelectric power production.

2.2 Hydro Generation

Currently, Ghana operates two main hydro power plants and two thermal plants. The first and the biggest hydro plant to be built is the Akosombo hydro plant with an installed capacity of 1020 MW located in the Eastern part of the country in 1966 and the main purpose initially was to supply electric power to the aluminium industry (Zakhary, 2007). The building of the Akosombo hydro dam flooded the Volta river basin creating

the largest manmade lake in the world which covers approximately 3.6% of Ghana's land area (Fobil, 2003). The power generated from the Akosombo plant serves as the driving force behind Ghana's economic development and also supported neighbouring countries such as Togo and Benin by exporting power to these countries (Suave, 2002). With Ghana's expanding industry and economic development caused greater demand for electric power, so in 1982, a second but smaller hydro power plant called the Kpong Hydro plant with an installed capacity of 160 MW was developed on the downstream of the same Volta River to supplement the Akosombo hydro plant (VRA, Ghana). Between 1982 and 1984 occurred one of the most severe droughts in the Volta River Basin in recorded history (ISSER, 2005). This greatly affected the production output of the two hydroelectric power plants and led to the search and additional sources of producing electricity other than hydro source.

2.3 Thermal Addition

To complement the existing hydro power plants, the Volta River Authority (VRA) in 1997 imitated the Takoradi Thermal Power Station (TPPS) in the Western region of the country, the first of its kind in Ghana. A 550 MW installed capacity with a joint private partnership as part of the government plans to allow private participation in the electricity generation sector. The Takoradi thermal Power Company consist of two companies all located in the same region. It consists of a 330 MW combined cycle plant called Takoradi Thermal Power Company (TAPCO) with a private partnership with CMS Energy of USA in a ratio of 90% (VRA) to 10% (CMS Energy, USA). And the second part is the Takoradi international company (TICO), A 220 MW installed gas turbine plants in a ratio of 10% (VRA) to 90% (CMS Energy, USA). Currently, all the thermal power plants are fuelled with light fuel. However with expected natural gas from

Nigeria (as Ghana is part of a West African joint project called the West African Gas Pipe line project) high cost of fuel associated with the light fuel is expected to fall as natural gas is relatively cheaper than light fuel.There is also a 30 MW diesel power plant at Tema near the capital in the Greater Accra region of the country.

Advance plans are under way to develop a third hydro power plant called the Bui Dam with expected installed capacity of approximately 400 MW. Unlike the two other hydro plants, the Bui Dam is a joint venture between the Government of Ghana (GoG) and a Chinese construction company Sino Hydro.

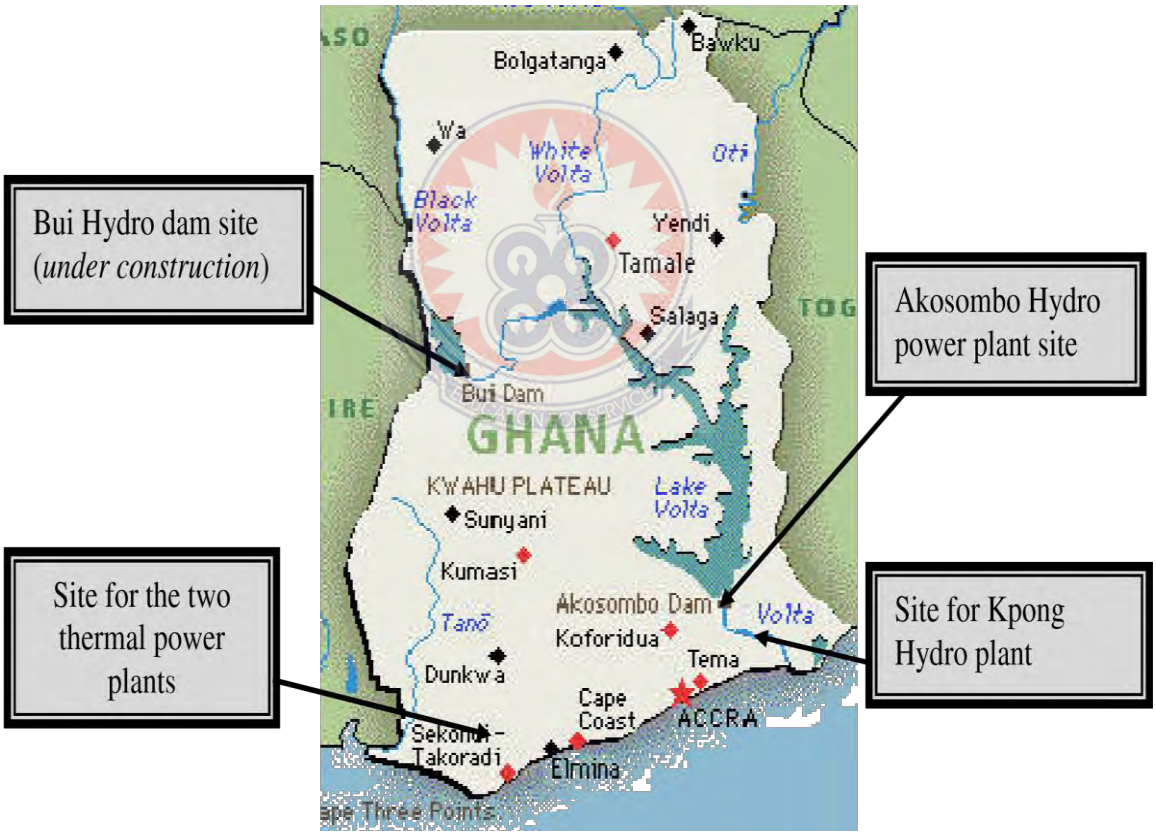

Figure 2.1, Map of Ghana showing sites of hydro and thermal power plants. Map Source: greenwichmeantime.com (accessed 25.05.08)

2.4 Electricity Usage in Ghana – Facts and Figures

Ghana generates electricity basically from two main sources being hydro and thermal source. According to data gathered from the Energy commission of Ghana and the Volta River Authority the share of electric power generation from these to source stood at 68% of hydro and 32% of thermal as of 2005 compared to 65% and 35% respectively in 2000. With nearly 1.6 million customers base (Ghana Energy Commission Statistics, 2007); about 54% *(of which approximately 17% are found in rural areas of Ghana compared to the west African sub regional average of 9% rural penetration and access – Wilson, 2004)* of Ghanaians have access to electricity (Baiden, 2008).Therefore, majority of these people can be found in the cities and the regional capitals across the country. The total electricity consumption as of 2005 *(from ECG and NED sales)* stood at 4127 GWh (Ghana Energy Commission, 2007). Out of this nearly 50%was used by the private sector, i.e. residential and commercial sectors and the rest for industries. The rural penetration of electricity consumption in Ghana vary greatly with the rural communities along the coast having the highest penetration of 27% followed by those along the forest belt regions with 19% with the least being the savannah regions in the northern part of Ghana with around 5% penetration. Since the 1980s various governmental policies and programs have been geared towards rural electrification. The idea was to boost these rural economies by creating employment and also to help curb the influx and acceleration of rural – urban migration. The annual electricity demand growth is approximately between 10 – 15% (ISSER, 2005). The following tables and figures below show the installed generation electric power capacities, the generation mix of hydro power and thermal, electricity consumption and electricity distribution among different end users. For these tables and figures, unless

otherwise stated they are taken directly or modified from the Ghana Energy Commission Statistics for 2007.

NAME OF PLANT	2000	Share (%)	2005	Share (%)
Total Hydro	**1,072**	**65**	**1,180**	**68**
Akosombo Hydro	*912*	*55*	*1020*	*59*
Kpong Hydro	*160*	*10*	*160*	*9*
Total Thermal	**580**	**35**	**550**	**32**
TAPCO	*330*	*20*	*330*	*19*
TICO	*220*	*13*	*220*	*13*
Tema Diesel	*30*	*2*	*0*	*0*
TOTAL	**1,652**		**1,730**	

Table 2.1 A comparative illustration of Ghana´s installed generation capacity (MW) of electric power for 2000 and 2005.

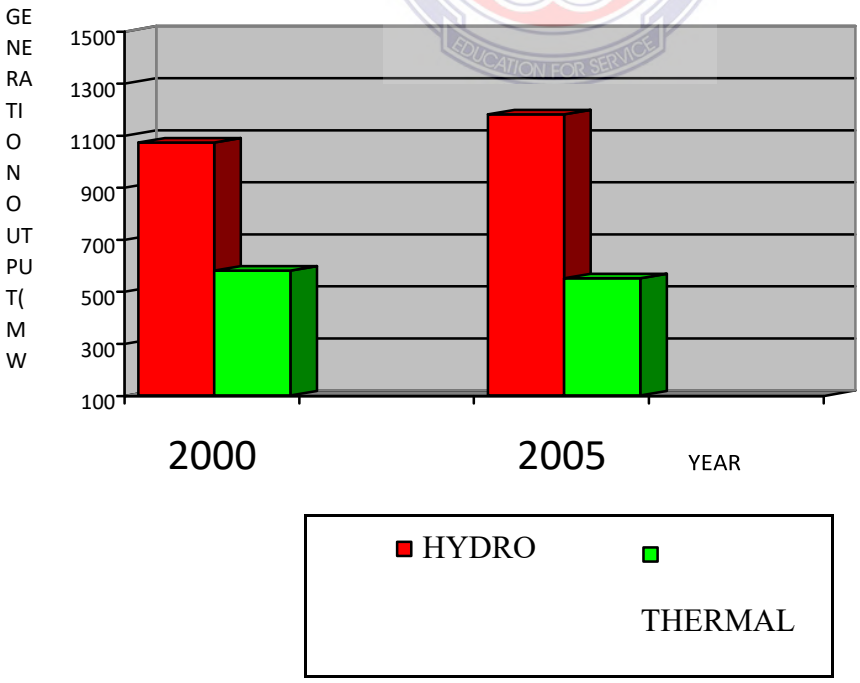

Figure 2.2 Showing the generation mix capacity of Ghana for 2000 and 2005. Source: authors illustration based on table 2.1.

From table 2.1 and figure 2.2, it can be seen that, the proportion of electric power generation has relatively remain unchanged since 2000. However this trend is expected to change as more and more Independent Power Producers (IPP) have been attracted to start generating electric power especially since later parts of 2007. As of now, there have been finalized agreements with six of such companies by the Government of Ghana (Baiden, 2008). The electricity crisis of 2007 somehow facilitated the process to allow more independent producers into the generation of electric power in Ghana; however some of these power producers are yet to start actual generation. With the Bui dam *(see figure 2.1),* already under construction, power generation from hydro source is also expected to increase with the Bui hydro power plant adding around 200/400MW.

However, some experts have raised concerns about continual development of centralized large hydro power plants in the face of increasing threats of flooding and prolong droughts. The generation of hydroelectric power is very sensitive to unstable precipitation levels due to global climate changes and other local effects (Mwandosya, 2006 and Philip, 2007). As mentioned in Chapter already, the bitter lesions from the electricity crisis in Ghana during the past year because of inadequate water levels in the Akosombo hydro plant should guide any planning for any future hydro plant installation. Another concern is the fact that, the Bui hydro plant will be situated on the one of the tributaries of the Volta River which supplies water for the Akosombo and Kpong hydro plants. So the question is, will there be enough water flow during the construction of the Bui dam and in cases of prolongs droughts as happened in last year.

One notable feature of *the electric supply sector in Ghana* is the high level of distribution losses. Distribution losses average 26% of purchases from VRA compared to 11% to an industry standard of 11% for similar distribution systems (ADF, 2007). Some possible explanation to these high distribution losses may be due to technical issues

(such as poorly maintained overloaded network) or commercial reasons *(such as defective metering and fraud).* These internal inefficiencies of the distribution utilities could be passed on to end users as part of the production cost hence increasing the marginal cost for consumers *(reducing marginal utility of end users)*. Addressing such inefficiency could enhance efforts to promote end use efficiency by giving the distribution utilities a competitive standing in promoting end use efficiency.

Table 2.2 below shows a summary of the two main distribution companies in Ghana, Electricity Company of Ghana *(ECG)* and the Northern Electricity Department *(NED)* customer and sales profile for 2000 – 2005. The table shows an increase in customer base of more than 63% from just over 900,000 to 1,500,000 over the same period, with the biggest increase in the residential and commercial customers. There is a similar increase in the sales of electric power from a total of 3974GWh distributed in 2000 to over 5000GWh in 2005 representing approximately 31% increment.

This growth in customer base *(more households are connected to the grid)* in the residential and commercial sector could be attributed to a lot of factors. Among them is the government nationwide policy of embarking on electrification projects especially in the non-urban areas of the country since the late 90s. Also, the country has experienced a significant improvement in her democracy paving the way for a steady economic growth which has resulted improved standards of living. This in turn has triggered increasing demand of basic necessities including connection to grid electricity. Last but not the least, there is a large influx of people from the rural to urban areas of the country and this has increase the electric power demands especially in the urban regions of the country.

	2000		2003		2005	
	Customer Population	Energy Sales GWh)	Customer Population	Energy Sales GWh)	Customer Population	Energy Sales GWh)
Residential/Non-Residential	931,803	2005	1,245,085	2325	1,523,389	2,673
High voltage >33kv	22	395	23	507	29	431
Medium voltage 11 - 33kv	126	437	144	485	174	586
Low Voltage ≤ 1kv	647	305	713	318	761	511
Total	**932746**	**3974**	**1246132**	**4628**	**1524556**	**5218**

Table 2.2 showing a summary of ECG and NED distribution with electric power sales and customer profile. Source; authors compilation from Energy Commission statistics 2007.

2.5 Electric Power Setup in Ghana

The electricity sector setup in Ghana can be group under three headings, namely the generation/transmission, the distribution and regulatory/monitoring. Within this three levels, there are several key organizations involve in the production, distributing, setting up tariffs for consumers and monitoring the activities of the utilities ensuring that they meet the required standards and operate within the laid down regulations.

The rest of this chapter will be devoted in discussing the major players in the three levels. It must be noted that, this discussion is not a stakeholder analysis in the electricity or in the energy sector will be discussed under subsequent chapters. *Figures*

*2.3 and 2.4*below illustrate the three levels of components in the electricity sector and organizations in these three levels.

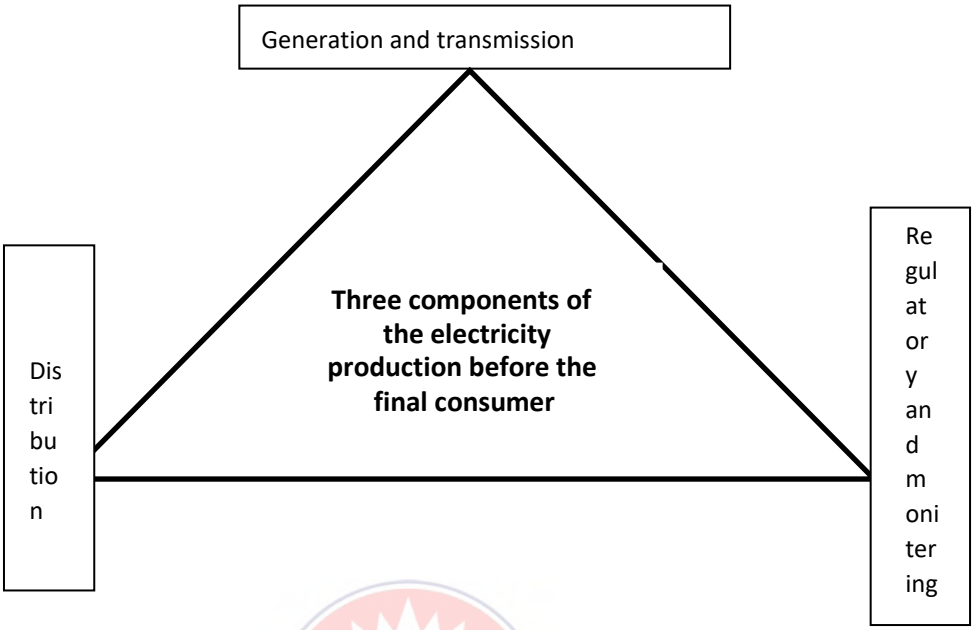

Figure 2.3 authors illustration of the components of the electricity production before it reaches final consumer

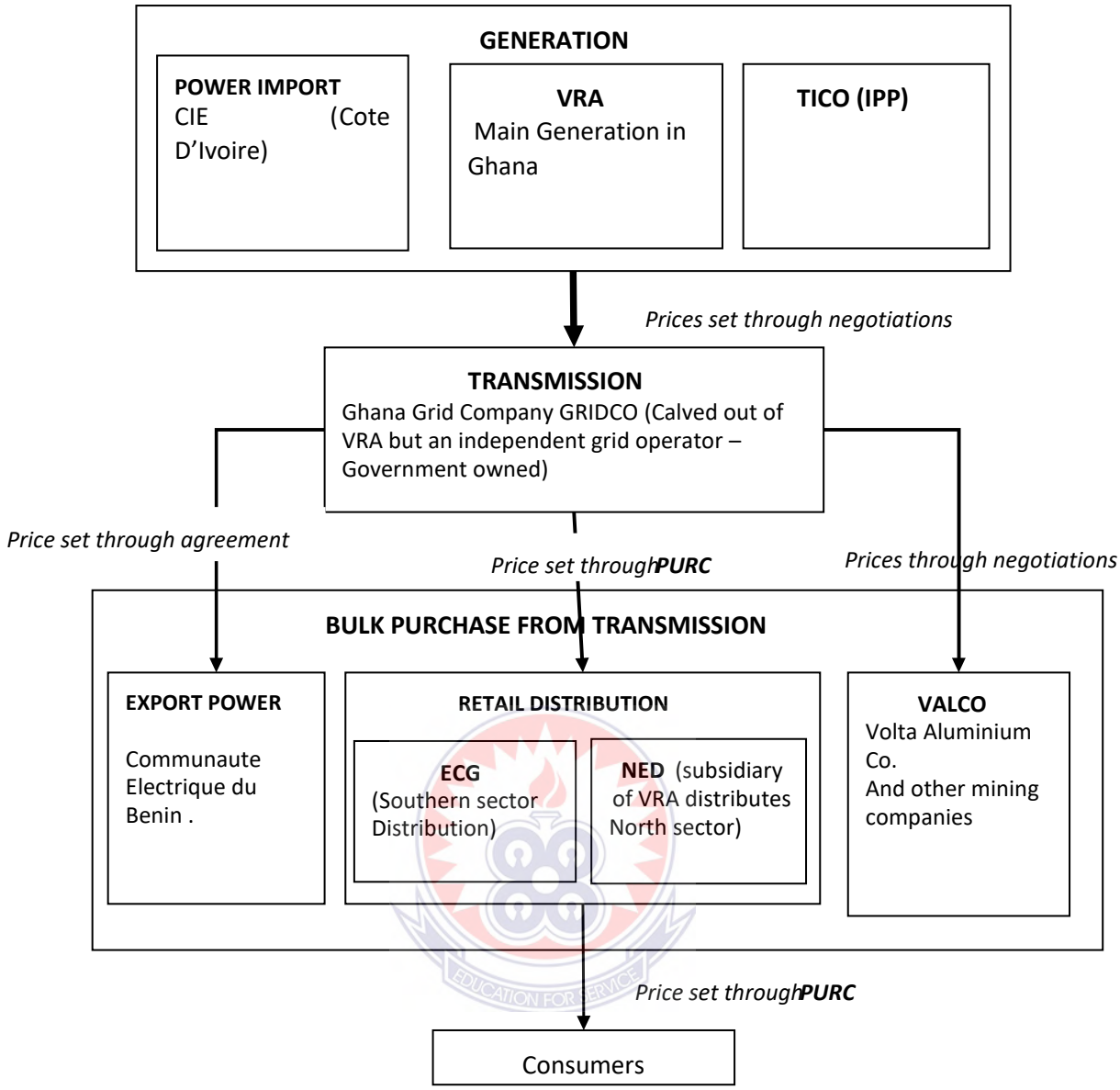

Figure 2.4 showing the current structure of electricity sector in Ghana. Inspired by Ministry of energy structure of the electricity sector in Ghana in PSIA Report, 2004

2.5.1 Generation

As can be seen in *figure 2.4*, there are three main proponents of electric power generation in Ghana, i.e. from VRA being the largest and most influential, from foreign imports (CIE Cote D'Ivoire) and from joint VRA and private partnership. However, the main discussion and description of electric power generation focuses on VRA. Below are a brief description, history and primary functions of the Volta River Authority.

Institution: Volta River Authority *(VRA)*

Enabling Legislation: Volta River Development Act, Act 46, 1961

Brief History: The Volta River Authority *(VRA)* formally came into existence on 26th April 1961, under the Volta River Development Act, Act 46 of the Republic of Ghana. The Authority's primary function is to supply electrical energy for industrial, commercial and domestic use in Ghana. VRA started with the development of the hydroelectric potentials of the Volta River and the construction and maintenance of a nation-wide grid transmission system. Today, it has assumed responsibility for the development of other energy potentials of the Republic of Ghana as well.

Primary Function: The Authority's primary function is to generate electrical energy for industrial, commercial and domestic use in Ghana. Generation of Electricity, Management of Volta Reservoir and related activities. Until recently, the VRA also was responsible for the transmission of electric power in the country. However, since the last year, that function has been taken over by a newly created transmission company called Ghana Grid Company (GRIDCO).

Transmission

Institution: Ghana Grid Company *(GRIDCO)*

Enabling Legislation: Volta River Development Act, Act 46, 1961 as amended

Brief History: As part of the power sector reform that was initiated in the beginning of 2004, the parliament of Ghana made an amendment to the Volta river development Act, Act 46 to create an independent transmission company in 2007.

Primary Function: Separate Transmission Company wholly-owned by government to offer level playing field for all participants in power market

Distribution

A. Southern sector of Ghana

Institution: Electricity Company of Ghana *(ECG)*

Enabling Legislation: companies code, 1963 *(Act 179)* limited by shares on the 21st day of February, 1997.

Brief History: The first Government sponsored public electricity supply in the country began in the year 1914 at Sekondi using diesel engines. It was operated by the then Railway Administration which extended supply to Takoradi in 1928. The advent of the Volta Dam at Akosombo managed by the Volta River Authority *(VRA)* occasioned the spread of electricity wider to various parts of the country until 1967, when the ECG was born by NLCD 125 making it an autonomous organization to operate purely on commercial lines.

Primary Function: To supply and distribute electricity within Ghana. It also purchases electrical energy in bulk from VRA for distribution. To construct, re-construct, assemble, repair, maintain, operate or remove electrical generating stations, sub-transmission lines, transformer sub-stations, electrical appliances, fittings and installations. To sell, hire, or otherwise dispose of electrical appliances and fittings. It also operate, maintain, supervise and safe control of network operations. Market, distribute, sell and bill electric power to customers and collect billed revenue.

Northern sector of Ghana

Institution: Northern Electrification Department *(NED)*

Enabling Legislation: A subsidiary of Volta River Authority

Brief History: as a government policy to extend electricity and encourage investments in the three northern regions of Ghana, NED was instituted as subsidiary of VRA to take

care of distributing electric power to these areas. These regions of Ghana are sparsely populated and have one of the low population densities in the country and also high poverty level.

Primary Function: distributes and supply electric power to the four northern regions *(Brong Ahafo, Northern, Upper west and Upper East – see figure 2.1)* in Ghana under the supervision of the Volta River Authority.

Regulatory and Monitoring

Standards of Performance and Code Of Practice

Institution: Ghana Energy Commission *(EC)*

Enabling Legislation: Established in 1998 by the Energy Commission act 1997 *(Act 541)*.

Brief History: The Energy Commission is a statutory body corporate established by the Energy Commission act 541m 1977. The Commission was formally inaugurated on November, 7 1999. The Commission consists of seven commissioners appointed by the President of Ghana in consultation with the council of state.

Primary Function: To advice the ministry of energy on the policies for efficient use of electricity and safety of supply with regard to other energy sources. Set standards of performance and technical and operational rules of practice for the supply, distribution, sale of electricity and natural gas, and petroleum products to consumers by public utilities. The Commission's foremost mandate is however the issuance of licenses to all operators in the energy sector and the establishment and enforcement of standards of performance for public utilities, petroleum product marketing companies and their retail outlets (*Energy Commission official website, accessed 29/05/08).*

Tariff Regulation. Utility – Consumer Cooperation

Institution: Public Utility Regulatory Commission of Ghana *(PURC)*

Enabling Legislation: Act of parliament *(ACT 538)*

Brief History: The Public Utilities Regulatory Commission of Ghana is an independent body set up to regulate and oversee the provision of the highest quality of electricity and water services to consumers. In 1997, an Act of parliament *(ACT 538)* established the public utility regulatory commission to regulate and oversee the activities of the utility companies in the country. There are three main utility companies in the country, the electricity company of Ghana *(ECG),* VRA and the Ghana water company limited *(GWCL).*

Primary Function: Provide guidelines for rates to be charged for the provision of utility services. Monitor and enforce standards of performance for provision of utility services. Examine and approve water and electricity rates. Promote fair competition among public utilities. Receive and investigate complaints and settle disputes between consumers and public utility. Protect the interest of consumers and provides of utility services *(PURC official website, accessed 29/05/08).*

2.6 Empirical framework of the Study

2.6.1 The impact of using CFL bulbs on energy consumption

Some actions that increase household disposable incomes and/or business revenues.

A number of energy efficiency programmes, and notably the Solar Lantern Distribution Programme, the Efficient Lighting – CFL Replacement Programme, and the Refrigeration Appliances Rebate and Replacement Scheme have resulted in increased household disposable income. The introduction of efficient lightbulbs reduced an

estimated 40% of household electricity costs for lighting (BUR, 2015), while the use of efficient refrigerators reportedly led to a total increase in disposable income of GH¢ 21 760 for the 5000 households that were involved per year (BUR, 2015).

The Solar Lantern Distribution Programme reduces kerosene demand for lighting and in that way also results in an increase in household disposable income. They are sold or distributed by the government at 30 GH¢, while the market price is up to 90 GH¢ (BUR, 2015).

Furthermore, the Installation of Capacitors in Commercial/Industrial Buildings project has a positive impact on business revenues, with an average 12-month pay-back time for the capacitor and negative costs thereafter due to electricity cost saving, TNC, 2015; BUR, 2015). The BRT project may also lead to increased business revenues, due to enhanced access to local commercial zones (Okoye et al., 2010: 43).

Job creation and capacity building (mainly technicians and engineers) has resulted from those initiatives in the energy sector that require the fabrication and installation of solar PV systems, CFL light bulbs, efficient fridges, capacitor banks and improved and LPG cookstoves. The BRT project, in addition, also involves the employment of bus drivers and operators, in addition to other social benefits such as reduced traffic time and congestion levels.

2.6.2 The importance of using CFL bulbs

2.6.3 How Ghana stands to gain from replacing all incandescent lamps with compact fluorescent lamps.

This is just a simple calculation by the author to illustrate the extent of saving in energy consumption and in monetary terms by enforcing and replacing all the inefficient incandescent lamps in the country with efficient CFL ones. This calculation in no way is

conclusive for it does not take into consideration the payback time for the investing in replacement exercise and others.

Assumptions:

- 5 million 80Wincandescent (IL) bulbs to be replaced by 5 million 40W CFL.
- CFL last 10 times longer than IC and use 4.5 less energy (Kemp, 2005)
- Lights will be used for 5 hours a day (from 5pm to 11pm normarly in Ghana)
- 5*7*4*12 = 1680 hr/yr
- Electricity price – 12US cent

Cost with incandescent lamps

Electricity consumption = 5*80W* 1680hr = 67,200,000,000kWh

Cost per yers = 672,000,000kWh * 0.12 = USD 80,640,000

Cost with CFL

Electricity consumption = 5*40W*1680hr = 336,000,000kWh

Cost per yers =336, 000,000 kWh *0.12 = USD 40,320,000

Total Electricity Svings = (672,000,000kWh - 336, 000,000 kWh)

= 336, 000,000 kWh/yr

Total cost savings = (USD 80,640,000 - USD 40,320,000) = USD 40,320,000

2.6.4 Electricity End Use Saving Potential in Ghana

Increasing trend of rural-urban migration*(these urban areas already have 100% access to grid electric power but does not mean every household or building is*

connected, Baiden, 2008) and improving standards of living mean more people have access to electricity and increasing consumer electrical in the country which increase the demand for grid electricity in the country. Again, the Government policy of nationwide electrification projects including rural electrification projects adds to the strain on the demand for more electric power in the country. So the purpose of this sub heading is to provide an empirical data to show that saving potential of end use efficiency measures in the residential and commercial sectors.

Due to time resources constraints, the author could not conduct a first time survey and a case study on this but relies on a previous one conducted by the Energy Foundation of Ghana. The results of that study are used in this section to support the saving potentials of end use electricity in the residential and commercial buildings in Ghana. The data and some discussions are taken form the Energy Foundation official website; www. Ghanaef.org/publications./documents. With permission (*in a form of telephone request)* from the Energy Foundation, the cases are presented below. However detail discussion, analyses, results implications and the production of charts and figures based on the data are the done by the author.

There are two case presented, one for residential savings and the other for a commercial saving. For the purpose of simplicity and clarity, unnecessary details and information may be avoided.

2.7 The perception of key stakeholders and households on the significance and expectations of the intervention.

2.7.1 Case Study for Residential Saving Potential using the CFL bulbs

This case study involves six selected residential households in the Ashanti region of the country. The type of residence was that of compound housing units in Ghana. The

study involve two parts a) educating participants on various housekeeping measures to reduce their electricity consumption and b) the introduction and usage of compact fluorescent lamps *(CFL)* to replace all incandescent lamps *(onion bulbs)* in the various houses. The study lasted for eight months during which data for electricity consumption was monitored and taken. The eight months study was conducted in three stages.

- *Stage 1:* the usual electricity usage and consumption patterns were monitored without any comments for the first three months of the study duration
- *Stage 2:* after the first three months, the participants were educated on some ways to avoid using electricity inefficiently and basic housekeeping measures for the next two months.
- *Stage 3:* the last stage involve replacing all incandescent bulbs in the various residences with compact fluorescent lamps by the study team and electricity consumption patterns were monitored for the last three months of the study period.
- *Note: the monitoring of the electricity consumption was done through the normal metering system of the electricity company of Ghana (ECG).*

Figure 2.5Showing CFL common on the Ghana market and these were used in the case study for residential electricity savings.

Results

The following tables and figures show the results of study of residential electricity end use savings.

Household	Distribution of Lamp Type		
	CFL	Incandescent	Total
A	3 = 50%	3 = 50%	6
B	1 = 25%	3 = 75%	4
C	3 = 37.5%	5 = 62.5%	8
D	3 = 75%	1 = 25%	4
E	1 = 17%	5 = 83%	6
F	0 = 0%	10 = 100%	10
Total			38

Table 2.3: Showing the frequency distribution of lamps in selected household. Source: Energy Foundation of Ghana.

Household	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Consumption (average) *before* education kWh/month	164	67	433	242	225	390	1521
Consumption (average) *after* education. kWh/month	84	58	377	161	171	268	1119
Savings *after* education (%)	49%	14%	13%	33%	24%	31%	26%
Consumption (average) *after* CFL introduction kWh/month	43	37	303	89	No meter reading	198	670
Savings *after* CFL introduction on original consumption (%)	74%	45%	30%	63%	No meter reading	49%	52%

Table 2.4 Showing the percentage electricity end use saving potential in selected residential households.

Source: Energy Foundation of Ghana.

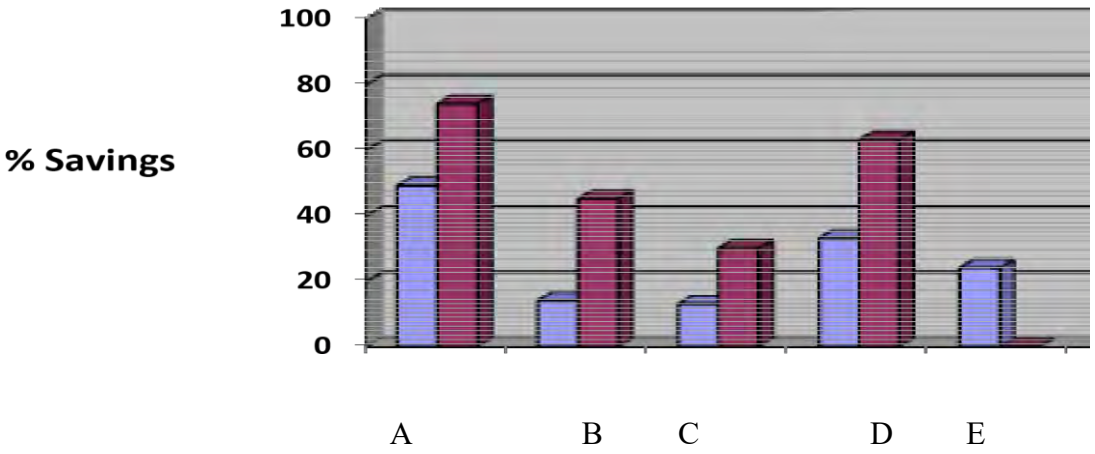

Figure 2.6 showing a comparison of savings in electricity end used efficiency measures through educations and CFL in case study one.

The percentage savings shown in figure 2.5 are not aggregate or compound saving and show separate saving potentials with demand side management such as education and efficient appliance. Both show percentage savings over the original energy consumption of each household. Setting the two savings side by side, it is clear that the biggest savings come from the introduction of CFL. The least recorded savings was 30% compared to 13% for education and the biggest was impressive 74% compared 49% for education. There could be a number of reasons for these differences in the factor of savings with the two measures. Among them are:

- Households might have ignored some of the educational measures that were given to them.
- The same educational measures might not work for all the different householders in the experiment hence some householders might find some of the educational measures impractical or unhelpful.
- The replacement of all incandescent bulbs with CFL with will have impact across all householders *(though it might vary depending on the number replaced).*

- After replace the lamps, the households may have little influence as to ignoring the basic measures compared to the educational one hence given the full impact of the CFL.

2.7.2 Summary of Results in Residential Savings Case Study

- Total electricity consumption of six households after they have been educated on electricity end use saving and other housekeeping techniques was reduced from 1521kWh per month to 1119kWh per month representing 26% *(see table 5.5)* improvements and saving of electricity at the end use.
- After the introduction of the compact fluorescent lamps, total electricity consumption for the six households reduced drastically from 1521kWh per month to only 670 kWh per month representing a 52% improvement and saving of end use electricity over the original consumption.
- Great improvement and saving potential in promoting end use efficiency in the residential sector. From the study, the savings ranges from 13% *(being the lowest recorded)* to the as high 52% *(being the highest recorded)* of improvements over the study period. This means that, replacing all incandescent lamps in all houses in Ghana will greatly save some generation capacity or add to the generation capacity of the country and improve the "demand gap" in the electricity sector. The following simple calculation will demonstrate that.

2.7.3 Electricity Sector Reforms and Institutions in Ghana – the Competitive Approach

With more than a decade of experience in electricity reform in Ghana, there is both an opportunity and a need to analyse the lessons learned and the way to improve the service delivery in the electricity sector in Ghana. This subheading is not exhaustive of

all the fundamental issues of the various reforms that have taken place and how things should been implemented to reflect the needs of the sector but draws out some policy issues and the need for improvement in the electricity sector reforms.

We have already seen how before the 90s the electricity sector in Ghana was highly government driven, with all major utilities owned by the government, the absence of independent system regulators such as tariff setting and allowing private participation. The main objective was to extend electricity to all parts of the country and most of the utilities operated far below their marginal production cost. This led to many utilities unable to cover cost of production and left them highly dependent on the national budget to cover the rest of operating cost and new capital investment for expansion. Most often, that needed state funding was not forth coming and that led to VRA and ECG undercapitalized and suffered supply shortages, deteriorating systems and system losses.

However, for Ghana to fully benefit from such sector reforms and improve the services from the electricity sector, some key characteristic and objectives should be pursued in addition to what have happened in the past. A broader look at the sector reforms that have taken place as discussed in previous chapters show a ”private-investment” and economic growth as the main driven forces compared to ”competition, efficiency and choice”. Granted, state owned utilities need much needed private investment to increase capital inflows *(as the Ghana government has shown over and over again that, it lacked the single capacity to deliver all the capital inflow),* such efforts should be effected by deregulating the sector for other non-state owned companies to enter the sector to generate competition. Without state owned utilities enjoying monopoly, they will compete and will be able to break-even if not make profit. Competition will then lead to more secure and efficient service by utility companies. With this utility companies will be able to march their long term marginal cost and

promote supply side efficiency. On the other hand, consumers will be faced with choices because of competition and utilities will be forced to sit up to improve service in order to stay in operation. Some may argue that, such deregulation and competition will increase tariff for the final consumers. That might not be the case since the state object allowing such deregulation is to reduce price per unit cost and promote higher efficiency and increase national efficiency, such competition will be reasonably and fairly be controlled by the politically neutral policies. This will not only ensure low prices but that will again make it very attractive to private investors to invest in the sector. These were the key ingredients in many developed countries, e.g. in Denmark, the electricity market was liberalized in accordance with a decision of the Danish Parliament, "*the Folketing"*, in the mid-1990s. Generation and supply of electricity is subject to competition. There are a lot of private suppliers and producers of electricity in Denmark and consumers are free to exercise their choice of which supplier to use. However, consumers who do not want to exercise this right will still be supplied with electricity with state own companies (Danish Energy Agency website, *accessed 17.06.08 and Olesen*). The electricity supply service in Denmark is stable and promotion of end use efficiency is part of the overall agenda of security of supply. For this reason 2øre is levied on the end user tariff price to promote end use efficiency measure.

In the survey conducted by the author, nearly 100% of the people surveyed expressed their dissatisfaction of the service of the utilities in Ghana most especially the distribution company ECG. The two serious electricity outages throughout the country experienced in Ghana for the past decade (in 1998 and 2007- Baiden, 2008) and large annual financial debts of Electricity Company of Ghana and VRA *(The debt profile of VRA amounts to over USD200 million as of August, 2007, according the Ghana news agency)* shows that the various ongoing sector reforms must be strengthened.

Granted, the electricity sector is one of the many sectors of Ghana´s economy but given the strategic importance of the sector to almost all other sectors, focusing on and eliminating other major bottlenecks such government interference for political interests, corruption and other malfeasance for should be addressed to make any electricity sector reforms based on competition work.

It must be mentioned that successfully embarking on competitive sector reforms in Ghana mostly depends on foreign capital (*Donor Agencies, China for Bui dam)* which often the country has less control of. There should be caution though, that national government cannot entirely leave the sector reforms in the hand market competition and should fairly intervene to provide a balanced cushion of the reforms. The national government can do that by protecting the most vulnerable in the country including those who fall within the poverty classification. That is why the government initiated programme of the "life line tariff" is commendable. Protecting the residential consumers especially from exploitation of any unfair tariff increases is important in a country where access and supply of grid electricity is perceived as a *"social good"* and a basic right where a consumer is entitled to.

In summary, pursuing the objectives of a successful electricity sector reform both in utility and institutional capacity should be guided by four basic principles, these are;

- Increased competition and efficiency
- A wider choice for consumers,
- High security of energy supply,
- Protecting the environmental
- Low utility and cost effectiveness

2.7.4 Electricity Tariff Reforms and End Use Efficiency

A country faced with end use inefficiencies and struggling utilities to meet their marginal cost or production, it will be interesting to analyse how full long run marginal cost recovery *(LRMC)* through tariff increase could strengthen the utilities while ensuring an efficient use at the demand side. What this means is that, utilities will be able to meet their marginal cost of producing a unit of electricity with similar unit price to the consumer. Full Cost Recovery *(FCR)* as a strategy for promoting end use efficiency in Ghana has two sided advantage. First, it makes the utilities completive and attractive to investment and secondary it makes end users aware of the direct cost between end use inefficiencies and their electricity tariff charges. So it can be said that, full cost recovery by utility firms has a "top-down" and a "bottom-up" effects on efficiency in the electricity sector. Full cost recovery as a strategy to promote end use efficiency uses the basic principles price, demand and supply theory.

2.7.5 Price and Demand – the principle behind Full Cost Recovery and End Use Efficiency

In neoclassical economics, this relates to the individual's rationality and his or her ability to maximize utility or profit (Nordhaus and Paul 2001; Varian 1984). That is given the same level of marginal utility; an individual will choose the one that will satisfy his or her marginal utility the most at lesser price. With price as a determinant factor, an increase in price of a good (*in this case tariff*) will result in a reduction in demand of electricity use all things being equal. In a competitive market, price will function to equalize the quantity demanded by consumers, and the quantity supplied by producers, resulting in an economic equilibrium of price and quantity.

However, the demand and supply paradigm tends to change slightly in the power sectors. Most power plants with inflexible cost of production *(like huge hydro power plants due to high capital cost cannot stop production)*, so supply will be restricted and constant *(unless in periods of drought as in the case of Ghana, which might affect generation outputs).* So in reality, "in a power system the supply always equals demand" (Bernd, 2008). This holds true for a sufficient electricity sector where there are no unmet demands. However, the case for Ghana with a demand gap where fluctuating and insufficient supply of electricity lead to quantity demanded far outwitting quantity that can be supplied at any time. Therefore, it is common to find power outages and rationing in the county to maintain this supply-demand equilibrium. So with increase in price, it is not possible for the power plants in Ghana to increase their supply in the short run *(but countries with excess installed capacity will be able to do so),* but maybe able to do so in the long run where high marginal cost returns gives the needed capital investment for expansion. Power plants in Ghana can use the demand gap reasoning to push tariff prices upwards in the short run for power supply increase in the long run. In Ghana´s situation where the actual quantity demanded will be more than the quantity supplied of electricity, it can be said that the quantity supplied of electricity supplied by the utilities in the short run is fixed supply.

2.8 Electrical Appliance Market Reforms and End Use Efficiency

Approximately 51% Ghana´s electricity use is consumed in the residential and commercials sectors of the country. with this comes the increase in the use of electrical appliances mainly use in the residential and commercial sector such as lighting, refrigerators-freezers, stereo, television, electric fans, air conditioners, computers, fax, photocopiers and scanners, printers, etc. The Ghanaian market for these appliances in

diverse, comprising of brand new and used appliances mainly imported into the country from developed and transitional countries in Europe, North America and Asia. The "second hand market" by far forms the largest and is often characterised by inefficient appliances which have been imported by local dealers into the country or dumped by developed nation. It is worth mentioning that, even not all the brand new electrical appliances found in Ghana are of the highest efficiency standards compared to similar brands and models in the OCED markets.

It is not uncommon to find greater proportion of the Ghanaian population patronising the "second hand market". In the survey conducted, 39 out of 40 people surveyed confirm they have purchased either more than half or all of their current electrical appliances from a second hand market. Almost all, 99% of those surveyed had around 5 different electrical appliances they currently use at home.

Improved economic conditions in Ghana may lead to acquiring more and new electrical appliance whereas in many OCED countries today, demand in new electrical appliance is mainly driven by replacing old appliances with more efficient and quality products on the market (Steenblik et al, 2006). The "second hand market" for electrical appliances in Ghana is highly unregulated, small scale retailers, diverse and can be found nationwide especially in the urban areas of the country (Accra and Kumasi, etc). Unregulated second hand electrical appliances can have significant impact on any end use efficiency promoting measures and even affect the peak load demand of the electricity sector. For example, a modern refrigerator-freezer found in most OCED countries today will have an average consumption 500 – 550kWh per year compared to an inefficient to 1200-1800kWh per year that may be found on the second hand market in Ghana (Steenblik et al, 2006). The differences in energy consumptions of the two appliances demonstrate how much savings exit by ensuring a drastic change in the

appliance purchase market. The choice is obvious; *to successfully promote electricity end use efficiency in the residential and commercial sectors in the Ghana, the "second hand market" for electrical appliances should be monitored and regulated.*

Since it is difficult regulate the "second hand market" for end use electrical appliance in Ghana the model of using "electricity tariff pricing" as a deterrent from purchasing efficient end use electrical appliance will seem even more appreciated. This approach may hurt some consumers who patronize a very diverse market of used appliances however; investing in efficient end use electrical appliances can typically be viewed as involving a "trade off" between higher initial purchase price for new and efficient appliances and lower operating expenses for incremental increases in energy performance. With this education consumers will be faced with a choice. To a large extent many Ghanaian consumers consistently make investments in energy consuming products with heavy focus on the purchase price and little attention to subsequent energy cost of inefficient over the operating life of the product mainly due to lack of capital and cash flow problems. They look at the "first cost" rather than the "life cycle cost". In effect they undervalue the savings associated with efficiency.

2.9 Cost Savings

Some interventions (e.g., the sale of energy efficiency devices) lead to cost savings for commercial customers. These savings can be passed on to the consumer in the form of lower prices, can allow the business to grow through the availability of more financial capital or can provide other benefits such as job creation. However, keeping track of all possible outcomes was not possible in this study. Also, no information regarding cost savings to customers was found. Further, it is questionable whether such information can provide any indication of the potential beneficial outcomes or whether

cost savings can be calculated as directly attributable to a particular intervention. Effects such as administration costs, other efficiency gains in the company etc. may complicate the issue.

No method of monitoring cost savings within enterprises was found to be suitable and it is considered in this case that it the focus of monitoring should be on the outcomes, with the monitoring of these outcomes (e.g., job creation) either being the subject of other aspects of an enterprise monitoring regime or other monitoring efforts.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

This chapter forms the core session of the field work for this study. It introduces the research design, the population of interest, the sampling method and the research instruments that would be used to sample respondents. Also, the chapter captures the number of respondents that will participate in the study and how the data collected from the field will be processed and analyzed.

3.1 Research Design

This study employed quantitative and descriptive methodology to collect data and analyze data. This was because it generates statistics through which the use of large-scale survey by using methods such as questionnaire and structured interviews. This type of research reaches many more people and the contact with those people is much quicker (Dawson 2002). However, the weakness of the descriptive study design is that it does not help in discovering new insights about the phenomenon being studied. This is because it does not manipulate the variables being studied but only attempts to explain what has already happened.

Though, the data description may be factual, accurate and systematic, the use of descriptive research does not help find out what caused an event or situation. Thus it does not show a causal relationship between variables. The descriptive study design is more of qualitative and may also lead to unreliable results because it bases its analysis on data gathered from respondents which may not be the objective truth about the situation. In spite of these potential disadvantages, the descriptive research design was considered the most appropriate for this study (Dawson 2002).

3.2 Population

The population for this study comprises individuals who consume electricity in the Twifo Hemang lower Denkyira District in the Central Region of Ghana. The population for the study was nine hundred and seventy (970).

3.3 Sample and sampling techniques

The random (probability) sampling technique was used to sample electricity consumers within the study area to collect data in order to predict and generalized the whole research population. This method was used because all elements in the population have an equal chance of being included in the sample. It also minimized the possibility of an unrepresentative sample. This however can be time consuming process (Fisher 2010).

The ever increasing need for a representative statistical sample in empirical research has created the demand for an effective method of determining sample size. To address the existing gap, Krejcie & Morgan (1970) came up with a table for determining sample size for a given population for easy reference. According to the Krejcie & Morgan (1970), table of determining sample size, a population of nine hundred and seventy requires a sample size of 274. Moreover, the lottery technique was used to select the electricity consumers for the study. This method of sampling therefore ensured that all respondents had an equal opportunity of being selected for the study. Furthermore, numbers 1-300 were written on white papers including blank papers, electricity consumers who selected the first 274 papers formed part of the research. Therefore, 274 respondents were sampled through the lottery method.

3.4 Sources of Data

This survey relied on structured questionnaires designed purposely for the study and extraction information from official reports, journals, books and other relevant documents on the usage of CFL bulbs.

3.5 Instrument for Data Collection

The instruments used for the study were structured questionnaires. According to (Ofori & Dampson, 2011) self-completed questionnaire is perhaps the most single, widely used research tool in educational research. The main benefits of a questionnaire are its low cost, as well as saving you time and effort as a data collection tool. In particular, where a researcher wishes to make population parameter estimates, the cost advantage of questionnaires over for example, interview, means that more people can be sampled for a given budget that might otherwise be possible. However, questionnaires are not without their inherent problem. The data you collect are superficial and there is little or no check on the honesty or seriousness of responses, as well as misinterpretations. The study therefore used questionnaires because they are valuable methods of collecting a wide range of information from a large number of respondents.

3.6 Data Collection Procedures

Regarding the type of questions, the questionnaire contained both closed-ended and opened questions. The closed-ended questions were “Yes or No, don’t know’’ which seek to limit the respondents alternatives, while a few opened-ended questions. Allowed the respondents to express an opinion without being influenced by the researcher (Foddy, 1993). Thus the opened-ended questions allowed the respondents to include more information, including feeling, attitude and understanding of the subject. To make data

analysis as easy as possible, majority of the questions were coded. The questionnaires were self-administered by the researcher. This was considered necessary because the population of study was partially literate who could not comprehensively read and adequately respond to the items on the questionnaire. Moreover, out of 274 questionnaires sent out for primary data, 269 questionnaires were retrieved and 5 questionnaires were not retrieved. Therefore, the analysis of the study was based on 98% response rate. This figure was considered appropriate for the study.

3.7 Pre-testing

To determine the reliability of a survey instrument, it is necessary for it to be pre-tested before actually using it. The questionnaire was subjected to pre-testing with twenty (20) CFL consumers within the Twifo Hemang lower Denkyira District in the Central Region of Ghana. Pre-testing of the survey instrument was to identify potential challenges to be encountered during the main study to improve the questions in terms of wording repetition and key issues to be investigated. After successful pilot testing, the researcher realized that the questionnaires were adequate for mass distribution to the respondents.

3.8 Data Analysis

The data collected from primary and secondary sources were coded and entered into a computer equipped with the Statistical Package for Social Scientists (SPSS) Software (Version 16.0) and Microsoft (MS) Excel 2007 was also used for tables and figures. This was done to make the presentation and analysis of data collected easy.

CHAPTER FOUR

RESULTS AND FINDINGS

The study revealed that out of 274 questionnaires sent out for primary data, 269 questionnaires were retrieved and 5 questionnaires were not retrieved. Therefore, the analysis of the study was based on 98% response rate. This figure was considered appropriate for the study.

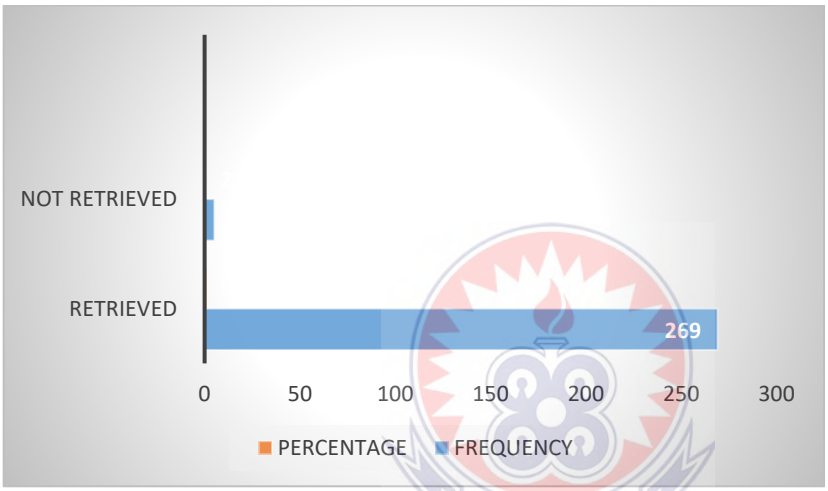

Figure 4.1: Response rate

Source: Field survey, 2016

4.1 Demographic information of the respondents

This section contains Tables, frequencies and percentages that portrays the demographic information of the respondents, including the respondent's gender, age and educational qualifications.

Table 4.1: Gender of Respondents

Gender of Respondents	Frequency	Percent
Male	137	50.9
Female	132	49.1
Total	269	100.0

Source: Field survey, 2016

Table 4.1 shows that 50.9% of the respondents were males while 49.1% were females.

Table 4.2: Age of Respondents

Age of Respondents	Frequency	Percent
18-29 years	63	23.4
30-39 years	61	22.7
40-49 years	45	25.3
50-59 years	39	14.5
60 years and above	38	14.1
Total	269	100.0

Source: Field survey, 2016

Table 4.2 indicates that 25.3% of the respondents were between the agesranges 40-49 years, 23.4% were between the agesranges 18-29 years, 22.7% were between the agesranges 30-39 years, 14.5% were between the age ranges 50-59 years while 14.1% were more than 60 years.

Table 4.3: Educational background of the Respondents

Educational background	**Frequency**	**Percent**
No formal education	70	26.0
BECE	33	12.3
SSSCE/WASSCE	73	27.1
Diploma	63	23.4
Bachelor's degree	21	7.8
Master's degree	9	3.3
Total	269	100.0

Source: Field survey, 2016

Table 4.3 depicts that 27.1% of the respondents were possessing SSSCE/WASSCE, 26% of the respondents had no formal education, 23.4% of the respondents had Diploma as their highest qualification, 12.3% of the respondents were holding BECE, 7.8% were holding Bachelor's degree while 3.3% were holding Master's degrees.

4.2 Knowledge and usage of compact fluorescent lamps in Twifo Hemang Lower Denkyira District

Table 4.4: Do you know what compact fluorescent lamp (bulbs) are`

Do you know what compact fluorescent lamp (bulbs) are	Frequency	Percent
Yes	247	91.8
No	13	4.8
Do not know	9	3.3
Total	269	100.0

Source: Field survey, 2016

Table 4.4 shows that 91.8% of the respondents affirmed that they know what compact fluorescent lamp are, 8.1% said that they do not know what compact fluorescent lamps are. The study concluded that most respondents are aware of the usage of compact fluorescent lamp (bulbs).

Table 4.5: Who introduced you to energy savings bulbs (CFL)

Who introduced you to energy savings bulbs (CFL)	Frequency	Percent
Government Intervention	53	19.7
ECG	51	19.0
Advertisement	146	54.3
Friends	19	7.1
Total	269	100.0

Source: Field survey, 2016

Table 4.5 shows that 54.3% of the respondents affirmed that they were introduced to energy saving bulbs (CFL) through advertisements, 19.7% of the respondents were introduced to energy savings bulbs (CFL) through government intervention, 19% of the respondents were introduced to energy savings bulbs through ECG while 7.1% of the respondents were introduced to CFL bulbs through friends. With more than a decade of experience in electricity reform in Ghana, there is both an opportunity and a need to analyse the lessons learned and the way to improve the service delivery in the electricity sector in Ghana.

Table 4.6: How long have you been using energy savings bulbs (CFL)

How long have you been using energy savings bulbs (CFL)	Frequency	Percent
1 year	60	22.3
2 years	34	12.6
3 years	29	10.8
4 years	113	42.0
5 years and above	33	12.3
Total	269	100.0

Source: Field survey, 2016

Table 4.6 indicates that 42% of the respondents said that they have been using energy savings bulbs (CFL) for 4 years now, 22.3% of the respondents have been using CFL bulbs for 1 year now, 12.6% have used the CFL bulbs for 2 years, 12.3% have used the CFL bulbs for more than 5 years now.

Table 4.7: What type of Wattage (W) of CFL bulbs do you buy?

What type of Wattage (W) of CFL bulbs do you buy?	Frequency	Percent
9 W	61	22.7
15 W	38	14.1
20 W	43	16.0
25 W	86	32.0
80 W	31	11.5
105 W	10	3.7
Total	269	100.0

Source: Field survey, 2016

Table 4.7 revealed that 32% of the respondents said that they use 25W of CFL bulbs, 22.7% of the respondents use 9W of CFL bulbs, 16% use 20W of CFL bulbs, 14.1% use 15W of CFL bulbs, 11.5% use 80W of CFL bulbs while 3.7% of the respondents use 105W.

Table 4.8: Do the CFL bulbs last longer than the incandescent bulbs?

Do the CFL bulbs last longer than the incandescent bulbs?	Frequency	Percent
Yes	226	84.0
No	18	6.7
Do not know	25	9.3
Total	269	100.0

Source: Field survey, 2016

Table 4.8 indicates that 84% of the respondents affirmed that CFL bulbs last longer than the incandescent bulbs while 16% of the respondents do not know. The study revealed that CFL bulbs last longer than the incandescent bulbs.

4.3 The impact of using CFL on energy consumption in Twifo Hemang Lower Denkyira District

Table 4.9: Change in power consumption from incandescent lamps (Onion bulbs) to CFL bulbs

Change in power consumption from incandescent lamps (Onion bulbs) to CFL bulbs	Frequency	Percent
Yes	251	93.3
No	9	3.3
Do not know	9	3.3
Total	269	100.0

Source: Field survey, 2016

Table 4.9 depicts that 93.3% of the respondents said that they notice changes in their power consumption since they changed their lamps from incandescent lamps (Onion bulbs) to CFL bulbs while 6.6% do not know. The respondents noticed changes in their power consumption since they changed their lamps from incandescent lamps to CFL bulbs. One notable feature of *the electric supply sector in Ghana* is the high level of distribution losses. Distribution losses average 26% of purchases from VRA compared to 11% to an industry standard of 11% for similar distribution systems (ADF, 2007). Some possible explanation to these high distribution losses may be due to

technical issues *(such as poorly maintained overloaded network)* or commercial reasons *(such as defective metering and fraud).* These internal inefficiencies of the distribution utilities could be passed on to end users as part of the production cost hence increasing the marginal cost for consumers *(reducing marginal utility of end users)*. Addressing such inefficiency could enhance efforts to promote end use efficiency by giving the distribution utilities a competitive standing in promoting end use efficiency.

Table 4.10: Has your power consumption reduced since you started using CFL bulbs?

Has your power consumption reduced since you started using CFL bulbs?	**Frequency**	**Percent**
Yes	232	86.2
No	12	4.5
Do not know	25	9.3
Total	269	100.0

Source: Field survey, 2016

Table 4.10 indicates that 86.2% of the respondents said that their power consumption reduced since they started using CFL bulbs while 13.8% do not know. The study revealed that CFL bulbs reduced power consumption.

Total electricity consumption of six households after they have been educated on electricity end use saving and other housekeeping techniques was reduced from 1521kWh per month to 1119kWh per month representing 26% *(see table 5.5)* improvements and saving of electricity at the end use.

After the introduction of the compact fluorescent lamps, total electricity consumption for the six households reduced drastically from 1521kWh per month to only 670 kWh per month representing a 52% improvement and saving of end use electricity over the original consumption.

Great improvement and saving potential in promoting end use efficiency in the residential sector. From the study, the savings ranges from 13% *(being the lowest recorded)* to the as high 52% *(being the highest recorded)* of improvements over the study period. This means that, replacing all incandescent lamps in all houses in Ghana will greatly save some generation capacity or add to the generation capacity of the country and improve the "demand gap" in the electricity sector. The following simple calculation will demonstrate that.

Table 4.11: The use of CFL bulbs and reduction in electricity bill

The use of CFL bulbs and reduction in electricity bill	Frequency	Percent
Yes	261	97.0
No	3	1.1
Do not know	5	1.9
Total	269	100.0

Source: Field survey, 2016

Table 4.11 depicts that 97% of the respondents confirmed that the use of CFL bulbs reduced electricity bill in their home while 3% do not know. The study concluded that the use of CFL bulbs reduced electricity bill in the respondent's homes. Some interventions (e.g., the sale of energy efficiency devices) lead to cost savings for commercial customers. These savings can be passed on to the consumer in the form of

lower prices, can allow the business to grow through the availability of more financial capital or can provide other benefits such as job creation. However, keeping track of all possible outcomes was not possible in this study. Also, no information regarding cost savings to customers was found. Further, it is questionable whether such information can provide any indication of the potential beneficial outcomes or whether cost savings can be calculated as directly attributable to a particular intervention. Effects such as administration costs, other efficiency gains in the company etc. may complicate the issue.

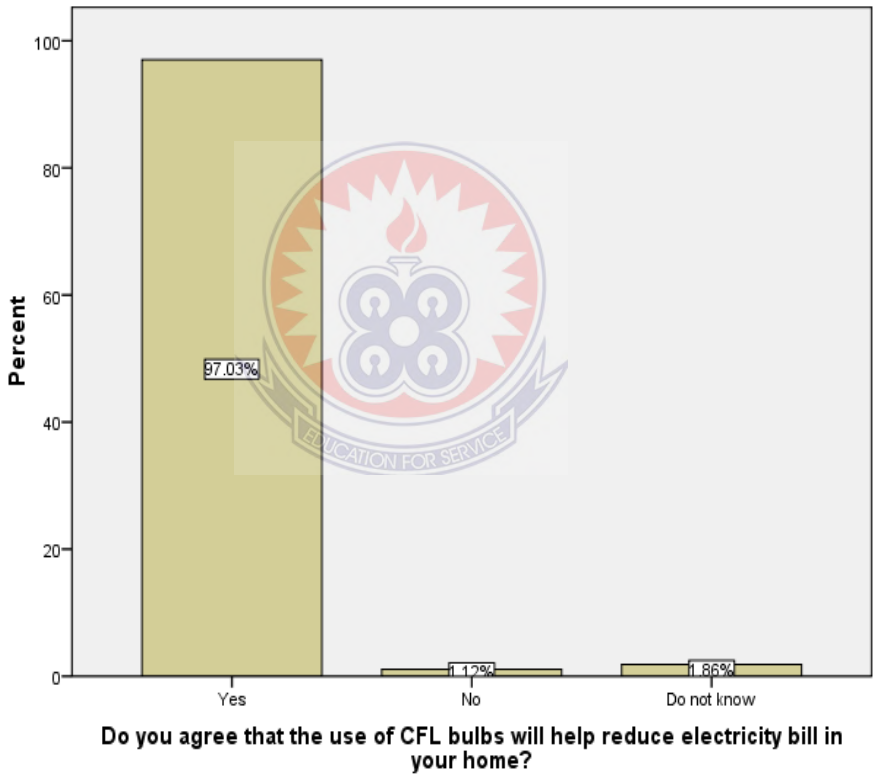

Figure 4.2: The use of CFL bulbs reduce electricity bill in the home

Source: Field survey, 2016

Table 4.12: Have you made any changes in your electricity usage because of increasing electricity prices?

Have you made any changes in your electricity usage because of increasing electricity prices?	Frequency	Percent
Yes	176	65.4
No	56	20.8
Do not know	37	13.8
Total	269	100.0

Source: Field survey, 2016

Table 4.12 depicts that 65.4% of the respondents said that they have made changes in their electricity usage because of increasing electricity prices while 34.6% of the respondents do not know. The respondents made changes in their electricity usage because of increasing electricity prices. In neoclassical economics, this relates to the individual's rationality and his or her ability to maximize utility or profit (Nordhaus and Paul 2001; Varian 1984). That is given the same level of marginal utility; an individual will choose the one that will satisfy his or her marginal utility the most at lesser price. With price as a determinant factor, an increase in price of a good (*in this case tariff*) will result in a reduction in demand of electricity use all things being equal. In a competitive market, price will function to equalize the quantity demanded by consumers, and the quantity supplied by producers, resulting in an economic equilibrium of price and quantity.

However, the demand and supply paradigm tends to change slightly in the power sectors. Most power plants with inflexible cost of production *(like huge hydro power plants due to high capital cost cannot stop production)*, so supply will be restricted and

constant *(unless in periods of drought as in the case of Ghana, which might affect generation outputs).* So in reality, "in a power system the supply always equals demand" (Bernd, 2008). This holds true for a sufficient electricity sector where there are no unmet demands. However, the case for Ghana with a demand gap where fluctuating and insufficient supply of electricity lead to quantity demanded far outwitting quantity that can be supplied at any time. Therefore, it is common to find power outages and rationing in the county to maintain this supply-demand equilibrium. So with increase in price, it is not possible for the power plants in Ghana to increase their supply in the short run *(but countries with excess installed capacity will be able to do so),* but maybe able to do so in the long run where high marginal cost returns gives the needed capital investment for expansion. Power plants in Ghana can use the demand gap reasoning to push tariff prices upwards in the short run for power supply increase in the long run. In Ghana´s situation where the actual quantity demanded will be more than the quantity supplied of electricity, it can be said that the quantity supplied of electricity supplied by the utilities in the short run is fixed supply.

Table 4.13: The importance of reducing power consumption at home

The importance of reducing power consumption at home	Frequency	Percent
Yes	246	91.4
No	8	3.0
Do not know	15	5.6
Total	269	100.0

Source: Field survey, 2016

Table 4.13 shows that 91.4% of the respondents said that it is important to reduce power consumption at home while 8.6% said they do not know. The study concluded that it is important to reduce power consumption at home.

Table 4.14: The introduction of CFL bulbs has impacted in reducing power consumption in households in the Twifo Hemang Lower Denkyira District.

The introduction of CFL bulbs has impacted in reducing power consumption in households	Frequency	Percent
Yes	255	94.8
No	5	1.9
Do not know	9	3.3
Total	269	100.0

Source: Field survey, 2016

Table 4.14 indicates that 94.8% of the respondents agree that the introduction of CFL bulbs has impacted in reducing power consumption in households in the Twifo Hemang Lower Denkyira District while 5.2% said they do not know. The study holds it that the introduction of CFL bulbs had impacted in reducing power consumption in households in the district.

Table 4.15: Respondents willingness to use CFL bulbs to conserve electrical energy and save money

Are you willing to use CFL bulbs to conserve electrical energy and save money	Frequency	Percent
Yes	264	98.1
No	3	1.1
Do not know	2	.7
Total	269	100.0

Source: Field survey, 2016

Table 4.15 shows that 98.1% of the respondents said that they are willing to use CFL bulbs to conserve electrical energy and save money while 1.9% said they do not know. The respondents were willing to use CFL bulbs to conserve electrical energy and save money.

4.4 Factors that influence electrical energy conservation in households in Twifo Hemang Lower Denkyira District

Table 4.16: Does education play any role in electrical energy consumption?

Does education play any role in electrical energy consumption?	Frequency	Percent
Agree	209	77.7
Disagree	6	2.2
Strongly agree	54	20.1
Total	269	100.0

Source: Field survey, 2016

Table 4.16 shows that 97.8% of the respondents agreed that education play significant role in electrical consumption while 2.2% disagreed. The study concluded that education played significant role in electrical consumption.

The percentage savings shown in figure 2.5 are not aggregate or compound saving and show separate saving potentials with demand side management such as education and efficient appliance. Both show percentage savings over the original energy consumption of each household. Setting the two savings side by side, it is clear that the biggest savings come from the introduction of CFL. The least recorded savings was 30% compared to 13% for education and the biggest was impressive 74% compared 49% for education. There could be a number of reasons for these differences in the factor of savings with the two measures. Among them are:

- Households might have ignored some of the educational measures that were given to them.
- The same educational measures might not work for all the different householders in the experiment hence some householders might find some of the educational measures impractical or unhelpful.
- The replacement of all incandescent bulbs with CFL with will have impact across all householders *(though it might vary depending on the number replaced)*.
- After replace the lamps, the households may have little influence as to ignoring the basic measures compared to the educational one hence given the full impact of the CFL.

Table 4.17: income and electrical consumption

Income and electrical energy consumption?	Frequency	Percent
Agree	29	10.8
Disagree	125	46.5
Strongly Agree	93	34.6
Strongly disagree	15	5.6
Do not know	7	2.6
Total	269	100.0

Source: Field survey, 2016

Table 4.17 indicates that 52.1% of the respondents disagreed that income influence their electrical consumption, 45.4% of the respondents agreed while 2.6% said they do not know. The respondent's income influenced their ability to use CFL bulbs to conserve electrical energy.

Table 4.18: Age and electrical energy conservation

Age and electrical energy conservation	Frequency	Percent
Agree	16	5.9
Disagree	205	76.2
Strongly agree	28	10.4
strongly disagree	10	3.7
Do not know	10	3.7
Total	269	100.0

Source: Field survey, 2016

Table 4.18 indicates that 79.9% of the respondents disagreed that age influenced electrical energy conservation, 16.3% of the respondents agreed while 3.7% of the respondents said that they do not know. The respondent's age does not influence the use of CFL bulbs to conserve electrical power.

Table 4.19: Occupation and electrical energy conservation

Occupation and electrical energy conservation	Frequency	Percent
Agree	161	59.9
Disagree	40	14.9
strongly agree	36	13.4
strongly disagree	21	7.8
Do not know	11	4.1
Total	269	100.0

Source: Field survey, 2016

Table 4.19 depicts that 73.3% of the respondents agreed that occupation play significant role in conserving electrical energy, 22.7% of the respondents disagreed while 4.1% of the respondents said they do not know. The study revealed that the respondent's occupation played significant role in conserving electrical energy.

Table 4.20: The importance of conserving electrical energy

The importance of conserving electrical energy	Frequency	Percent
Agree	97	36.1
Disagree	12	4.5
strongly agree	114	42.4
strongly disagree	21	7.8
Do not know	25	9.3
Total	269	100.0

Source: Field survey, 2016

Table 4.20 revealed that 78.5% of the respondents agreed that it is important to conserve electrical energy, 12.3% disagreed while 9.3% of the respondents were neutral. The study results affirmed that it is very important to use CFL bulbs to conserve electrical energy.

However, for Ghana to fully benefit from such sector reforms and improve the services from the electricity sector, some key characteristic and objectives should be pursued in addition to what have happened in the past. A broader look at the sector reforms that have taken place as discussed in previous chapters show a ”private-investment” and economic growth as the main driven forces compared to ”competition, efficiency and choice”. Granted, state owned utilities need much needed private investment to increase capital inflows *(as the Ghana government has shown over and over again that, it lacked the single capacity to deliver all the capital inflow),* such efforts should be effected by deregulating the sector for other non-state owned companies to enter the sector to generate competition. Without state owned utilities enjoying monopoly, they will compete and will be able to break-even if not make profit. Competition will then lead to more secure and efficient service by utility companies. With this utility companies will be able to march their long term marginal cost and promote supply side efficiency. On the other hand, consumers will be faced with choices because of competition and utilities will be forced to sit up to improve service in order to stay in operation. Some may argue that, such deregulation and competition will increase tariff for the final consumers. That might not be the case since the state object allowing such deregulation is to reduce price per unit cost and promote higher efficiency and increase national efficiency, such competition will be reasonably and fairly be controlled by the politically neutral policies. This will not only ensure low prices but that will again make it very attractive to private investors to invest in the sector. These were the key

ingredients in many developed countries, e.g. in Denmark, the electricity market was liberalized in accordance with a decision of the Danish Parliament, "*the Folketing"*, in the mid-1990s. Generation and supply of electricity is subject to competition. There are a lot of private suppliers and producers of electricity in Denmark and consumers are free to exercise their choice of which supplier to use. However, consumers who do not want to exercise this right will still be supplied with electricity with state own companies (Danish Energy Agency website, *accessed 17.06.08 and Olesen*). The electricity supply service in Denmark is stable and promotion of end use efficiency is part of the overall agenda of security of supply. For this reason 2øre is levied on the end user tariff price to promote end use efficiency measure.

Granted, the electricity sector is one of the many sectors of Ghana´s economy but given the strategic importance of the sector to almost all other sectors, focusing on and eliminating other major bottlenecks such government interference for political interests, corruption and other malfeasance for should be addressed to make any electricity sector reforms based on competition work.

It must be mentioned that successfully embarking on competitive sector reforms in Ghana mostly depends on foreign capital (*Donor Agencies, China for Bui dam)* which often the country has less control of. There should be caution though, that national government cannot entirely leave the sector reforms in the hand market competition and should fairly intervene to provide a balanced cushion of the reforms. The national government can do that by protecting the most vulnerable in the country including those who fall within the poverty classification. That is why the government initiated programme of the "life line tariff" is commendable. Protecting the residential consumers especially from exploitation of any unfair tariff increases is important in a country where

access and supply of grid electricity is perceived as a *"social good"* and a basic right where a consumer is entitled to.

In summary, pursuing the objectives of a successful electricity sector reform both in utility and institutional capacity should be guided by four basic principles, these are;

- Increased competition and efficiency
- A wider choice for consumers,
- High security of energy supply,
- Protecting the environmental
- Low utility and cost effectiveness

Table 4.21: Respondents conserve electrical energy because they want to save money

Respondents conserve electrical energy because they want to save money	Frequency	Percent
Agree	142	52.8
Disagree	30	11.2
strongly agree	87	32.3
strongly disagree	4	1.5
Do not know	6	2.2
Total	269	100.0

Source: Field survey, 2016

Table 4.21 shows that 85.1% of the respondents agreed that saving money in the long run is reason why people conserve electrical energy, 12.7% of the respondents disagreed while 2.2% said they do not know. The study revealed that the respondents conserve electrical energy because they want to save money.

Table 4.22: Has ECG done enough to educate consumers on electrical energy consumption?

Has ECG done enough to educate consumers on electrical energy consumption?	Frequency	Percent
Yes	114	42.4
No	144	53.5
Do not know	11	4.1
Total	269	100.0

Source: Field survey, 2016

Table 4.22 shows that 53.5% of the respondents affirmed that ECG has not done enough to educate consumers on electrical energy consumption, 42.4% of the respondents said that ECG has done enough to educate consumers on electrical energy consumption while 4.1% said that they do not know. The study findings concluded that there is the need for ECG to intensify the public education regarding the use of CFL bulbs and energy conservation. In the survey conducted by the author, nearly 100% of the people surveyed expressed their dissatisfaction of the service of the utilities in Ghana most especially the distribution company ECG. The two serious electricity outages throughout the country experienced in Ghana for the past decade (in 1998 and 2007-Baiden, 2008) and large annual financial debts of Electricity Company of Ghana and

VRA *(The debt profile of VRA amounts to over USD200 million as of August, 2007, according the Ghana news agency)* shows that the various ongoing sector reforms must be strengthened.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The main purpose of the study was to investigate into the impact of using CFL bulbs on energy consumption in Ghana- a case study of Twifo Hemang lower Denkyira district in the central region of Ghana. This study employed quantitative and descriptive methodology to collect data and analyze data. The population for this study comprises individuals who consume electricity in the Twifo Hemang lower Denkyira District in the Central Region of Ghana. The population for the study was nine hundred and seventy (970).The random (probability) sampling technique was used to sample 274 electricity consumers within the study area to collect data in order to predict and generalized the whole research population. This method was used because all elements in the population have an equal chance of being included in the sample. It also minimized the possibility of an unrepresentative sample. This however can be time consuming process (Fisher 2010). The instruments used for the study were structured questionnaires. Moreover, out of 274 questionnaires sent out for primary data, 269 questionnaires were retrieved and 5 questionnaires were not retrieved. Therefore, the analysis of the study was based on 98% response rate. This figure was considered appropriate for the study. The data collected from primary and secondary sources were coded and entered into a computer equipped with the Statistical Package for Social Scientists (SPSS) Software (Version 16.0) and Microsoft (MS) Excel 2007 was also used for tables and figures.

5.2 Key Findings of the Study

5.2.1 Knowledge and usage of compact fluorescent lamps in Twifo Hemang Lower Denkyira District

The study shows that 91.8% of the respondents affirmed that they know what compact fluorescent lamp are. Moreover, 54.3% of the respondents affirmed that they were introduced to energy saving bulbs (CFL) through advertisements, 19.7% of the respondents were introduced to energy savings bulbs (CFL) through government intervention, 19% of the respondents were introduced to energy savings bulbs through ECG while 7.1% of the respondents were introduced to CFL bulbs through friends. Also, 42% of the respondents said that they have been using energy savings bulbs (CFL) for 4 years now. The revealed that 32% of the respondents said that they use 25 W of CFL bulbs. The study indicates that 84% of the respondents affirmed that CFL bulbs last longer than the incandescent bulbs.

5.2.2 The impact of using CFL on energy consumption in Twifo Hemang Lower Denkyira District

The study results depicts that 93.3% of the respondents said that they notice changes in their power consumption since they changed their lamps from incandescent lamps (Onion bulbs) to CFL bulbs. The study indicates that 86.2% of the respondents said that their power consumption reduced since they started using CFL bulbs. Furthermore, 97% of the respondents confirmed that the use of CFL bulbs reduced electricity bill in their home. Moreover, 65.4% of the respondents said that they have made changes in their electricity usage because of increasing electricity prices. The study shows that 91.4% of the respondents said that it is importance to reduce power consumption at home. The study indicates that 94.8% of the respondents agree that the

introduction of CFL bulbs has impacted in reducing power consumption in households in the Twifo Hemang Lower Denkyira District. To add more, 98.1% of the respondents said that they are willing to use CFL bulbs to conserve electrical energy and save money.

5.2.3 Factors that influence electrical energy conservation in households in Twifo Hemang Lower Denkyira District

The study shows that 97.8% of the respondents agreed that education play significant role in electrical consumption. The study results indicates that 52.1% of the respondents disagreed that income influence their electrical consumption. Also, 79.9% of the respondents disagreed that age influenced electrical energy conservation. Moreover, 73.3% of the respondents agreed that occupation play significant role in conserving electrical energy. The study revealed that 78.5% of the respondents agreed that it is important to conserve electrical energy. The study shows that 85.1% of the respondents agreed that saving money in the long run is reason why people conserve electrical energy. The study depicts that 53.5% of the respondents affirmed that ECG has not done enough to educate consumers on electrical energy consumption.

5.3 Conclusions

The study concluded that the respondents are aware of the usage of compact fluorescent lamp. Moreover, the respondents were introduced to energy saving bulbs (CFL) through advertisements, government intervention, through ECG and friends. Also, they have been using energy savings bulbs (CFL) for 4 years now. Most respondents used 25 W of CFL bulbs. The CFL bulbs last longer than the incandescent bulbs.

The respondents noticed changes in their power consumption since they changed their lamps from incandescent lamps (Onion bulbs) to CFL bulbs. The respondent's power consumption reduced since they started using CFL bulbs. Moreover, the use of CFL bulbs reduced electricity bill in the respondent's home. Moreover, the respondents have made changes in their electricity usage because of increasing electricity prices. The study concluded that it is importance to reduce power consumption at home. The introduction of CFL bulbs has impacted in reducing power consumption in households in the Twifo Hemang Lower Denkyira District. The respondents were willing to use CFL bulbs to conserve electrical energy and save money.

The study concluded that education, income, age and occupation, played significant role in electrical conservation and consumption. The study concluded that it is important to conserve electrical energy because people conserve electrical energy to save money. The ECG has not done enough to educate consumers on electrical energy consumption.

5.4 Recommendations

According to the key findings and conclusions, the study recommended that;

1. The ECG should organise periodic advertisements and awareness programmes to educate electricity consumers on the importance of using the CFL bulbs to conserve electrical energy.
2. The Government of Ghana through the ECG should provide free CFL bulbs to the households in the Twifo Hemang Lower Denkyira District to promote the conservation of electrical energy.
3. The households in the Twifo Hemang Lower Denkyira District should be encouraged to use the CFL bulbs to reduce electricity bill in their homes.

4. The Respondents should be advised to make changes in their electricity usage and reduce power consumption at home because of increasing electricity prices.

5.5 Suggestions for further Research

Based on the recommendations of the study, the researcher suggested that a similar study should be conducted to assess the impact of organising periodic advertisements and awareness programmes to educate electricity consumers on the importance of using the CFL bulbs to conserve electrical energy.

REFERENCES

ADF (2007). *Energy-Efficiency Labels and Standards*: A Guidebook for Appliances, Equipment, and Lighting - 2nd Edition 2005. *Formal Report, 4th International Conference on Energy Efficiency in Domestic Appliances and Lighting* (EEDAL 06), 05/2005 2005-04-28. LBNL-45387

Baiden, R. (2008). *Electricity reform in developing and transition countries*: A reappraisal, 2006. Energy and Resources Group, University of California at Berkeley, 310 Barrows Hall, Berkeley, CA 947203050, USA. Energy Volume 31, Issues 6-7, May-June 2006, Pages 815-844.

Bernd, L. (2008). *The impact of FDI on Regional industrial energy efficiency*: An empirical analyses on FDI source. China Population, Resources and Environment 6, 32-37.

BUR, (2015). *The empirical research of the impact of economic globalization to China's energy utilization efficiency-based on China's industry panel data.* Economic Science 1, 102–11.

Doe F, and Asamoah E. S. (2014). *The Effect of Electric Power Fluctuations on the Profitability and Competitiveness of SMEs:* A Study of SMEs within the Accra Business District of Ghana. Accessed 29.10.15. http://www.cjournal.cz/files/174.pdf 15.

Douglas F. B., and William M. F. (2012*). Rural Energy in Developing Countries:* A Challenge for Economic Development. Accessed

Energy Commission of Ghana (2007). *Transforming the West African Market for Energy Efficiency:* Ghana Leads the Way with Mandatory Standards and Labels draft April 2002.

Energy Commission Ghana www.energycommission.org accessed 29/05/08

Gyamfi, S. Mawufemo, M. and Sinisa, D. (2015). *Improving Electricity Supply in Ghana*-The potential of renewable energy. Accessed 12.11.15 http://www.researchgate.net/publication/271118063_Improving_electricity_supply_security_in_GhanaThe_potential_of_renewable_energy

ISSER, Institute of Statistical, Social and Economic Research, (2005). Guide to Electric Power in Ghana, 2005.*Resource Centre for Energy Economics and Regulation. First Edition,* University of Ghana P. O. Box LG 74 Legon, Accra Ghana.

Kemp, W. H. (2005). *The renewable energy handbook – A guide to rural energy independence, off-grid and sustainable living*. Canadian Cataloguing in Publication Data. ISBN 0-9733233-2-9.

Marful, S. S. (2009). *Security of electricity supply in Ghana*. Accessed 6.11.15 file:///C:/Users/Joe/Downloads/cepmlp_car13_63_868500920.pdf 34.

Mwandosya, M.J. (2006). *Main Streaming Environment and Climate Change Concerns in National Planning in Tanzania, 2006.* The United Republic of Tanzania, vice president´s office, September 2006

Okoye, F., Xu W., Gu, R., Liu Y., and Dai Y. (2010). *Forecasting energy consumption using a new GM-ARMA model based on HP filter:* The case of Guangdong Province of China. Economic Modelling 45, 127-135.

Philips, M. (2007). *How Ghana´s Economic Turnaround is Threatened, Falling Water Levels Stunts Hydro Power, 2007.* The Wall Street Journal – More Energy needed, page A5.

Public Utility Regulatory Commission of Ghana Electricity Setting Rate Guidelines, 1999.

Steenblik R, Vaughan S. and Waide P. (2006). *Can Energy-Efficient Electrical Appliances Be Considered "Environmental Goods.* OECD Trade and Environment Working Paper No. 2006-04.

Suave N, Dzokoto A. and Opare, B. (2002). The price of development: HIV infection in a semi urban community of Ghana, *Journal of Acquired Immune Deficiency Syndrome* [JAIDS] 20(4): 402-408.

Wilson, I. (2004). *Overview of the Energy Sector in the Sub-region. Programme Manager Inter-governmental Panel on Climate Change. Freetown Office Tower Hill,* Freetown, Sierra Leone. Workshop on "Biomass Technology for Sustainable Energy in Western Africa"

Varian, H. (1984). Macroeconomic Analysis, 1984 Norton, NY.

Volta River Authority (2005). *Annual Reports and Accounts report. Profile of Volta River Authority.*

Nordhaus, W. D. and Samuelson A. Paul, (2001). *Economics 2001*, 17th edition, McGraw-Hill, p. 157. ISBN 0072314885.

Zakhary, K. (2007). *Factors affecting the prevalence of schistosomiasis in the Volta region of Ghana 1997*. McGill Journal of Medicine 3: 93-101.

APPENDIX

QUESTIONNAIRES FOR THE RESPONDENTS

The researcher is a product of UEW, Kumasi campus conducting a piece of research to investigate into the impact of using CFL bulbs on energy consumption in Ghana- case study of Twifo Hemang Lower Denkyira District in the Central Region. I respectively request that you form part of this research by completing the attached questionnaire. It is my fervent hope that you participate in the study. May I thank you for your valuable cooperation.

SECTION A: DEMOGRAPHIC INFORMATION FOR THE RESPONDENTS

1. Gender: Female [ ] Male [ ]
2. Age:
   18-29 years [ ] 30-39 [ ] 40-49 years [ ]
   50-59 years [ ] 60years and above [ ]
3. Educational background:
   Non Formal Education [ ] BECE [ ] WASSCE [ ]
   Diploma [ ] Bachelors' Degree [ ] Masters' Degree [ ] PHD [ ]

SECTION B: KNOWLEDGE AND USAGE OF COMPACT FLUORESCENTLAMPS IN TWIFO HEMANG LOWER DENKYIRA DISTRICT (THLDD)

4. Do you know what compact fluorescent lamp (bulbs) are

   Yes [ ] No [ ] Do not know [ ]

5. Who introduced you to energy saving bulbs (CFL)

   Government Intervention [ ] ECG [ ] . Advertisement [ ] Friends [ ]

6. How long have you been using energy saving bulbs (CFL)

   1 year [ ] 2years [ ] . 3 years [ ] 4 years [ ] 5 years and above [ ]

7. What type of wattage (W) of CFL bulbs do you buy?

   9 W [ ] 15 [ ] 20W [ ] 25 W [ ] 80W [ ] 105W [ ]

8. Do the CFL bulbs last longer than the incandescent bulbs?

   Yes [ ] No [ ] Do not know [ ]

SECTION C: THE IMPACT OF USING CFL ON ENERGY CONSUMPTION IN TWIFO HEMANG LOWER DENKYIRA DISTRICT (THLDD)

9. Did you notice any changes in your power consumption since you changed your lamps from incandescent bulbs (Onion bulbs) to CFL bulbs.

   Yes [ ] No [ ] Do not know [ ]

10. Has you power consumption reduced since you started using CFL bulbs.

    Yes [ ] No [ ] Do not know [ ]

11. Do you agree that the use of CFL bulb will help reduce electricity bill in your home.

    Yes [ ] No [ ] Do not know [ ]

12. Have you made any changes in your electricity usage because of increasing electricity prices?

    Yes [ ] No [ ] Do not know [ ]

13. Do you think reducing power consumption at home is important?

Yes [ ] No [ ] Do not know [ ]

14. In your own assessment, do you agree that the introduction of CFL bulbs has impacted in reducing power consumption in households in the Twifo Hemang Lower Denkyira District (THLDD).

Yes [ ] No [ ] Do not know [ ]

15. Are you willing to use CFL bulbs to conserve electrical energy and save money?

Yes [ ] No [ ] Do not know [ ]

SECTION D: FACTORS THAT INFLUENCE ELECTRICAL ENERGY CONSERVATION IN HOUSEHOLDS IN TWIFO HEMANG LOWER DENKYIRA DISTRICT (THLDD)

16. Does education play any role in electrical energy conservation?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

17. Your income, does it influence your electrical energy consumption?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

18. Age, does it influence the way people conserve electrical energy?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

19. Occupation, does it play any role in conserving electrical energy,

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

20. Is it important to conserve electrical energy?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

21. Are you always aware of the link between tariffs and conservation?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

22. Do you agree that saving money in the long run is reason why people conserve electrical energy?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]

23. Has ECG done enough to educate consumers on electrical energy conservation?

Agree [ ] Disagree [ ] Strongly Agree [ ]

Strongly Disagree [ ] Do not know [ ]