UNIVERSITY OF EDUCATION, WINNEBA

CONSUMERS PERCEPTION OF PREPAID METER SYSTEM IN THE KOFORIDUA MUNICIPALITY

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A Dissertation in the Department of **AUTOMOTIVE /ELECTRICAL 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 (Electrical Technology) degree.

AUGUST, 2017

DECLARATION

STUDENT'S DECLARATION

I, MARY OFORIWAA, 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: PROFESSOR AHMAD ADDO

Signature ……

Date ……

ACKNOWLEDGEMENT

I am grateful to Almighty God for His guidance and protection. Secondly, to my supervisor, Professor Ahmad Addo for making this work possible.

DEDICATION

This work is dedicated to my Husband and children who assisted me in my studies.

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ABSTRACT

The main purpose of the study was to evaluate the perception of the consumers of electricity regarding the use of prepaid meter system in the Koforidua Municipality. This study employed quantitative and descriptive research design to collect and analyze data. The population for this study was individuals who consume electricity in the Koforidua Municipality in the Eastern Region of Ghana. The population for the study was two thousand six hundred (2600). The random (probability) sampling technique was used to sample three hundred and thirty five electricity consumers within the study area. The main instrument used for the study were structured questionnaires. The study findings concluded that most of the respondents preferred the prepayment metering system but they still used the old metering system due to the disadvantages involved in the use of the prepayment metering system. The respondents had a fair and poor opinion regarding the prepayment system. The ECG did not do enough to educate consumers on the implementation of the prepayment metering system. This has generated some misconception in the minds of the consumers and has affected the adoption of the new metering system. The study recommended that the Management of the Electricity Company of Ghana (ECG) and Volta River Authority (VRA) should organise periodic education programmes through the media platforms like the Television and Radio stations to inform and educate the electricity consumers regarding the benefits of the prepayment meter system in order to enhance its implementation in the Koforidua Municipality.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Electric meters measure the amount of electric current supplied to a shop, house or any other source including machines. The electricity board has different terms and conditions for installing various electric meters depending on their usage. These meters help in measuring the amount of electricity being utilized by various sections of society, and therefore, should not be tampered with. Electricity cannot be stored in large amounts, and hence, needs generators to produce it. The need of generators would be endless if electricity is not used efficiently (King, 2007).

Electric meters are designed to reduce power consumption during peak hours and also control the power supply to different consumers. Electric meters are broadly classified into two categories – electromechanical meters and electronic meters. Furthermore, they can be of various types such as numeric display meters, standard meters, variable rate meters, prepayment meters, electromechanical meters, etc. Throughout the world, high electric energy usage has been a matter of great concern since it relates directly to the amount of money an individual or entity pays for benefiting from the supply of energy. Some challenges that these energy utilities face include, the increasing demand and supply gap and high technical losses leading to financial losses (Chartwell, 2008). To solve these problems, it has been argued that the conventional credit metering system was not good enough. This has necessitated the upgrading through the use of the new technologies like the prepayment meter systems that enables customers or consumers to administer or regulate their energy consumption effectively. Utilities are upgrading their systems with the use of

Information Technology (IT) systems and these help increase the efficiency and utilization of their assets (Chartwell, 2008).

Energy saving is a very vital issue in every country, therefore adequate monitoring and restricted usage of these energy are enforced. The benefit of this energy saving is to have perfect control over the electricity bills without any misconception between utility management and consumers when electricity bills are distributed.

Electricity, gas and water prepayment meters are now installed by the utilities to market their product, with over 20 million units installed worldwide. Technology upgrading has increased considerably and also has offered great benefits to both utilities and consumers, such growth being the outcome of AMI technology. Based on its implementation, some customers retracted to its use (Chartwell, 2008). However, it has been positively accepted by customers who have seen its great benefit. Other developed countries account for its massive usage of 87% percentage, these being China, United Kingdom (UK) and South Africa. Apart from Turkey being 10% further, no other country goes beyond 0 .3%. China has the largest number with 7 million prepayment meters, mostly for electricity. The UK is the largest user of prepayment meters and account for 55%. South Africa has the largest proportion at 54% of all the electricity meters and this amount to less than 1% of the total base of all meters in the country. 50 other countries use prepayment meters but the problem being the payers (Amit and Mohnish, 2011).

These meters have been installed in tenement building and individual rented room or houses, educational institutions where human movements are mostly populated. 3.8 million prepayment meters are still in use in the UK for electricity. France has a few of these meters being installed and it was planned to install between

500,000 and 1 million prepayment meters (Amit and Mohnish, 2011). Throughout the world prepayment metering has been accepted in more than 40 countries across the globe. South Africa and UK have succeeded in developing those large volumes of prepayment. Prepaid meters are used in other countries such as Argentina, Bangladesh, Belgium, Brunei, Czech Republic, France, Ivory Coast, Kuwait, Israel, Lesotho, Malaysia, New Zealand, Poland and Ghana. Prepayment metering system was first introduced in the UK about 100 years ago. It was launched in the early 1990's in South Africa when the decision was taken to expand the level of electrification and there it has been an outstanding success. Moreover, it is until recently that China is being the largest. South Africa is now the leading country, which motivates others. The prepayment metering system is an information Technology-based innovation which involves the purchase of electricity by consumers or customers before its use. Utilities companies across the world are now practicing this technology. While there are more demand in other countries others have less aspect of it (Amit and Mohnish, 2011).

As utilities invest in prepayment metering system, acceptance becomes most difficult to other consumers. Prepayment of power is a new form of payment that is enabled by today's smart metering system. The prepayment metering system has improved, since it is accepted by consumers in other countries such as Ghana. In March 2009, Kenya Power and Lighting Company (KPLC) accepted to expand its prepayment system to 25,000 customers, in which the first phase of it was done in April 2009. KPLC owns and operates the national transmission and distribution grid and provides electricity to over 1.2 million customers throughout Kenya. KPLC connects an additional 200,000 customers each year (Arthur, 2009). The objective is to convert most of the residential customers to prepayment system. The five Pacific

countries also launched their Prepayment system in August 2009. The meters were installed in all business, homes and offices. Along with the installation of the meters and their activation into prepayment mode, the Naura Utilities Authority is now providing 24 hour power to all its customers, thus ending the load shedding schedule that had been in place over the past several years. Residential customers will now pay their electricity entirely in cash with this initial public view about the new prepayment system had been encouraging since customers now have 24 hour access to electricity and pay for the improved level of service.

Prepayment meter was first launched in South Africa on the African continent (Arthur, 2009). Meter readers had the problem with the meter reading due to township conflict, social pressure and political conflict. These situations led Eskom to develop a basic no-frills prepayment metering system. Eskom supplied electricity to large customers in industries mining and other distributers to end users. Some challenges that informed Eskom's decision are as follows: consumers withholding prepayment for a long time, ability to afford fixed cost in a tariff, access to meters in the remote areas, deposit management problems, mistrust on fixed charges in tariff structure by customers, and lack of postal system to allow households to check on their bills (Burke, 2014). The program increased electrification from 33% in that year to 69% in 2003. With 7.5 million customers and 4 million prepayment meters, South Africa has the highest penetration of prepayment metering in the world. Prepayment was seen as a means of direct budgeting where the consumer was able to directly relate electricity usage with the amount of money required. In 1990 came a revolutionary change themed "Electricity for All". Eskom embarked on a prepayment metering system while bringing the time between purchase and consumption to as short an interval as possible (Carlson, 2013). This method also enabled consumers to

make conscious decisions about expenditure such as food and other household requirements against the cost of electricity.

Initially, meter manufacturers developed proprietary technologies, but now the Standard Transfer Specification (STS), developed in 1993, manages the secure transfer of credit in electricity prepayment and is the only globally accepted open standard for electricity prepayment systems, adopted by the International Electro-technical Commission (IEC 62055-41). This standard was adopted by Eskom and other supply authorities, which have subsequently replaced all proprietary meters installed with STS-compliant technologies. Prepayment meters require a robust design for a host of reasons, not least for the ability to withstand transients and other network anomalies from the high incidence of lightning in many regions of the country. This requirement has resulted in the meter designs of South Africa being superior to those sourced from other countries (Carlson, 2013).

The advantages of prepayment metering have led the regulators to support its implementation in India. In one of the other utilities which had adopted prepayment to ensure 100% cash collection in advance, reduce system losses, provide better customer services, and ensure load management to optimize its availability and distribution of supply. The results that were achieved are noteworthy. After installing more than 10,000 prepayment meters, there was a revenue improvement of 30% within the first month due to accurate billing (Chandler, 2015). Also due to energy consciousness, the energy demand on the average had reduced from 3MW to 2.5MW; a reduction of 17%. Many state regulators have introduced reduced electricity charges for consumers with prepayment metering. Apart from this, the Ministry of Power in New Delhi has issued a notification to implement prepayment metering for all government offices and residences. Since the meters show energy consumption in

money terms, the consumers can see the cost of energy in real time; this provides a strong push to reduce their consumption as that saves money. On the whole, the fact that prepayment meters help make customers energy conscious and persuade them to budget their expenditure on electricity has been empirically proven. The importance and the role of prepayment metering help to conserve energy is further corroborated. The success of the pilot trials has provided the consumers as well as the utility company the required confidence to adopt the prepayment systems (Chandler, 2015). From the foregoing, the study assessed prepaid meter system of consumers in the Koforidua Municipality.

1.2 Statement of the Problem

The researcher realised that most consumers of electricity in the Koforidua Municipality default in payment of electricity bills. Due to the delay in payment, the Electricity Company of Ghana Limited hired people to disconnect and reconnect power sources for those default consumers. The study sought to develop a prepaid meter system that would help the electric company to manage consumers difficulty to maintain due to payment lags and eliminate the need of hiring people whose jobs would only be disconnecting and reconnecting power sources for those consumers.

1.3 Purpose of the Study

The main purpose of the study is to evaluate the perception of the consumers of electricity as related to the use of prepaid meter system in the Koforidua Municipality.

1.4 Objectives of the Study

The specific objectives of the study are;

1. To assess the perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality.
2. To evaluate the effectiveness of the Prepayment Metering Implementation in Koforidua Municipality.
3. To identify the benefits of switching to the prepayment metering system.
4. To evaluate the effects of prepayment metering on customer energy usage in the Koforidua Municipality.

1.5 Research Questions

The following research questions will guide the study;

1. What are the perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality?
2. What is the effectiveness of the Prepayment Metering Implementation in Koforidua Municipality?
3. What are the benefits of switching to the prepayment metering system?
4. What are the effects of prepayment metering on customer energy usage in the Koforidua Municipality?

1.7 Significance of the Study

This study will help the electricity consumers in the Koforidua Municipality to pay for their electrical consumption in a quick and simple manner. Consumers using this system will no longer receive any electric bill, and they can easily remember how much they have to pay since the prepaid cards would have certain

denominations that will suit their needs and budget. Prepaid cards are also bought in a hasty manner since no processing of account occurs when one buys it. The time that is allotted for paying the charges for electricity is now reduced and the consumers will have more time to do other important tasks in their everyday lives. Consumers will also be able to avoid the hassle of reconnection since the wires involved in their power connection isn't actually cut off; all they have to do is to restore power in their homes to load up their meter. Users of this prepaid system will also be unaffected, if ever power rates go up for postpaid users since the prepaid denomination with its corresponding kWh load equivalent is already set, thus help them save more money.

On the part of the electric company, there will be less difficulty in keeping track of the consumption of their customers since it is prepaid, and they do not have to prepare and distribute any bill. It will also reduce their consumption of resources such as ink and paper for printing. It is also expensive for electric companies to hire people whose function will just be disconnecting and reconnecting power usages for consumers who have difficulty to update their accounts due to payment lags. With this system, the electric company will not have to recruit a personnel to visit consumers to perform disconnection or reconnection of electricity if that consumer uses the prepaid power meter, thus saving money more money.

1.7 Scope of the Study

This research is focused on evaluating the perceptions of electricity consumers regarding prepaid metric system usage in the Koforidua Municipality.

1.8 Organization of the Chapters

This study consists of five chapters. Chapter one deals with the background of 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 describes the research design, the population sample and sample procedures, data gathering instruments and data collection procedures of the study, 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 and recommendations and suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviewed comprehensive literature regarding the credit conventional metering system and the prepaid metering system. Moreover, literature reviewed include classification of Prepayment Meters, smart card electronic prepayment meter, token prepayment meter, remote-controlled prepayment meter, integrated single phase (ISP) electric meter, the Integrated Three Phase (ISP) Meter, the Split Single Phase (SSP) Meter, the operation of remote controlled prepayment meter, some characteristics of remote-controlled prepayment meter, key Prepayment Meters, some Benefit of Prepayment Meter, prepayment Metering Implementation in Ghana, methods of Billing in Prepayment System, electromechanical Technology, communication Technology, automatic Reading, effects of Prepayment Metering on Customer Energy Usage, prepaid Metric System and Energy conservation, types of Electric Meters, Numeric Display Meters, electromechanical Induction Meter or Standard Meter, Variable Rate Electric Meters, Solid State Electric Meters, Electronic Meters, Smart Meters, The Technology and Economics of Prepaid Electricity, The Adoption of Prepaid Meters, Electricity Consumers' Perception about Prepaid Meters, Effects of Prepay Meter System, How do Prepayment Meters work? And the development of Prepaid Metering Systems. The chapter ended with the conceptual framework of the study.

2.1 Prepayment Metering System

Prepayment metering is the trade measurement of electricity which is required to be purchased by a consumer in advance of the consumption of electricity.

Generally, in a prepayment application, a consumer must prepay for electricity in order to activate their load through the meter. The types of prepayment applications for electricity may vary and can range from a simple advance monetary payment for electricity to the pre-purchase of a fixed quantity of electricity. In principle, under a prepayment application, the consumer may not receive a subsequent bill as payment is made in advance for electricity. The terms and conditions for prepayment are established by the electricity and the utility service (also referred to in the industry as suppliers or energy providers), and are subject to regulation by the Provinces. In their earliest form, prepayment meters consisted of coin operated mechanical meters (Chandler, 2015).

From the late 1980's forward, electronic meter technology combined with card encoding and various telemetering communication techniques have been used in prepayment meter design. In recent years, there has been a growing interest amongst government departments and industry stakeholders to identify new methods for managing and conserving energy to meet rising demand at the residential and commercial/industrial trade levels. In the electricity industry, the use of prepayment applications combined with time-of-use is being closely reviewed as a viable means for reducing overall demand in the electricity marketplace. In general, it is considered that the electricity prepayment meter measures energy in the same manner as a conventional meter. The main difference with a prepayment meter lies in the intended manner in which the meter is to be operated and used for the sale of electricity (Chandler, 2015).

In the case of a conventional electricity meter, once a customer's load is energized, energy consumption is measured integrally on a continuous basis and a measurement reading is taken or established by the utility service on a periodic basis

for the purpose of establishing a charge for electricity. Payment for electricity is made by the purchaser following the declaration or estimation of consumption of electricity for a certain period of time (Chartwell, 2008). In the case of a prepayment electricity meter, the meter also measures electricity consumption integrally but the measurement is actually started and stopped in conjunction with the activation and deactivation of the load circuit by the prepayment control system. To activate the load circuit, the consumer must prepay for electricity usage or purchase a quantity of electricity (note: the utilities' fixed charges may be included in this purchase). The payment information may be loaded on the meter through a specific peripheral control device (e.g., magnetic card reader or telemetering system). Once activated, the load circuit will run and remain activated until the monetary or equivalent energy information loaded into the prepayment control system has run out, subject to any other conditions established by the utility services (Chartwell, 2008).

2.1.1 Classification of Prepayment Meters

The types of prepayment meters with respect to this project are under listed below:

- Smart card electronic prepayment meter
- Token prepayment meter
- Remote control prepayment meter
- Key prepayment meter

2.1.2 Smart card electronic prepayment meter

Smart Card Prepayment Metering System is a new billing methodology that is combining a superior electronic customer account management system, state-of-the-art metering equipment and smart card technology and provides Power Utility, a

substantial saving both in manpower and money while providing new payment option for the customers. It reduces operational cost with paperless revenue (Devidas and Ramesh, 2010). Figure 2.1 shows smart card electric prepayment metering sample.

Figure 2.1: A smart Card Prepayment Metering System on Electronic Energy Meter

The system eliminates the need of sending a meter reader to collect data at the customer premises. Instead as a customer inserts his charged Smart Card into the meter and the information such as total kWh consumption, previous 12-month kWh consumption, available credit among others, is then transferred by the meter to the card. The downloaded data will then be transferred to the utility database once the customer recharges their card (Devidas and Ramesh, 2010). The various available softwares that can be embedded into the meter, the Smart Card and the backend system together make the system very flexible and can cater for any utility requirement. An electronic prepaid kWh meter will act as a "bank", as long as some credit is available inside the meter, electricity will be made available to the customer. The level of credit inside the meter will be deducted according to the tariff as programmed for the respective customer (Devidas and Ramesh, 2010).

Smart meters go a step further than simple AMR (automatic meter reading). They offer additional functionality including a real-time or near real-time reads, power outage notification, and power quality monitoring. They allow price setting agencies to introduce different prices for consumption based on the time of day and the season. These price differences can be used to reduce peaks in demand (load shifting or peak lopping), reducing the need for additional power plants and in particular the higher polluting and costly to operate natural gas powered peaker plants. The feedback they provide to consumers has also been shown to cut overall energy consumption (Devidas and Ramesh, 2010).

2.1.3 Token Prepayment Meter

This system of metering which made use of Tokens and was introduced in the late 1980s and was adopted by approximately half of the UK utilities. Many suppliers expressed a certain amount of dissatisfaction with token meters which are the oldest technology in use. They are the most basic type of prepayment meters and have a number of limitations including a greater susceptibility to fraud and misdirected payments than the other types of meters, high maintenance cost deriving from the need for site visits, inflexibility in the recovery of debt, and general account balancing issues (Edison Electric Institute, 2016). Figure 2.2 shows the magnetic/token prepayment system.

Figure 2.2: A magnetic/token prepayment system Source: Edison Electric Institute (2016).

Tokens for prepayment can be categorized as being "One-Way" or "Two-Way". The one-way tokens transfer credit and control information from the sale point to the meter and the tokens are usually discarded after use. The major drawback with one-way is that the supplier cannot know how much electricity has been disbursed through the prepayment meter. Personnel therefore have to visit the customer's premises to verify consumption physically. The two-way tokens require the customer to return to the point of sale for the next purchase. This allows the supplier personnel to read the data stored by the meter from the returned token (Edison Electric Institute, 2016).

Two types of token technology are currently in use: Disposable paper card with magnetic stripe and Numeric tokens which are strips of paper with a unique, encoded 16 or 20 digit numbers to be entered by the customer via a keypad on the face of the meter. This makes the token essentially a slip of paper, very cheap to produce (Edison Electric Institute, 2016).

2.1.4 Remote-Controlled Prepayment Meter

Remote Control (RC) Prepayment System is composed of prepayment watt-hour meter, RC controller, energy dispenser device, and management software. RC controller is a carrier for data exchange between meter and management system. The

system could make it easy to control and manage electricity consumption. The prepayment watt-hour meter has constantly been improved. It is very popular in China and welcomed by the customers due to its advanced design, sound quality, flexible setup, competitive price, and good technical support (Edison Electric Institute, 2016). Figure 2.3 depicts a remote-controlled prepayment meters.

Figure 2.3: Remote-controlled prepayment meters.

Source: Edison Electric Institute (2016).

A Prepayment Meter is an easy way to pay for your gas and electricity. It allows you to pay for your energy supply before you use it. If you would like to pay for your gas and electricity in this way, it can be easily fitted into your home, providing it is safe and practicable to do so. A Prepayment meter will charge for any gas or electricity as you use it. It may also be used to recover any outstanding debt from you at an agreed weekly rate. Some electricity Prepayment Meters may also take a weekly amount to cover fixed unit charges as part of our two-tier pricing structure. When we install a Prepayment Meter, we will provide you with details of our gas or electricity charges. Where there are any additional charges in connection with your Prepayment Meter, we will always tell you what they are beforehand (Edison Electric Institute, 2016).

According to UK Power Limited (2012), Prepayment meters work in exactly the same way as their name would suggest; instead of paying for your electricity after

you have used it, you pay before. UK Power Limited (2012) also noted that, there are two main types of prepayment meters. The first, standard prepayment meters may either display one or two readings and these should simply be read as above like other meters. The second type is meters connected to the Pay-point network. This system works by accepting tokens, usually in the form of plastic keys which can be bought and then your supply topped up.

According to Measurement Canada (2006), Prepayment metering is the trade measurement of electricity or gas which is required to be purchased by a consumer in advance of the consumption of electricity or gas. Generally, in a prepayment application, a consumer must prepay for electricity or gas in order to activate their load through the meter. The types of prepayment applications for electricity and gas may vary and can range from a simple advance monetary payment for electricity or gas to the pre-purchase of a fixed quantity of electricity or gas. In principle, under a prepayment application, the consumer may not receive a subsequent bill as payment is made in advance for electricity or gas. The terms and conditions for prepayment are established by the electricity and gas contractors (also referred to in the industry as suppliers or energy providers), and are subject to regulation. The design, construction, performance, installation and usage of meters intended for prepayment applications are subject to regulation in most countries. Prepayment Electric meters now come in various types. Among them are:

2.1.5 Integrated Single Phase (ISP) Electric Meter

The Integrated Single Phase (ISP ED) meter is a compact, two wire, keypad-based prepayment electricity meter in a housing compatible with the ESKOM standard common base electricity dispenser socket (Meter Mate, 2012). This meter is

most suited to new reticulation and is directly and easily interchangeable with common base prepayment meters from other approved manufacturers using the common base configuration. User interaction with the meter and access to meter information (such as a low credit warning, energy consumption, and load contactor status) are available using the keypad and LCD display.

The ISP ED meter is based on the ESKOM Specification, which calls for a prepayment meter that can be fitted into a standard, plug-in common base. This concept ensures simple installation and replacement procedures. The meter is keypad based, fully STS compliant and supports the 20 digit STS encryption algorithms (Electricity Guide, 2013). The meter has a wide range of information registers which can easily be accessed by pressing the information button on the keypad and then entering the number of the register. The plug-in-base, which also conforms to ESKOM‘s specifications, allows the commissioning of the meter to be separated from the installation of the wiring, thereby adding flexibility and installation convenience. Included with the base is a Metal Oxide Varistor (MOV), which ensures that the meter complies with SANS IEC 61643-1 for class 3 arrestors. The base is optional and can be supplied separately to the meter (Electricity Guide, 2013).

2.1.6 The Integrated Three Phase (ISP) Meter

The Integrated Three Phase (ISP) meter is a four-wire 100 Amp per phase, keypad-based prepayment meter in a compact BS housing. The meter is suitable for residential, commercial and light industrial environments. The meter also features a dedicated diagnostic indicator which shows the status of communication to the optional remote Customer Interface Unit (CIU). This valuable visual aid assists the field technician to validate the installation and determine probable fault types. The

meter boasts a large custom display and also features a host of standard Meter Mate software features including the ability to operate as a prepayment meter or in credit metering mode (Electricity Guide, 2013).

As a standard feature, the Three Phase meter offers an IEC 62056-21 compliant optical communications port. This allows the utility to access a variety of information stored inside the meter, and to upload it to a hand-held unit. The meter has two parts, the prepayment meter and the customer interface unit. The meter is connected to the customer interface unit by a two core communications wire up to a distance of 130 metres (Electricity Guide, 2013). It operates independently of the customer interface unit and is usually installed in a secure, locked enclosure outside the consumer‘s home. The customer interface unit is compact with a user-friendly keypad and display. An optional local keypad and display can be fitted to the meter at the time of manufacture. The meter also features a dedicated diagnostic indicator which shows the status of communication to the customer interface unit. The meter contains all critical metering, token decryption and load control functionality. It operates independently and is immune to any form of tampering on the Customer Interface Unit (Electricity Guide, 2013).

The meter is usually installed outside the home in a secure, locked enclosure which should not be accessible to the consumer. This facilitates easy inspection by the utility at any time and reduces the opportunity of fraud by tampering. The customer interface unit is installed inside the consumer‘s house in a convenient location. The communications interface can withstand voltage surges of 6kV, however it is recommended that one of the communication lines be earthed at the meter for additional protection (Graeme, 2014).

2.1.7 The Split Single Phase (SSP) Meter

This is a compact, two wire, keypad-based prepayment electricity meter which comprises two parts, the Energy Management Unit (EMU) and the Customer Interface Unit (CIU). User interaction with the meter and access to meter information (such as a low credit warning, energy consumption, and load contactor status) are available using the keypad and LCD display on the CIU. The meter consists of two parts namely, the CIU and the EMU. The CIU is the customer‘s only interface with the meter, and is a compact unit with a user-friendly keypad and display. It is usually installed in a convenient location in the consumer‘s home - remote from the EMU, and is connected to the EMU with a pair of communications wires (Graeme, 2014).

The EMU contains all critical metering, number decryption and load control functionality. It operates independently and is immune to any form of tampering on the CIU interface. The EMU is usually installed in a secure, locked enclosure, typically a pavement kiosk or pole-mounted equivalent. It is outside the consumer‘s home to facilitate easy inspection by the utility at any time and to reduce the opportunity of fraud by tampering. As an option, the EMU can be supplied with its own LCD display and keypad, which allows the utility to view important meter parameters without the need for an interrogation tool (Graeme, 2014).

The communications interface can withstand voltage surges of 6kV, however it is recommended that one of the communication lines be earthed at the EMU for additional protection. Should the customer not want to earth a communication line during installation, the meter can be fitted with protection circuitry in the terminal cover (Graeme, 2014).

2.2 The Operation of Remote Controlled Prepayment Meter

The current signal and voltage signal will be sent to a special integrated circuit after sampling and dividing, and then treated by special CPU chips to obtain the pulse signal of frequency positive rated to load consumption power. The pulse signal to be sent to LED and the value of power through the meter will be indicated by the speed-ratio of pulse number/kWh. Even when the connection is not correct which causes the adverse power, the meter can also recorded the data correctly (Hoffman, Scheer, Marchionini, 2014).

2.2.1 Some Characteristics of Remote-Controlled Prepayment Meter

a) Controlled by the Micro-PC with Advanced SCM, measured digitally and with smart anti-tampering function (no influence in measurement and keep record if connection is in reserved between input and output wire)

b) Both Meter and Power-selling Management System could read the RC card that could rerecord the remains, accumulative energy and working status of meter.

c) It keeps data security automatically once power failed and recovery completely as power back.

d) Meter could work on the base of that only any one of three phases has the electricity

e) Low power consumption, mini volume; tamper proof function and no confined condition for installation

f) It adopts the load switch with high overload capability and magnetic retainable relay switched by high reliability impulse (Hoffman *et al,* 2014).

2.2.2 Key Prepayment Meters

Key prepayment systems, where the customers charge their key at a payment outlet, were introduced in the early 1990s and are used by 1.5 million customers in the UK. The interest in prepayment metering technologies has grown throughout the world as electricity supply authorities search for more cost effective solution to customer service demands while ensuring consistent revenue streams. In an attempt to address how complex tariffs, customer service and cost effectiveness new system were put in place (Hoffman *et al,* 2014).

This invention concerns a prepayment metering system using a key on which information may be stored and from which information may be erased. This comprises a terminal having means for receiving the key, means for reading a first number recorded on the key, encryption means utilizing the first number to obtain a second number, and recording means for recording the second number on the key in place of the first number, and further comprising a meter having means for receiving the key, means for reading the said second number from the key, a store in which is stored the first number, read from the key during its previous insertion, means for carrying out a comparison step involving a complementary decryption process or the same encryption process and utilizing the second number from the key and the first number stored in the meter, and means for registering a credit if the comparison is successful, the meter then replacing the first number in its store by the second number read from the key in preparation for the next key insertion (Hoffman *et al.,* 2014).

In one embodiment the first number read from the key at the terminal station is itself encrypted using a key stored in the terminal station to provide the second number to be recorded on the key in place of the first number. At the meter, the

second number read from the key is subjected to a decryption process utilizing a key stored in the meter, which corresponds to the stored in the terminal station, and is then compared with the said first number stored in the meter (Hoffman *et al.,* 2014).

2.3 Some Benefit of Prepayment Meter

Prepayment for electricity is a way of life in many countries and for good reason.

For customers, Smart Grid prepayment means:

- No deposits.
- No monthly bills.
- Smaller payment amounts over time. Experience shows that customers frequently make weekly payments of $10 or $20.
- Easy consumption monitoring.
- Greater awareness and control of costs.
- No late payment or reconnection charges.
- Voluntary participation.
- No extra cost (because there's little or no special equipment).
- Dignity. Anecdotes indicate that this is one of the most important benefits of prepayment.

Families struggling with bills can keep their relationship with utility companies entirely private. There are no utility crews pounding on doors and yelling about meter shut-offs in full sound and view of the neighbors. Disconnection is entirely under the customer's control (Chartwell, 2008).

For the utility, Smart Grid prepayment means:

- Improved cash flow.
- Reduced credit & collections costs. There are no confrontations on the phone, no turning
- Over accounts to collection agencies. And prepayment easily accommodates gradual payments of past-due bills without manual monitoring.
- Lowered write-off expense.
- Promotion of energy conservation.
- Reduced high-bill complaints.
- Increased customer satisfaction.
- No costs for extra equipment or infrastructure.
- Use of existing payment methods.
- No paper bills.
- Reduced disconnects/reconnects by field crews, with associated improvements in employee safety and productivity.

2.4 Prepayment Metering Implementation in Ghana

Over the years, the VRA-NED and ECG have used the conventional credit metering and billing system in their revenue collection efforts. Measures such as termination of service of defaulters, use of bonded cashiers, private debt collection companies, threat of prosecution and raffles did not result in a significant reduction in the debtors' position of the utility service providers. Rather, the debtors' position of these companies worsened. Prepayment metering was seen as a better option for improving the cash flow position and reducing the level of debts owed to these companies by customers. Between 1994 and 1995 ECG ran the prepayment

programme on a pilot basis in Accra, Tema and Kumasi for residential and non-residential customers with small loads. Areas where the meters were installed were Adenta SSNIT flats and surrounding areas, Sakumono Estates, some communities in Tema, Asuoyeboah SSNIT flats, Kwadaso, Patase and Danyame areas of Kumasi (Chartwell, 2008). Based on the implementation in Ghana, there were some improvements these being;

- Improving revenue collection
- Creating awareness on the need for customers to conserve energy and reduce wastage
- Reducing costs associated with meter reading, billing errors, bill production and delivery of bill

2.5 Methods of Billing in Prepayment System

The billing processes are based on the following:

- Electromechanical Technology
- Communication Technology
- Automatic Reading

2.5.1 Electromechanical Technology

The electromechanical induction meter operates by counting the revolutions of an aluminum disc which is made to rotate at a speed proportional to the power. The number of revolutions is thus proportional to the energy usage. It consumes a small amount of power, typically around 2 W. The metallic disc is acted upon by two coils. One coil is connected in such a way that it produces a magnetic flux in proportion to the voltage and the other produces a magnetic flux in proportion to the

current (Hoffman *et al.,* 2014). The field of the voltage coil is delayed by 90 degrees using a lag coil. This produces eddy current in the disc and the effect is such that a force is exerted on the disc in proportion to the product of the instantaneous current and voltage. A permanent magnet exerts an opposing force proportional to the speed of rotation of the disc. The equilibrium between these two opposing forces results in the disc rotating at a speed proportional to the power being used. The disc drives a register mechanism which integrates the speed of the disc over time by counting revolutions, much like the odometer in a car, in order to render a measurement of the total energy used over a period of time (Hoffman *et al.,* 2014).

2.5.2 Communication Technology

Remote meter reading is a practical example of telemetry. It saves the cost of a human meter reader and the resulting mistakes, but it also allows more measurements, and remote provisioning. Many smart meters now include a switch to interrupt or restore service. Historically, rotating meters could report their power information remotely, using a pair of contact closures attached to a KYZ line. In a KYZ interface, the Y and Z wires are switch contacts, shorted to K for half of a rotor's circumference. To measure the rotor direction, the Z signal is offset by 90 degrees from the Y. When the rotor rotates in the opposite direction, showing export of power, the sequence reverses. The time between pulses measures the demand. The number of pulses is total power usage (Hoffman *et. al,* 2014).

2.5.3 Automatic Reading

Automatic Meter Reading (AMR) and Remote Meter Reading (RMR) describe various systems that allow meters to be checked without the need to send a

meter reader out. This can be effectively achieved using off-site metering, that is an electronic meter is placed at the junction point where all the connections originate, inaccessible to the end-user, and it relays the readings via the AMR technology to the utility (Hoffman *et al.,* 2014).

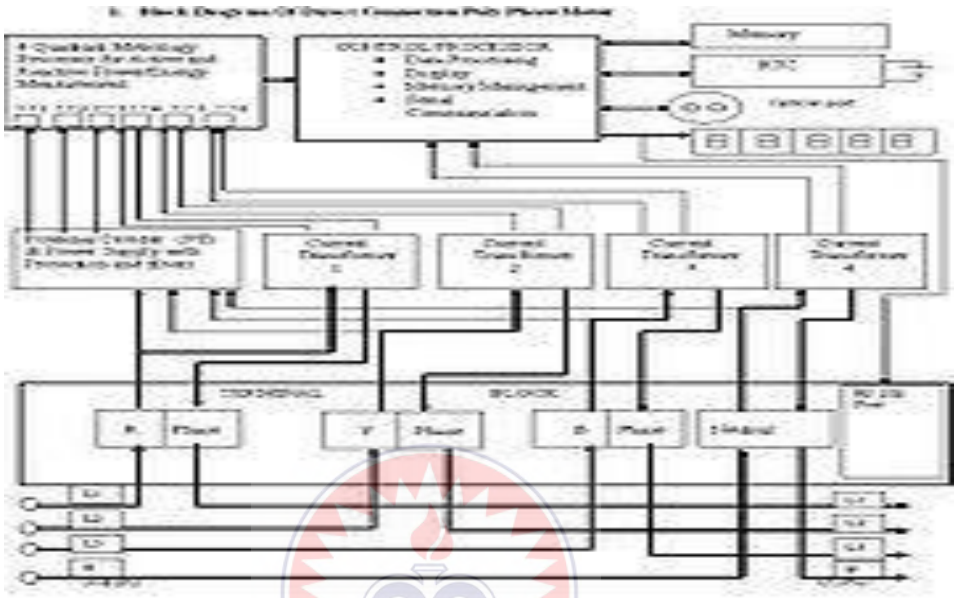

Figure 2.4: The basic block diagram of an electronic energy

As shown in the block diagram (figure 2.4), the meter has a power supply, a metering engine, a processing and communication engine (i.e. a microcontroller), and other add-on modules such as RTC, LCD display, communication ports/modules and so on. The metering engine is given the voltage and current inputs and has a voltage reference, samplers and quantizes followed by an ADC section to yield the digitized equivalents of all the inputs (Hoffman *et al.,* 2014). These inputs are then processed using a Digital Signal Processor to calculate the various metering parameters such as powers, energies and so on. The largest source of long-term errors in the meter is drift in the pre-amp, followed by the precision of the voltage reference. Both of these vary with temperature as well, and vary wildly because most meters are outdoors. Characterizing and compensating for these is a major part of meter design. The processing and communication section has the responsibility of

calculating the various derived quantities from the digital values generated by the metering engine. This also has the responsibility of communication using various protocols and interface with other add on modules connected as slaves to it (Hoffman *et al.,* 2014).

RTC and other add-on modules are attached as slaves to the processing and communication section for various input/output functions. On a modern meter most if not all of this will be implemented inside the microprocessor, such as the Real Time Clock (RTC), LCD controller, temperature sensor, memory and analog to digital converters. When energy suppliers increase or cut their prices, customers with Smart card or Key prepayment meters automatically have their prices changed. For households using Token prepayment meters, price changes are manually effected at the vending points (Hoffman *et al.,* 2014).

2.6 Effects of Prepayment Metering on Customer Energy Usage

According to James and Marcel (2014), Prepayment has gained increased attention in the last several years. The primary reason is that customers switching from credit billing to prepayment almost always reduce their electricity consumption.

- Salt River Project reports a 12.8 percent reduction in energy use when customers switch from credit to prepay.
- Northern Ireland Electricity says that prepay customers use 4.9 percent less electricity than the average customer.
- Oklahoma Electric Cooperative reports that customers lowered consumption 13 percent after switching to prepayment.

Granted, customers electing prepayment are likely to be those most motivated to reduce utility bills. However, in the vast majority of cases, these customers were equally motivated under a Credit billing system.

1) Exactly how much power they were using in near real time, and

2) How closely their consumption matched their planned budget.

In recent months, Measurement Canada has received requests for information from electricity meter approval applicants and contractors regarding the Agency's policies and requirements for prepayment meters. As a result of initiatives being introduced and promoted in certain provincial deregulated electricity markets, there is a growing interest in the use of prepayment applications as a method for managing and conserving energy to meet the rising demand for electricity. In the electricity industry, the use of prepayment applications combined with time-of-use multi-rate billing functions is being closely reviewed as a viable means for reducing overall demand (James and Marcel, 2014).

This evolution in the use of prepayment metering has required Measurement Canada to review the applicable requirements of the Act, Regulations, and meter approval and verification specifications. As a result of this review, Measurement Canada has determined that a policy is needed to clarify the federal requirements and the Agency's position with regard to approval, verification, installation and use of prepayment meters (James and Marcel, 2014). To meet the immediate need to service approval applications, Measurement Canada has developed draft approval-of-type specifications, contained in this document, which will be authorized for use under bulletin GEN-06. Pursuant to the policies of bulletin GEN-06, meters which successfully meet the criteria of the authorized draft specifications will receive a conditional approval. A decision to grant full approval will be performed once

formal national specifications have been adopted by Measurement Canada and all approval conditions have been met. Measurement Canada will undertake the development of formal national specification in consultation with electricity and gas industry stakeholders (James and Marcel, 2014).

Prepayment is especially popular with customers who:

- Share room with others and want to ensure that no one moves out without paying a fair share of the utility bill.
- Need to win the cooperation of children in reducing energy budgets. Children may be far more responsive to an in-home display showing little television time remaining than they are to parental admonitions to turn off unneeded lights.
- Need to ensure that they do not inadvertently exceed tightly budgeted amounts for utilities.
- Want to reduce energy use for either financial or environmental reasons.

Prepayment provides a discipline that many customers find helpful. In a July 2008, Chartwell Webinar on prepayment, Jonna Buck at Oklahoma Electric Cooperative cited the following letter to illustrate this point: "I appreciate customer service recommending prepaid using when we were in a bind. It has helped us to understand how much electricity we really use and to help us maintain a lower bill then being surprised when a monthly bill comes." It is important to note that low-income customers often have the most incentive to use the system to conserve. In general, it appears that the higher the prepayment penetration, the lower the conservation rate (James and Marcel, 2014).

2.7 Prepaid Metric System and Energy conservation

The study conducted revealed that Karen (2006), energy conservation refers to efforts made to reduce energy usage. Energy conservation can be achieved through increased efficient energy use, in conjunction with decreased energy consumption and/or reduced consumption from conventional energy sources. Because of the limited amount of non-renewable energy sources on Earth, it is important to conserve our current supply or to use renewable sources so that our natural resources will be available for future generations (Karen, 2006). Energy conservation is also important because consumption of non-renewable sources impacts the environment. Specifically, our use of fossil fuels contributes to air and water pollution. For example, carbon dioxide is produced when oil, coal, and gas combust in power stations, heating systems, and car engines. Carbon dioxide in the atmosphere acts as a transparent blanket that contributes to the global warming of the earth, or "greenhouse effect." It is possible that this warming trend could significantly alter our weather. Possible impacts include a threat to human health, environmental impacts such as rising sea levels that can damage coastal areas, and major changes in vegetation growth patterns that could cause some plant and animal species to become extinct (Karen, 2006).

Sulfur dioxide is also emitted into the air when coal is burned. The sulfur dioxide reacts with water and oxygen in the clouds to form precipitation known as "acid rain." Acid rain can kill fish and trees and damage limestone buildings and statues. You can help solve these global problems. In the U.S.A., the average family's energy use generates over 11,200 pounds of air pollutants each year. Therefore, every unit (or kilowatt) of electricity conserved reduces the environmental impact of energy use (Karen, 2006).

2.8 Types of Electric Meters

2.8.1 Numeric Display Meters

The numeric display meters display the reading in a numeric form. The first five numbers should be read in these meters starting from left to right.

2.8.2 Electromechanical Induction Meter or Standard Meter

The most commonly used electric meter is electromechanical induction meter or standard meter that operates by counting the revolutions of an aluminum disc. It measures the electricity in kilowatthours. In this case, the units are charged at the same rate throughout the day. The electric energy being used is directly proportional to the number of revolutions of the disc. These types of meters are generally used on single phase alternating current (AC) supply.

2.8.3 Variable Rate Electric Meters

The variable rate electric meters give two different types of readings depending on the day and night time. They are also known as economy 7 meters, often used by suppliers and industrialists. Usually, their rate is cheaper at night.

2.8.4 Prepayment Electric Meters

The prepayment electric meters accept tokens or prepaid cards to get electricity supply. The customer has to pay the charges for the power supply in advance. One can also top-up the amount for extending the period of electric supply or when the balance over the supply is automatically cut off by a relay in the electric meter. This is common in rented accommodations (Khan *et al.,* 2010).

2.8.5 Solid State Electric Meters

The solid state electric meters can be read automatically and their power displayed on an LCD screen. They calculate and show the exact value of the electricity consumed rather than its amount. The rate of the unit consumed varies according to the time and day of the week. They can also record, supply and load parameters such as power factor, reactive power, maximum demand, etc. Such types of meters use the remote meter reading technology (Khan *et al.,* 2010).

2.8.6 Electronic Meters

The latest electronic meters are based on automatic meter reading or remote meter reading technologies. They use GSM, GPRS, Bluetooth, etc. to transfer the information related to power consumption. They store the usage profiles and the load requirements of a consumer and process it accordingly. Electric meters also help in detecting energy theft or any attempts at meter tampering with the help of their inbuilt automatic sensors (Khan *et al.,* 2010).

2.8.7 Smart Meters

Smart meters are the latest in energy meter technology: instead of simply providing a total of energy consumption in your home like many conventional meters, smart meters can provide you with detailed information on how and when you used your energy. They also communicate with the electricity company, sending and receiving information so that no one need come out to read your bill and the energy supplier does not need to estimate your bill. There are many ways to get a smart meter reading. These include using a monitor, online monitoring and looking at your bills (UK Power Limited, 2012).

2.9 The Technology and Economics of Prepaid Electricity

Prepayment systems refer to the outlay made by a consumer for using a good or service before consumption. In the case of electricity, the distinctive feature of the prepayment system is the reversion of the conventional commercialization system: whereas in the latter consumers hold a consumption credit because they pay for their energy bills periodically and after consumption, in the prepayment system such credit is not available because the purchase and payment of energy are made prior to consumption. Thus, prepaid systems allow users to consume energy only when they have credit in electricity account, as supply is discontinued when such credit is exhausted (Kwan *et al.,* 2002). A Prepaid Energy Meter enables power utilities to collect electricity bills from the consumers prior to its consumption. The prepaid meter is not only limited to Automated Meter Reading [AMR] but is also attributed with prepaid recharging ability and information exchange with the utilities pertaining to customer‘s consumption details (Southgate *et al.,* 2006).

The prepayment technology was initially developed in South Africa in the late 1980s with the objective of supplying energy to a large number of low-income and geographically dispersed users. The system was initially geared to minimizing the difficulties arising from users’ irregular incomes and to overcoming the limited development of the infrastructure required for the dispatch and reception of credit slips. By the late 1990s, prepayment systems were very popular in India and in some OECD countries (Estache *et al.,* 2000), and had probably reached their highest development in Great Britain (Waddams *et al.,* 2007). In Argentina, prepayment meters were firstly introduced in 1993, when Energía Mendoza Sociedad del Estado (EMSE) put a few running in small shops at the Mendoza Bus Central Station. The experience was soon extended to other communities in the country.

From a technological point of view, the prepayment system consists of three well differentiated components. The first is a service meter installed at the unit where energy will be consumed, such as a household dwelling or a store. In general, these meters are of the —two-gang type and consist of a user‘s interface unit and a current measuring set. The interface unit is a device installed inside the building, which allows the user to interact with the meter. The metering unit, on the other hand, is the intelligent component that stores credit and consumption information and it makes up the element that either clears or switches off electricity supply. The second component of the system is the so-called credit dispensing unit, which is the vending machine where consumers can purchase electricity credit. In general, these sales outlets are located at the utility‘s commercial offices as well as in stores with long opening hours. The third component is the supporting device that links the various sales outlets to the utility‘s management system.

The way the system works for the user is simple. The user purchases energy at the sales outlet and, as part of the operation, receives a credit slip and a supporting device that identifies the operation, which may be a voucher with an identification code or another with a magnetic support. The user then utilizes the device to add on her new consumption credit, either by entering a code or inserting the magnetic medium into the interface unit, which in both cases will be possible only if the device identification matches that of the meter. The measuring unit then clears consumption of the amount of energy purchased and also displays, in real time, the available credit remaining for consumption. The meter switches off when credit is exhausted, and it switches on again only when the device corresponding to a new purchase is inserted.

From an economic perspective, the reversion of the commercialization system as implied by prepaid meters translates into changes in the cash flow of the utility and

in consumers´ behaviour. In the case of the firm, prepayment systems may result in a decrease in metering, billing and disconnection and reconnection costs. The fact that payment is made prior to consumption implies both a significant improvement in the collection of revenues and a reduction of working capital. Moreover, prepaid systems may constitute a way to provide more flexible payment options to users with minimal or unreliable income streams without increasing transactional costs to the firm. From the consumer‘s perspective, prepayment systems may result in a better understanding of how much energy is being consumed, inducing more control of energy use and budget management (Tewari and Shah, 2003). However, these apparent improvements are not cost free: not only the change from conventional to prepaid electricity imply a change in consumption habits, which may reduce the utility of consumers, but also it may result in too few electricity consumption or in the self-disconnection of poorer groups of consumers.

2.10 The Adoption of Prepaid Meters

Electricity is a vital element required for economic growth, poverty reduction and social development. For a stable and economically viable electricity distribution system and an effective and trust worthy revenue collection system a country wide pre-paid metering system is evident. An adaptation of pre-paid metering system can change the needs and the requirements of better solution for the utility companies that make the whole distribution system more dynamic and digitally enhanced. The Power Division has taken the initiative through all distribution utilities to implement a pre-payment metering system with a view to reduce non-technical losses, increase the revenue collection, improve customer's service and reduce the accounts receivable.

Governments across the globe have there for given priority to prepayment metering system, considering all the benefits (Power Division, 2011).

The concept of prepayment is not new. It was invented in United Kingdom before the Second World War, but major changes had taken place in the 1980‘s when electronic transfer of credit was introduced (Enbaya, 2003). The prepayment system in electricity was however adopted for the first time in Argentina in 1996, when CELCA4, the power distribution company of Carmen de Areco, a small municipality of the Buenos Aires Province, made optional to all consumers within its franchise area the use of prepaid meters. CELCA was created in 1945 and is one of the almost 200 municipal electricity distribution utilities operating in the Province of Buenos Aires. These utilities, most of which were organized as cooperatives, were traditionally allowed to set their own tariffs until 1996, when privatization of the then vertically integrated electricity operator of the provincial state called ESEBA resulted in the creation of independent power producers, three new regional electricity distribution utilities , in whose exclusive franchise areas municipal utilities operate and a new provincial regulatory authority, named as Organismo de Control de Energía Eléctrica de la Provincia de Buenos Aires (OCEBA). Following privatization, local electricity distributors purchase energy from one of the three regional utilities at OCEBA‘s regulated tariffs. This agency also regulated the final tariffs local distributors charge to final consumers.

2.11 Electricity Consumers’ Perception about Prepaid Meters

Several Countries including Ghana have changed from its normal post-paid electricity system to a new and advanced one, the prepaid electricity meter, which is popularly known as prepaid (Rexrichie, 2011). The question we should ask our self

now is ―are we ready to rank our energy resources specifically electricity, this high? According to Mr. Fred Enninson of the ECG, in charge of the pre-paid meter faults, the introduction of the prepaid meter, though having problems in the initial stages, people will soon get abreast with how it operates. The ECG's main concentration is the easiness that the prepaid meters has brought to their workers and not to the normal Ghanaian. Moreover he said ―customers of ECG are now free from monthly billing‖ He used the phrases free very nicely to my understanding but this might not be well understood by a well-resourced economist who knows the difference between his opportunity cost for prepaid meters and a mere free word as he used it.

Prepayment has gained increased attention in the last several years. The primary reason is that customers switching from credit billing to prepayment almost always reduce their electricity consumption.

- Salt River Project reports a 12.8 percent reduction in energy use when customers switch from credit to prepay.
- Northern Ireland Electricity says that prepay customers use 4.9 percent less electricity than the average customer.
- Oklahoma Electric Cooperative reports that customers lowered consumption 13 percent after switching to prepayment.

Granted, customers electing prepayment are likely to be those most motivated to reduce utility bills. However, in the vast majority of cases, these customers were equally motivated under a credit billing system. What was missing was the immediate feedback of knowing 1) exactly how much power or gas they were using in near real time, and 2) how closely their consumption matched their planned budget. Despite all the advantages to both customers and utilities, and despite many requests for prepayment programs from some consumers and their advocates, prepayment is not a

widespread global phenomenon. Three major issues have slowed adoption (Oracle, 2009):

High Cost

Today's utility typically views prepayment as a second, parallel metering and billing system largely separate from the system used for credit customers. For instance, in U.S. cost estimates of $225 to $450 per prepayment participant are common, far more than the anticipated investment return to the utility from early payments plus reduction in bad debt. The equation is different, of course, in jurisdictions that use prepayment for most or all customers. In South Africa, for instance, Eskom has typically implemented prepayment using rechargeable cards and top-up kiosks as it has expanded its grid to each new town and village. Such an approach may also be practical in regions now moving to metering after a long period in which gas and electricity were viewed as essential public services and therefore unmetered. Utilities with long histories of credit billing, however, have frequently balked at the prospect of spreading the costs of implementing a new and expensive metering and billing system across all customers when only a few will benefit. Some regulators have expressed similar concerns.

Fairness

In some jurisdictions, regulators and consumer advocates have expressed concerns that utilities might force prepayment onto customers in low-income areas, thus stigmatizing customers whose positive history of bill payment may equal or frequently exceed those of their wealthier neighbours. This concern has faded as prepayment has become the payment method of choice for mobile phone and similar

services (Oracle, 2009). A different fairness issue has arisen recently in the U.K. There are reports that retailers in this fully competitive market will agree to serve prepayment customers only at excessively high rates.

Health and Safety

Health and safety concerns may restrict prepayment (Oracle, 2009):

- When electrical service terminates in a prepayment system, appliances may still be on. If the person reinstating service fails to check appliances like stoves, a fire could result.
- Buildings with pilot lights need to maintain some gas flow even when prepayment deposits run out, lest reinstatement of service cause an explosion.
- For different reasons, water prepayment systems may choose to permit a minimal flow at all times, lest lack of water lead to a neighborhood public health crisis.
- Most jurisdictions have rules against utility disconnection of gas and electricity during the heating and air conditioning seasons. Customers could easily fall behind in payments during these periods, and catch-up payments may be difficult to administer in parallel with overall prepayment methodology.

According to Oracle (2009), these arguments have slowed the growth of prepaid metering. Today, however, the need for conservation plus new, less costly prepayment technologies are sparking a surge of interest.

2.12 Effects of Prepay Meter System

A big chunk of electricity that power companies generate is lost or remains unaccounted for. This is partly due to the technical losses at the power plants and in the transmission and distribution lines. There is another high percentage loss due to

non-technical reasons at customer level such as tampering with the meter, illegal connection and so on. Various attempts have been made to address these vexing problems of non-technical losses such as contracting out meter reading and billing, computerized billing and cut-offs and legal penalties. But nothing has been 100% successful so far. However, amongst all the efforts and endeavours, the one approach that proved to be consumer friendly and cost effective was the prepaid metering system (Power Division, 2011). Pre-payment metering system can reduce accounts receivable and non-technical losses up to zero per cent. The idea of using prepaid meters therefore is to stem the financial drain on power companies such as ECG (Power Division, 2011).

According to Ariel and Luciana (2008), consumers switching from the conventional to the prepayment system face two types of cost. One refers to the direct monetary cost, while the other refers to differences in habits that result from replacing a post-consumption and single monthly payment with more frequent payments, which occur prior to consumption. The main direct monetary effect is the cost of the new meter and its associated opportunity cost, which we proxy using the interest rate for savings accounts deposits, which was estimated relating consumers‘ average expenditure to a rate capturing the opportunity cost of money.

According to Eskom (2010), the prepaid meter (PPM) system has several important components. First, there is the prepaid meter or electricity dispenser- (ED) which is installed in the household. The ED is activated by the input of a token‘, which indicates how much energy the customer has purchased. The token comes in a variety of physical forms, but essentially it represents a string of numbers that are entered into the ED to authenticate the transaction. In the early stages of the industry, the tokens were disposable cards with magnetic strips, but in the late 1990s keypads

became more popular as input mechanisms. The token used for keypad activation is just a string of numbers, communicated to the consumer orally, in written form, or even via an SMS or e-mail.

Periodical purchases of electricity imply a change in consumer habits, because they have to incur the extra costs associated to the time spent on additional buys. The extent of this cost would vary with the periodicity of energy reloads (it would be neutral if reloads occurred once a month, as this would demand an effort similar to that incurred when paying the conventional monthly bill) and it would be directly dependent on the user‘s salary; it is possible to presume that the higher an individual‘s salary, the higher the opportunity cost of her time. We therefore estimate this cost by firstly computing an average hourly cost that we approximate using census income data for the district, and then multiplying that cost by both the estimated duration of each reload and the average number of yearly purchases made by each household using the prepayment system.

Thus, in principle, prepaid metering offers utility providers the possibility of decreasing the administrative and financing costs of electricity delivery, which in turn will bring down the cost of electricity delivery, or yield higher returns to the utility, or both. Utility providers have long been aware of the potential advantages of prepaid electricity delivery over credit metering, but it was not until the mid-1990s that (partly as a result of the technology development led by Eskom) the prepaid meter (PPM) technology evolved to a level that would allow its widespread implementation (Ariel and Luciana, 2008).

The Power Division of the Ministry of Power, Energy and Mineral Resources, Republic of Bangladesh, has summarized the benefits of prepaid meter as follows;

Customers like the system because (Power Division, 2011):

- It is transparent
- Easy to add credit to the meter through smart card
- They can control their own consumption
- They can control their budget
- No hassles with bill payment, disconnection or reconnection
- There is no minimum charge
- Require no deposit
- No more disputed bills
- Warning for low credit
- Abnormal voltage protection
- Automated record keeping

The power company also benefits in the following way (Power Division, 2011):

- Upfront payment,
- Improved cash flow,
- Decreased non-technical losses,
- Lower overheads expenses (no meter reading or billing),
- Increased revenue,
- No outstanding debt
- Tamper protection
- Non-allowance of over sanctioned load
- Better load management.
- Better customer services
- Automated record keeping
- Create power saving attitude to the consumers

Using software to run prepayment rather than hardware has a number of advantages (Oracle, 2011):

- Elimination of hardware costs—not just procurement but also installation, maintenance, and replacement.
- Extension of the program to all interested parties. There are no special meters. Any advanced meter will do, so long as it includes either remote connect / disconnect or flow restriction capabilities.
- The utility can use a single billing system for all customers, provided it has appropriate capabilities.
- Customers can use a utility‘s existing infrastructure for payments. Granted, some utilities may choose to offer tokens or smart cards, plus the ability to top them up.

Others may choose to offer in-house displays but neither is required.

2.13 How do Prepayment Meters work?

In general, it is considered that the electricity prepayment meter measures energy in the same manner as a conventional meter. The main difference with a prepayment meter lies in the intended manner in which the meter is to be operated and used for the sale of electricity. In the case of a conventional electricity meter, once a customer's load is energized, energy consumption is measured integrally on a continuous basis and a measurement reading is taken or established by the contractor on a periodic basis for the purpose of establishing a charge for electricity. Payment for electricity is made by the purchaser following the declaration or estimation of consumption of electricity for a certain period of time.

In the case of a prepayment electricity meter, the meter also measures electricity consumption integrally but the measurement is actually started and stopped in conjunction with the activation and deactivation of the load circuit by the prepayment control system. To activate the load circuit, the consumer must prepay for electricity usage or purchase a quantity of electricity (note: a contractor's fixed charges may be included in this purchase). The payment information may be loaded on the meter through a specific peripheral control device (e.g., magnetic card reader or telemetering system). Once activated, the load circuit will run and remain activated until the monetary or equivalent energy information loaded into the prepayment control system has run out, subject to any other conditions established by the contractor.

To charge the meter, consumer needs to buy electricity in advance according to his/her requirement. The consumer can buy electricity through various vending options. The vend results in a token with a code printed on it. The consumer punches the code into the meter either directly or through an in-home display using a key pad. The meter is credited with the amount of credit bought and supply is switched on automatically at load side. As the consumer‘s balance reaches the emergency limit provided by the utility, meter sends an alarm. The consumer needs to recharge the meter at this point. If recharged in time then the load is not disconnected. However, if even after warning, a consumer does not recharge their meter and all available balance is exhausted (as per the prevailing tariff defined in the meter) and there are no ―Friendly Credit Days / Friendly Credit Hours‖ then meter automatically disconnects the supply at load side.

The system provides real time consumption information in terms of money and connected load which attracts the consumer‘s attention and leads to their

involvement with the system. This also helps consumer in identifying their connected load at any given point of time and their consumption in terms of rupees. The system provides many features; few of them are listed below:

- Any time anywhere recharge facility: This becomes possible as the system works on keypad based technology, hence the token can be got by vend through phone, SMS or web at any time and at any place.
- Friendly days / hours: For the ease of the consumer as well as of the utility, the system is designed in such a manner that it will not disconnect the supply or will not give any alarms on predefined day or hours. These days or hours are called friendly days or hours.
- Emergency credit limit: To make the consumer aware that their credit will be exhausted within a specified time interval, the system has a provision of emergency credit limit. This is an optional feature, which depends upon the utility, they may choose to configure it or not.
- Alarms visual / buzzer: To attract the consumer‘s attention the meter gives an alarm to consumer regarding the actions it will be taking. This is a buzzing alarm as well as a visual display on meter/CIU. This enables consumer to take necessary action.
- Supports a variety of tariffs: The Indian tariff structure is complex and there are a variety of tariffs like slab rate, TOD / TOU, fixed charge, monthly minimum charge, etc. All tariffs are supported by the system.
- The meter has Load control mechanism to implement Load Management Program. They have provision to define the allowable loads for given time periods within a day, provision in the meter to accommodate the date of activation of the defined load allocation and Load limit. All tariff calculations are done within the meter

not in the vending stations. The meter is required to support stepped tariffs structures as well as time-of-use and maximum demand. The meters have remote communication option which is able to interface data communication with the central server from meters. So it is possible to control the meter from remote if necessary.

- The system provides standardized data exchange mechanism. The data exchange media is the smartcard or key code tokens. This carries both tariff and recharges amount data from utility to meter and carry usage data from meter to utility. A standardized data format for the smartcard has been proposed. Since many manufactures use different encoding and security within their meter. The meter manufacturer must provide Encrypted Data Generation SDKSDK/API to create this encoded data from raw data to the utility, generate encrypted that is suitable for the meter to process and understand.
- Software of the Pre-Paid Metering System has mainly two parts, the Master Information Center (MIC) and the Data Network Service Provider (Mobile Network Companies). There is one Master Information Center (MIC) per utility company. The Master Information Center (MIC) comprises of the Database Servers (RDBMS), Routers and the Firewalls, Application Server, Short Message Server (PUSH-PULL SMS), Accounting and Billing Server. The consumer of the electric utility will enjoy credit recharging facilities using Point of Sales (POS) services, where the utility consumers have to recharge their credits. Utility Vending Stations performs the same function as POS but this will be managed by the utility itself round the clock.

Contactor

A local contactor is the connecting link between the consumer load and utility supply. The opening and closing of this contactor depends on the balance present in the prepaid card at a moment. While the prepaid card has some fixed amount more than zero, it stays closed and keeps the utility supply uninterrupted to the consumer load. When the card runs out of balance, it opens and disconnects the load from the supply. Hence, even when the energy meter receives voltage supply, it does not reach the load while the contactor is open because the balance in the prepaid card is not available. Since the contactor too will consume some amount of electrical energy, it will be inclusive in the calculations made by meter and prepaid card.

2.14 Development of Prepaid Metering Systems

Despite being associated in most people‘s minds with the late 1980s and 1990s, prepaid technology in South Africa dates back to 1913, when the mining settlement of Jaggersfontein (situated in what is now the Free State) minted 10 000 special tokens, each of which released three gallons of water from the town pump (Balson, 2007). However, notwithstanding examples such as the Jaggersfontein water penny‘, the majority of electricity supplied to domestic consumers up to the 1980s was supplied using credit meters‘, in other words, meters which record consumption, with their records being collected by meter readers and bills then being issued based on metered (or in some cases, estimated) consumption. The process of reading such meters, distributing bills, dealing with arrears and so forth proved costly in economic, and maybe even more importantly, political terms, however. Since credit meters simply record consumption, the process of disconnecting a household from electricity supply involves an obvious intervention on the part of the electricity utility, and since

all domestic electricity utilities in South Africa have been state-owned, the process of electricity disconnection is an easy one to politicize.

As was noted above, electrification of black areas such as Soweto was accompanied by politicized payment boycotts, and in this context engineers working in the field of electricity supply were given an incentive to design revenue collection systems which could alleviate the need to physically manage electricity connections (and disconnections). In 1985, Don Taylor, an engineer who at the time was working for the South African Astronomical Observatory in Cape Town, was approached by the QwaQwa Development Corporation to solve the revenue collection problems they were experiencing in the electrification of the QwaQwa homeland‘ (in the eastern Free State). The development of low-cost integrated circuits from the 1970s onwards, and the resulting ability of implemented complex encryption algorithms in a compact device, allowed for the development of a fully electronic prepaid meter system, based on the sale of numeric tokens (in early devices supplied on paper cards, and in later devices printed on a payment slip) from a central point. These tokens then had to be entered into the prepaid meter for electricity to be supplied.

In their earliest form, prepayment meters consisted of coin operated mechanical meters. From the late 1980's forward, electronic meter technology combined with card encoding and various telemetering communication techniques have been used in prepayment meter design (Measurement Canada, 2006). In recent years, there has been a growing interest among government departments and industry stakeholders to identify new methods for managing and conserving energy to meet rising demand at the residential and commercial/industrial trade levels. In the electricity industry, the use of prepayment applications combined with time-of-use is

being closely reviewed as a viable means for reducing overall demand in the electricity marketplace.

Eskom was drawn into the development process of the prepaid meter by Taylor and his colleagues at an early stage, being consulted in 1986 during product development to comment on technical issues. This involvement alerted Eskom employees to the possibilities of electronic prepayment technology, and they later expressed an interest in using prepaid technology for their Electricity for All campaign. Although Electricity for All‘ was only launched in 1988, McRae speaks of the ideas for the project emerging from 1985 onwards; thus the discussions in 1986 fed into the early planning for the campaign, which, at the time, aimed to connect 5 million households to the electricity grid, on a purely business – i.e. cost recovery – basis (McRae, 2008).

With a product in hand, Taylor‘s colleague Rudi Coetzee went on a marketing campaign, -which led to small installations at Thabong Municipality (in the Free State), Witrivier Municipality (now in Mpumalanga, this installation was facilitated by the coloured House of Representatives, one of three racially defined houses in the apartheid Parliament) and elsewhere during 1987. Another early prepaid entrepreneur, Larry Barnett, gave a presentation in Parliament on prepayment technology, with the result that elements in the apartheid government moved to standardize the technology as a means towards quality control. Taylor mentions that there were fears that poor-quality prepaid technology products could exacerbate anti-government feeling in the townships. The South African Bureau of Standards, the Council for Scientific and Industrial Research and Eskom were all drawn into this standardization programme, which would take several years.

Eskom's involvement in the prepaid field shifted to an entirely new level, however, in 1989, when the decision was made to use prepayment technology for its national electrification programme. Taylor and Coetzee's venture, Angcon Technologies, received a contract to provide 6000 prepayment meters for installation in Kwamobuhle (near Uitenhage, now in the Eastern Cape). This was, however, only a small part of Eskom's overall Electricity for All programme, which grew to a maximum of more than 250 0000 installations in 1993 (Gaunt 2003:28).

At the same time that Angcon Technologies and others were providing prepaid meter systems to Eskom, multinational telecommunications firm Plessey-Tellumat started a programme of aggressively marketing prepayment technology to municipalities. By this time apartheid was crumbling, and white business was clearly focused on a post-apartheid future. In line with this planning, Nedbank and Old Mutual collaborated on a study in 1990 entitled South Africa: Prospects for a Successful Transition (Gaunt, 2003) which, amongst other things, promoted mass electrification as a mechanism for social and economic development. Engineers within local government also got involved in the debate, with Gaunt presenting s paper to the AMEU in 1991 promoting national electrification and tariff rationalization (Gaunt, 2003). The result of this policy work (which was also significantly supported by the University of Cape Town's Energy for Development Resource Centre) was an increasing number of new electricity users connected via municipal utilities, growing from 51 000 new connections in 1991 to 164 000 new connections in 1993. Already in 1989 Gaunt had proposed – in the journal of the South African Institute of Electrical Engineers – that _conventional systems' would not allow for large-scale electrification of domestic consumers, and so when electricity was rolled out, so were prepayment systems (Gaunt, 2003).

There is some disagreement in Cape Town as to when prepayment technology was actually adopted in the city. Neil Ballantyne, Manager for Revenue Protection for the Electricity Directorate of the City of Cape Town (CCT – the new name of the local authority that was formerly called the Cape Town City Council) in 2006, speaks of an initial rollout in Hanover Park (a historically coloured area of Cape Town characterized by council rental housing and the poverty y of its inhabitants) in 1993 (Ballantyne interview). Yet Hans Smith, who was in charge of housing projects in Cape Town in the 1980s, recalls using the technology in earlier projects (Smith, 2010). Details aside, it is clear that by the early 1990s both the notion of Electricity for All and the use of prepayment technology in the delivery of that electricity were established concepts in the city.

The concepts were further developed in a conference on the electrification of developing communities which was held by the South African Institute of Electrical Engineers in 1991, in the ANC‘s national Meeting on Electrification held in February 1992, and in the work of the National Electrification Forum (NELF), which met between 1992 and 1994. From 1990 onwards, Eskom developed the NRS009 standard, which allowed for standardization of prepayment technology and therefore the ability to make units sourced from different vendors interoperate. This was initiated from 1993 onwards (Eskom, 2007), eventually leading to the creation of the Standard Transfer Specification (STS) to which all South African prepaid meters comply. (The STS was later developed into an international specification by the International Electro-technical Commission with the result that STS-compliant prepaid meters are now in use throughout the world).

The narrative above demonstrates that, from its beginnings in a single small engineering project, prepayment technology rapidly became a tool adopted on a

national scale by policy-makers and professionals in the electricity sector. The engineers involved in this development were, however, acutely aware that the technology they were developing had to be adopted by electricity users, in particular the newly electrified townships users – black and poor – if it was going to be successful. As Taylor remarks, prepayment had [a] connotation with being ―not credit worthy (you had to pay first) and was also seen as being used by government as a way to counter the service payment boycotts.

As a result, prepayment technology was marketed not just to Eskom, municipalities and government decision-makers, but also to its intended recipients. Taylor mentions that the early prepaid meters were called Budget Energy Controllers (BECs), and were promoted as a way to put the consumer in control (of their electricity expenditure). Cosmetic approaches were also taken – BECs would not be black because black clothing and drove black cars). Neil Ballantyne notes that during the Cape Town City Council‘s prepayment pilot project in Hanover Park in 1993, township unrest was affecting the electricity department: that‘s why when we started with installation of the meters we actually branded our vehicles to support those meters completely differently. In other words, it was almost like the good guys and bad guys situation. The trucks for the disconnections, people knew what they looked like, and they were the bad guys, we were the good guys going in with cars with ―energy dispenser support written on the side, and the guys didn‘t really have trouble because they were seen as the guys helping them‘ (Ballantyne, 2013). In Lavender Hill, another coloured township in Cape Town Councilor Eulalie Stott held meetings with local residents, using electrical appliances to explain the details of electricity consumption (Smith, 2004). Don Taylor states that _we set up training and demonstrations in the community gathering halls with educational programmes

promoting the concept of prepayment and training consumers on how to use the meters; this was of cardinal or prime importance as the slightest sign of customer difficulty would jeopardize the entire installation.

2.15 Conceptual Framework

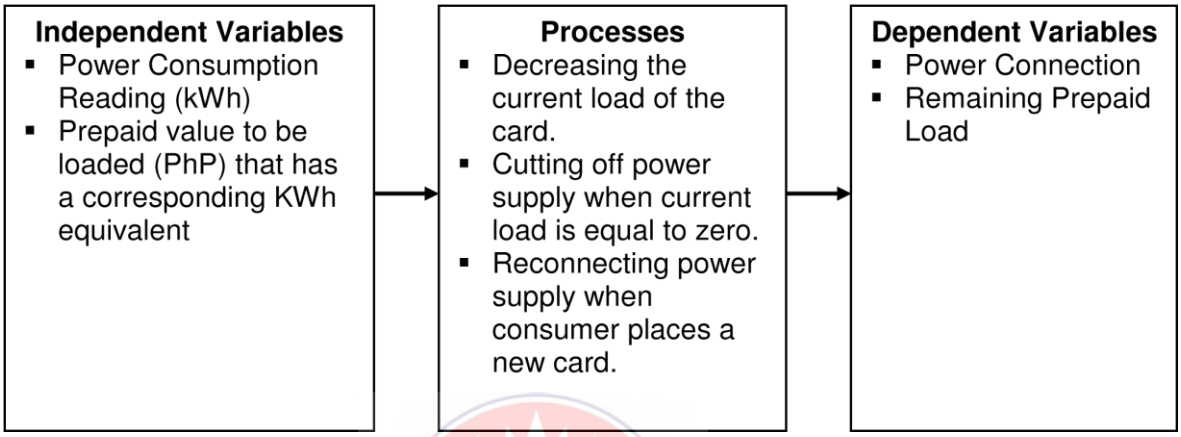

Figure 2.5: Conceptual Framework Diagram

The main inputs of this study are the readings from the power meter in Kilowatt-Hour, as well as the denomination of the prepaid value that consumers will be loading. Each denomination has a corresponding Kilowatt-Hour equivalent that will serve as the user's load. The power meter is responsible for measuring the current consumption of a certain subscriber. The prepaid value will determine how much power consumption will be allowed to the household utilizing this system. The outputs are the power connection for the subscriber and the remaining prepaid load.

When the load of a meter is nearly empty, a Light Emitting Diode would be provided to indicate to the user the system that s/he needs to reload already. If the current load needs to be viewed, a Liquid Crystal Display will show the remaining load of the power meter.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter deals with the statistical methods used for the study and includes study area, population and sampling techniques, data collection procedure, research instruments, research design and data analysis.

3.2 Research Design

This study employed quantitative and descriptive research design 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).

3.3 Population

The population for this study encompasses individuals who consume electricity in the Koforidua Municipality in the Eastern Region of Ghana. The population for the study was two thousand six hundred (2600).

3.4 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 and Morgan (1970) came up with a table for determining sample size for a given population for easy reference. According to the Krejcie and Morgan (1970), table of determining sample size, a population of two thousand six hundred (2600) requires a sample size of three hundred and thirty five (335). 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 1-400 were written on white papers including blank papers, electricity consumers who selected the first 335 papers formed part of the research. Therefore, 335 respondents were sampled through the lottery method.

3.5 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 prepayment metering systems.

3.6 Instrument for Data Collection

The instruments used for the study were structured questionnaires. According to Ofori and 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. Both the primary and secondary sources of data were used. The primary source of data was gathered through the use of questionnaires and it had highlighted issues such as the perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality, the effectiveness of the Prepayment Metering Implementation in Ghana, the benefits of switching to the prepayment metering system and the effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality. The study therefore used questionnaires because they are valuable methods of collecting a wide range of information from a large number of respondents.

3.7. 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. Furthermore, out of 335 questionnaires sent out for primary data, 268 questionnaires were retrieved and 68 questionnaires were not retrieved. Therefore, the analysis of the study was based on 80% response rate. This figure was considered adequate for the study.

3.6.1. Pilot-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 thirty (30) electricity consumers within the Koforidua Municipality in the Eastern 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. The essence of the pretesting was to ensure the reliability of the instrument.

3.7. 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 18.0) 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. The data gathered were presented using tables and charts. The purpose of the presentation is to summarize the data as well as give a pictorial analysis. The data presented was analyzed using percentages and frequencies.

CHAPTER FOUR

PRESENTATION OF RESULTS

4.1 Introduction

According to the empirical study conducted, out of 335 questionnaires sent out for primary data, 268 questionnaires were retrieved and 67 questionnaires were not retrieved. Therefore, the analysis of the study was based on 80% response rate. This figure was considered adequate for the study. This is depicted in figure 4.1 below.

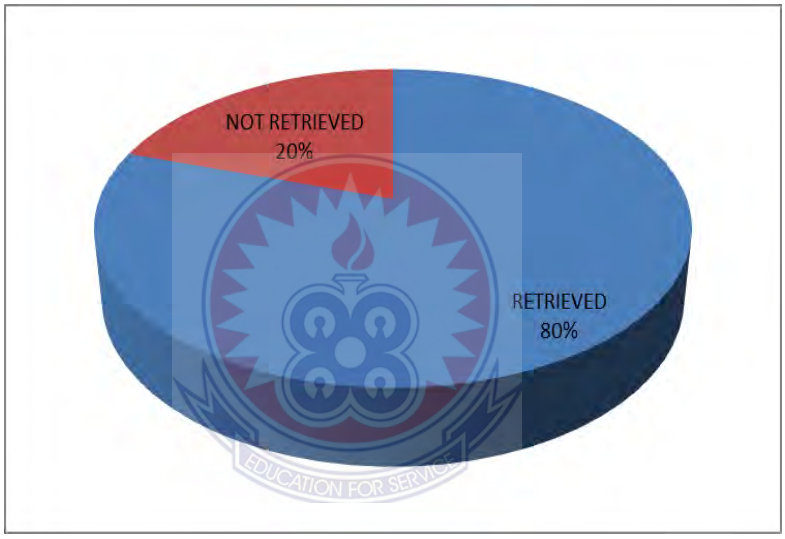

Figure 4.1: Response rate

Source: Field survey (2017)

4.2 Demographic information of the Respondents

Table 4.1: Gender of the Respondents

Gender of the Respondents	Frequency	Percent
Male	147	54.9
Female	120	45.2
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.1 indicates that 54.9% of the respondents were males whiles 45.2% of the respondents were females.

Table 4.2: Age of the Respondents

Age of the Respondents	Frequency	Percent
Below 18 years	4	1.5
19-29 years	27	10.1
30-39 years	30	11.2
40-49 years	96	35.8
50-59 years	45	16.8
60-69 years	44	16.4
above 70 years	22	8.2
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.2 shows that 35.8% of the respondents were between the ages 40-49 years, 16.8% were between the ages 50-59 years, 16.4% were between the ages 60-69 years, 11.2% of the respondents were between the ages 30-39 years, 10.1% of the respondents were between the ages 19-29 years, 8.2% of the respondents were above 70 years while 1.5% of the respondents were below 18 years.

Table 4.3: Educational qualification of the respondents

Educational qualification	Frequency	Percent
Never	84	31.3
BECE	50	18.7
SSSCE/WASSCE	41	15.3
Diploma	67	25.0
Bachelors' degree	17	6.3
Masters' degree	9	3.4
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.3 depicts that 31.3% of the respondents had no formal education, 25% of the respondents had Diploma as their highest qualification, 18.7% of the respondents were possessing BECE, 15.3% of the respondents had SSSCE/WASSCE as their highest qualification, 6.3% had Bachelor's degrees, 3.4% of the respondents had Master's degrees as their highest qualification.

4.3 The Perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality.

Table 4.4: the kind of metering system Respondents used

What kind of metering do you use at home?	Frequency	Percent
Old type metering	140	52.2
Prepaid metering	128	47.8
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.4 and figure 4.2 below show that 52.2% of the respondents affirmed that they used the old type metering while 47.8% of the respondents used the prepayment metering system. The study results holds that majority of the respondents still used the old type of metering. This means that the implementation and the migration of the old type metering to prepaid metering should be intensified.

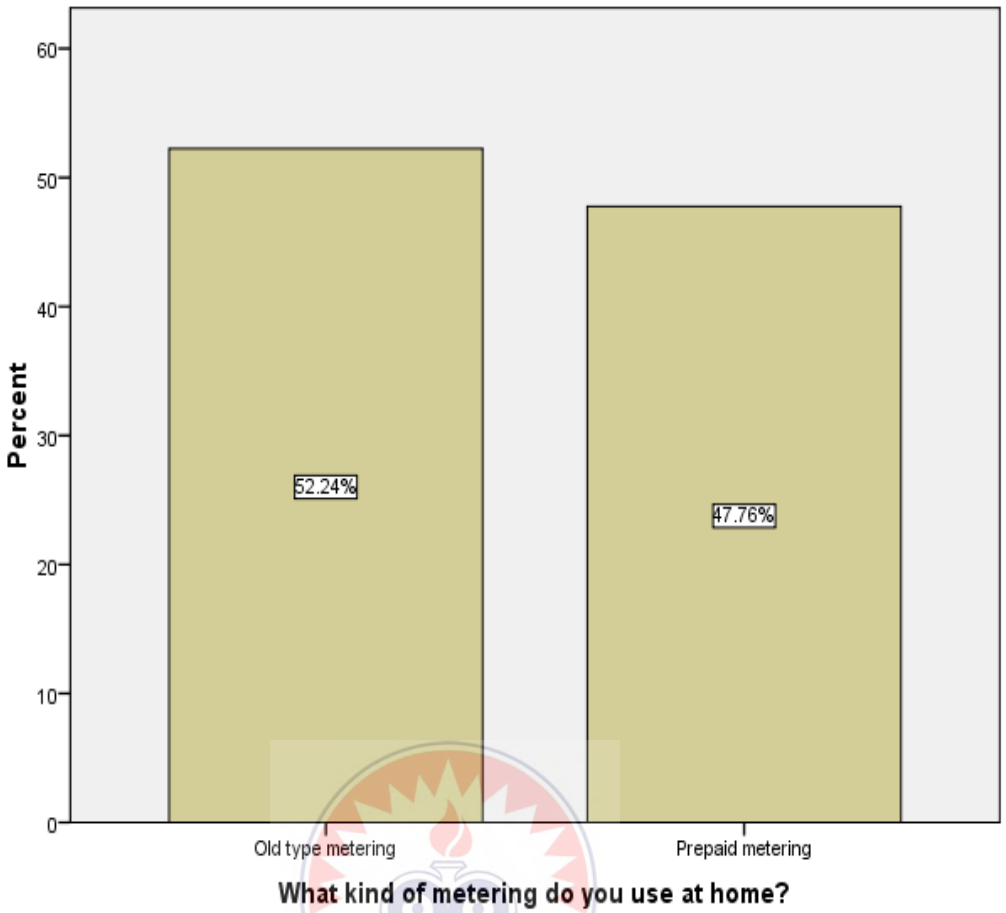

Figure 4.2: The type of metering system Respondents used

Table 4.5: The respondent's prefer a prepaid metering or the old metering

Do you prefer a prepaid metering or the old metering?	Frequency	Percent
Prepaid	157	58.6
Old metering	21	7.8
Any of them	69	25.7
Can't tell	21	7.8
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.5 indicates that 58.6% of the respondents preferred the prepaid metering system, 25.7% of the respondents preferred both the prepaid and old metering system, 7.8% preferred the old metering system while 7.8% also said they can't tell. The study results holds it that majority of the respondents preferred the prepaid metering system.

Table 4.6: Changes in respondent's electricity usage because of increasing electricity prices

Have you made any changes in your electricity usage because of increasing electricity prices?	Frequency	Percent
Yes, big changes	59	22.0
No, the same	132	49.3
Haven't taken notice	54	20.1
Don't know	23	8.6
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.6 shows that 49.3% of the respondents said that they have not made any changes in their electricity usage because of increasing electricity prices, 22% of the respondents said that they have made big changes, 20.1% said that they have not taken any notice while 8.6% said they do not know. This means that consumers must change their consumption habits in order to conserve energy.

Table 4.7: Respondents opinion on the prepayment system

What is your opinion on the prepayment system?	Frequency	Percent
Excellent	43	16.0
Good	78	29.1
Fair	130	48.5
Poor	17	6.3
Total	**268**	**100.0**

Source: Field survey (2017)

From Table 4.7, 48.5% of the respondents had a fair opinion regarding the prepayment system, 29.1% had a good opinion on the prepayment system, 16% had excellent opinion while 6.3% had poor opinion on the prepayment metering system. The study suggested that there is the need to intensify the public education regarding

the benefits of the prepayment metering system in order to enhance the customer's opinion and adoption.

Table 4.8: The Perception of the electricity consumers regarding the use of prepaid metric system

The Perception of the electricity consumers regarding the use of prepaid metric system	Yes Freq. (%)	No Freq. (%)	Do not know Freq. (%)	Total Freq. (%)
Do you think the use of prepayment metering system could help you to reduce the cost of electricity tariffs?	114 (42.5%)	129 (48.1%)	25 (9.3%)	268 (100%)
Do you think ECG has done enough to educate consumers on the implementation of the prepayment metering system?	45 (16.8%)	205 (76.5%)	18 (6.7%)	268 (100%)
Are you aware of link between price and conservation measures?	136 (50.7%)	30 (11.2%)	102 (38.1%)	268 (100%)
Are you always aware of electricity price increases in Ghana?	242 (90.3%)	15 (5.6%)	11 (4.1%)	268 (100%)
Are you willing to use prepayment metering system to conserve energy and save money?	206 (76.9%)	40 (14.9%)	22 (8.2%)	268 (100%)

Source: Field survey (2017)

The use of prepayment metering system and the reduction of the cost of electricity tariffs.

The study shows that 42.5% of the respondents affirmed that they think the use of prepayment metering system could help them to reduce the cost of electricity tariffs, 48.1% of the respondents said that prepayment metering system could not help them to reduce the cost of electricity tariffs, while 9.3% of the respondents said they do not know. It could be deduced from the study that the use of prepayment metering system could help to reduce the cost of electricity tariffs.

ECG's efforts to educate consumers on the implementation of the prepayment metering system

The study results holds it that 76.5% of the respondents said that the ECG has not done enough to educate consumers on the implementation of the prepayment metering system, 16.8% of the respondents said that the ECG has done enough to educate consumers on the implementation of the prepayment metering system while 6.7% of the respondents said that they do not know. The study suggested that electricity service provider's efforts to educate consumers regarding the prepayment metering system is not adequate.

Respondent's awareness of link between price and conservation measures

The study shows that majority 50.7% of the respondents said that they are aware of link between price and conservation measures, 38.1% of the respondents said that they do not know while 11.2% said that they are not aware of link between price and conservation measures. The study revealed that electricity consumers are `aware of the link between price and conservation measures.

Respondent's awareness of electricity price increases in Ghana

The study findings revealed that majority 90.3% of the respondents said that they are always aware of electricity price increases in Ghana, 5.6% said that they are not aware of electricity price increases in Ghana while 4.1% of the respondents said that they do not know. The study shows that that respondents are aware of the electricity price increases in Ghana.

Respondent's willingness to use prepayment metering system to conserve energy and save money

The study revealed that 76.9% of the respondents said that they are willing to use prepayment metering system to conserve energy and save money, 14.9% of the respondents said that they are not willing to use prepayment metering system to conserve energy and save money while 8.2% of the respondents said that they do not know. The study results depicts that the respondents are willing to use prepayment metering system to conserve energy and save money.

4.4 The effectiveness of the Prepayment Metering Implementation in Ghana.

Table 4.9: The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality

The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality	Frequency	Percent
The use of prepayment metering system saves money	84	31.3
Conserve energy	41	15.3
Great improvement and saving potential in promoting end use efficiency in the residential and commercial sector	143	53.4
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.9 shows that 53.4% of the respondents affirmed that the Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality is the great improvement and saving potential in promoting end use efficiency in the residential and commercial sector, 31.3% of the respondents said that the use of prepayment metering system saves money while 15.3% of the respondents said that prepayment metering system conserve energy.

Table 4.10: Do you find the prepayment metering system to be of any benefit to you?

Do you find the prepayment metering system to be of any benefit to you?	Frequency	Percent
Yes	122	45.5
No	146	54.5
Total	268	100.0

Source: Field survey (2017)

According to Table 4.10 and figure 4.3 below, 54.2% of the respondents said that even though there are other benefits of the prepayment metering system, they do not find the prepayment metering system to be of any benefit to them, while 45.5% of the respondents said that they find the prepayment metering system to be of benefit to them. This means that majority of the respondents had a negative perception that even though there are other benefits of the prepayment metering system, they do not find the prepayment metering system to be of any benefit to them.

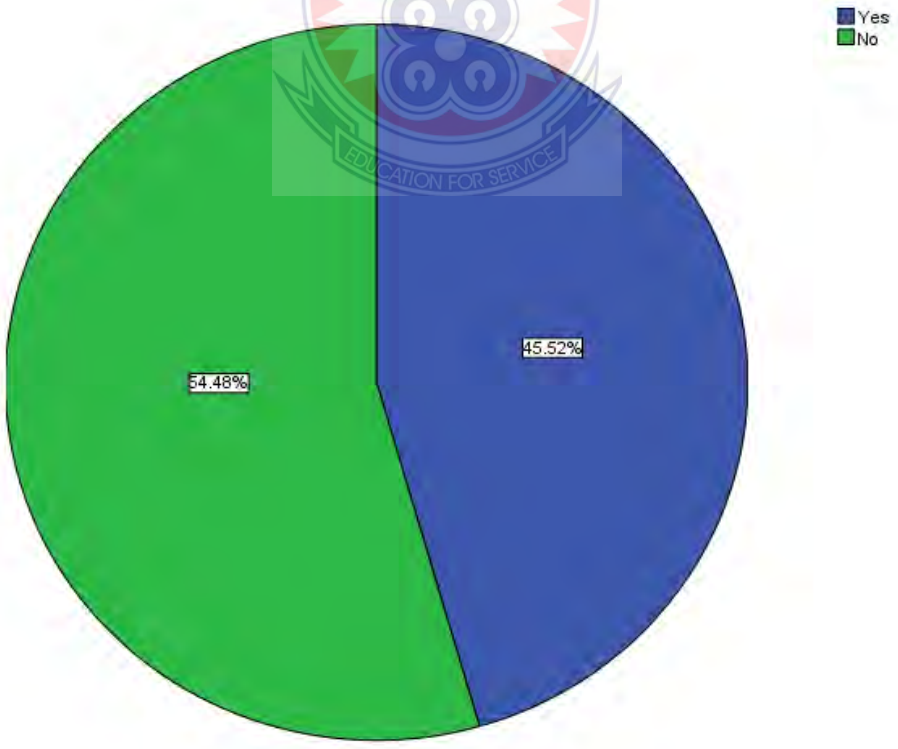

Figure 4.3: the benefits of the prepayment metering system

Source: Field survey (2017)

Table 4.11: Has the prepayment metering system made it easier for you to pay the bills and clear debts?

Has the prepayment metering system made it easier for you to pay the bills and clear debts?	Frequency	Percent
Yes	109	40.7
No	159	59.3
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.11 indicates that 59.3% of the respondents disagreed that that the prepayment metering system made it easier for you to pay the bills and clear debts however 40.7% of the respondents affirmed that the prepayment metering system made it easier for you to pay the bills and clear debts.

Table 4.12: Respondents satisfaction with the prepaid metering system

Satisfaction with the prepaid metring system	Frequency	Percent
Extremely satisfied	31	11.6
Satisfied	78	29.1
Not satisfied	137	51.1
Do not know	22	8.2
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.12 indicates that majority 51.1% of the respondents are not satisfied with the prepaid metering system, 40.7% of the respondents were satisfied while 8.2% said they do not know. The study concluded that majority of the respondents are not satisfied with the prepayment metering system.

Table 4.13: Has the prepayment metering system made it easier for you to budget on how to spend on electricity?

Has the prepayment metering system made it easier for you to budget on how to spend on electricity?	Frequency	Percent
Yes	113	42.2
No	141	52.6
Do not know	14	5.2
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.13 shows that 52.6% of the respondents said that the prepayment metering system has not made it easier for them to budget on how to spend on electricity because sometimes the units purchased get exhausted and they have to purchase more before the month ends, 42.2% of the respondents affirmed that the prepayment metering system made it easier for them to budget on how to spend on electricity while 5.2% of the respondents said that they do not know.

4.5 The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality.

Table 4.14: Saving electricity at home is very important

Saving electricity at home is very important	Frequency	Percent
Very important	67	25.0
Important	193	72
Do not know	8	3.0
Total	268	100.0

Source: Field survey (2017)

Table 4.14 indicates that majority 97% of the respondents affirmed that saving electricity at home is important while 3% said that they do not know. The study concluded that saving energy is important.

Table 4.15: The advantages of the prepayment metering system

The advantages of the prepayment metering system	Frequency	Percent
Saving money	45	16.8
Protect environment	47	17.5
Help the country to conserve energy	75	28.0
buy units according to available budgets	101	37.7
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.15 indicates that 37.7% of the respondents said that the advantage of the prepayment metering system is that they can buy units according to their earnings and available budgets. This means that monthly bills are no more needed, 28% said that prepayment metering system help the country to conserve energy, 17.5% said that it can protect energy and environmental conservation while 16.8% said that it saves money.

Table 4.16: Are you able to buy units on Sundays and holidays?

Are you able to buy units on Sundays and holidays?	Frequency	Percent
No	240	89.6
Sometimes	28	10.4
Total	**268**	**100.0**

Source: Field survey (2017)

Table 4.16 shows that 89.6% of the respondents said that the disadvantage of using the prepayment metering system is that they are unable to purchase units on Sundays and holidays while 10.4% said that sometimes they are able to buy units on odd days.

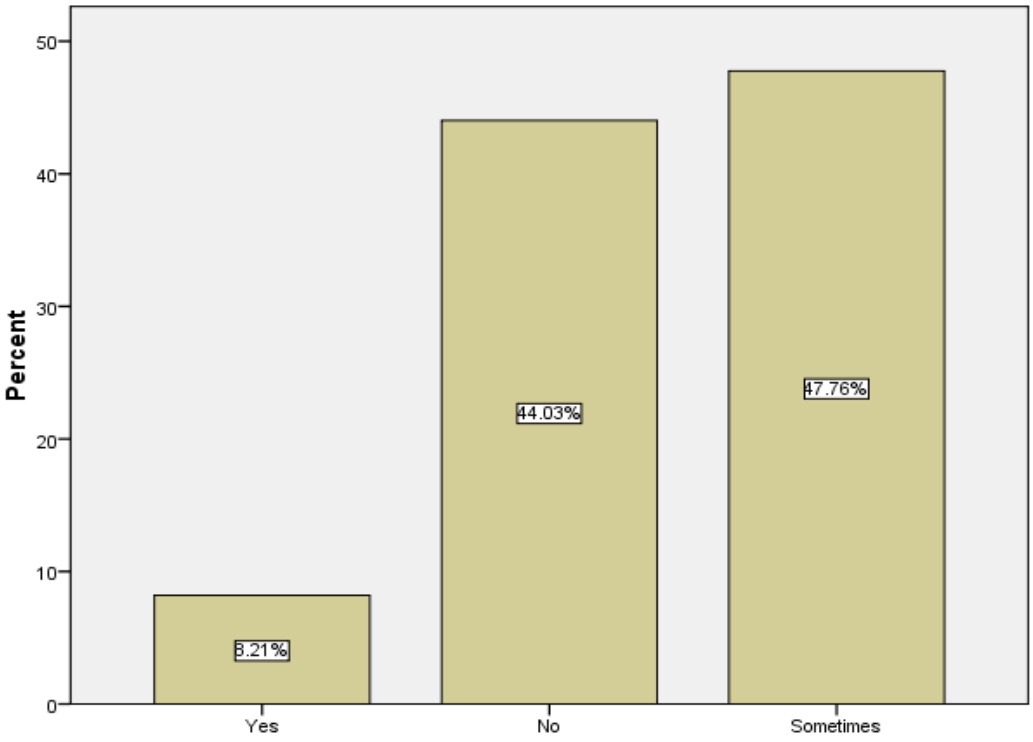

Figure 4.4: The ability to buy units on Sundays and holidays

Source: Field survey (2017)

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 The Perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality.

The study shows that 52.2% of the respondents affirmed that they used the old type metering while 47.8% of the respondents used the prepayment metering system. The study results holds that majority of the respondents still used the old type of metering. This means that the implementation and the migration of the old type metering to prepaid metering should be intensified. In general, it is considered that the electricity prepayment meter measures energy in the same manner as a conventional meter. The main difference with a prepayment meter lies in the intended manner in which the meter is to be operated and used for the sale of electricity. In the case of a conventional electricity meter, once a customer's load is energized, energy consumption is measured integrally on a continuous basis and a measurement reading is taken or established by the contractor on a periodic basis for the purpose of establishing a charge for electricity. Payment for electricity is made by the purchaser following the declaration or estimation of consumption of electricity for a certain period of time.

In the case of a prepayment electricity meter, the meter also measures electricity consumption integrally but the measurement is actually started and stopped in conjunction with the activation and deactivation of the load circuit by the prepayment control system. To activate the load circuit, the consumer must prepay for electricity usage or purchase a quantity of electricity (note: a contractor's fixed charges may be included in this purchase). The payment information may be loaded on the meter through a specific peripheral control device (e.g., magnetic card reader

or telemetering system). Once activated, the load circuit will run and remain activated until the monetary or equivalent energy information loaded into the prepayment control system has run out, subject to any other conditions established by the contractor.

5.1.2 The respondent's prefer a prepaid metering or the old metering

The study indicates that 58.6% of the respondents preferred the prepaid metering system, 25.7% of the respondents preferred both the prepaid and old metering system, 7.8% preferred the old metering system while 7.8% also said they can't tell. The study results holds it that majority of the respondents preferred the prepaid metering system. According to Eskom (2010), the prepaid meter (PPM) system has several important components. First, there is the prepaid meter (or electricity dispenser- ED) which is installed in the household. The ED is activated by the input of a token', which indicates how much energy the customer has purchased. The token comes in a variety of physical forms, but essentially it represents a string of numbers that are entered into the ED to authenticate the transaction. In the early stages of the industry, the tokens were disposable cards with magnetic strips, but in the late 1990s keypads became more popular as input mechanisms. The token used for keypad activation is just a string of numbers, communicated to the consumer orally, in written form, or even via an SMS or e-mail.

5.1.3 Changes in respondent's electricity usage because of increasing electricity prices

The study depicts that 49.3% of the respondents said that they have not made any changes in their electricity usage because of increasing electricity prices, 22% of

the respondents said that they have made big changes, 20.1% said that they have not taken any notice while 8.6% said they do not know. This means that consumers must change their consumption habits in order to conserve energy. This agrees with Ariel and Luciana (2008), who affirmed that periodical purchases of electricity imply a change in consumer habits, because they have to incur the extra costs associated to the time spent on additional buys. The extent of this cost would vary with the periodicity of energy reloads (it would be neutral if reloads occurred once a month, as this would demand an effort similar to that incurred when paying the conventional monthly bill) and it would be directly dependent on the user‘s salary; it is possible to presume that the higher an individual‘s salary, the higher the opportunity cost of her time. We therefore estimate this cost by firstly computing an average hourly cost that we approximate using census income data for the district, and then multiplying that cost by both the estimated duration of each reload and the average number of yearly purchases made by each household using the prepayment system.

Thus, in principle, prepaid metering offers utility providers the possibility of decreasing the administrative and financing costs of electricity delivery, which in turn will bring down the cost of electricity delivery, or yield higher returns to the utility, or both. Utility providers have long been aware of the potential advantages of prepaid electricity delivery over credit metering, but it was not until the mid-1990s that (partly as a result of the technology development led by Eskom) the prepaid meter (PPM) technology evolved to a level that would allow its widespread implementation (Ariel and Luciana, 2008).

According to James and Marcel (2014), Prepayment has gained increased attention in the last several years. The primary reason is that customers switching from credit billing to prepayment almost always reduce their electricity consumption.

- Salt River Project reports a 12.8 percent reduction in energy use when customers switch from credit to prepay.
- Northern Ireland Electricity says that prepay customers use 4.9 percent less electricity than the average customer.
- Oklahoma Electric Cooperative reports that customers lowered consumption 13 percent after switching to prepayment.

Granted, customers electing prepayment are likely to be those most motivated to reduce utility bills.

5.1.4 Respondent's opinion on the prepayment system

The study revealed that 48.5% of the respondents had a fair opinion regarding the prepayment system, 29.1% had a good opinion on the prepayment system, 16% had excellent opinion while 6.3% had poor opinion on the prepayment metering system. The study suggested that there is the need to intensify the public education regarding the benefits of the prepayment metering system in order to enhance the customer's opinion and adoption. In a study conducted by Balson (2007), however, notwithstanding examples such as the Jaggersfonte in water penny', the majority of electricity supplied to domestic consumers up to the 1980s was supplied using credit meters', in other words, meters which record consumption, with their records being collected by meter readers and bills then being issued based on metered (or in some cases, estimated) consumption. The process of reading such meters, distributing bills, dealing with arrears and so forth proved costly in economic, and maybe even more importantly, political terms, however. Since credit meters simply record consumption, the process of disconnecting a household from electricity supply involves an obvious intervention on the part of the electricity utility, and since all domestic electricity

utilities in South Africa have been state-owned, the process of electricity disconnection is an easy one to politicize.

5.1.5 The use of prepayment metering system and the reduction of the cost of electricity tariffs.

The study shows that 42.5% of the respondents affirmed that they think the use of prepayment metering system could help them to reduce the cost of electricity tariffs, 48.1% of the respondents said that prepayment metering system could not help them to reduce the cost of electricity tariffs, while 9.3% of the respondents said they do not know. It could be deduced from the study that the use of prepayment metering system could help to reduce the cost of electricity tariffs. According to Balson (2007), the process of reading the credit meters which is the old type meters, distributing bills, dealing with arrears and so forth proved costly in economic, and maybe even more importantly, political terms, however. Since credit meters simply record consumption, the process of disconnecting a household from electricity supply involves an obvious intervention on the part of the electricity utility, and since all domestic electricity utilities in South Africa have been state-owned, the process of electricity disconnection is an easy one to politicize.

5.1.6 ECG's efforts to educate consumers on the implementation of the prepayment metering system

The study results holds it that 76.5% of the respondents said that the ECG has not done enough to educate consumers on the implementation of the prepayment metering system, 16.8% of the respondents said that the ECG has done enough to educate consumers on the implementation of the prepayment metering system while

6.7% of the respondents said that they do not know. The study suggested that electricity service provider's efforts to educate consumers regarding the prepayment metering system is not adequate. This contradicts with the situation in Lavender Hill, another coloured township in Cape Town Councilor Eulalie Stott held meetings with local residents, using electrical appliances to explain the details of electricity consumption (Smith, 2004). Don Taylor states that we set up training and demonstrations in the community gathering halls with educational programmes promoting the concept of prepayment and training consumers on how to use the meters; this was of cardinal or prime importance as the slightest sign of customer difficulty would jeopardize the entire installation.

5.1.7 Respondent's awareness of link between price and conservation measures

The study shows that majority 50.7% of the respondents said that they are aware of link between price and conservation measures, 38.1% of the respondents said that they do not know while 11.2% said that they are not aware of link between price and conservation measures. A big chunk of electricity that power companies generate is lost or remains unaccounted for. This is partly due to the technical losses at the power plants and in the transmission and distribution lines. There is another high percentage loss due to non-technical reasons at customer level such as tampering with the meter, illegal connection and so on. Various attempts have been made to address these vexing problems of non-technical losses such as contracting out meter reading and billing, computerized billing and cut-offs and legal penalties. But nothing has been 100% successful so far. However, amongst all the efforts and endeavours, the one approach that proved to be consumer friendly and cost effective was the prepaid metering system (Power Division, 2011). Pre-payment metering system can

reduce accounts receivable and non-technical losses up to zero per cent. The idea of using prepaid meters therefore is to stem the financial drain on power companies such as ECG and conserve energy (Power Division, 2011).

5.1.8 Respondent's awareness of electricity price increases in Ghana

The study findings revealed that majority 90.3% of the respondents said that they are always aware of electricity price increases in Ghana, 5.6% said that they are not aware of electricity price increases in Ghana while 4.1% of the respondents said that they do not know. The study shows that that respondents are aware of the electricity price increases in Ghana. To charge the meter, consumer needs to buy electricity in advance according to his/her requirement. The consumer can buy electricity through various vending options. The vend results in a token with a code printed on it. The consumer punches the code into the meter either directly or through an in-home display using a key pad. The meter is credited with the amount of credit bought and supply is switched on automatically at load side. As the consumer‘s balance reaches the emergency limit provided by the utility, meter sends an alarm. The consumer needs to recharge the meter at this point. If recharged in time then the load is not disconnected. However, if even after warning, a consumer does not recharge their meter and all available balance is exhausted (as per the prevailing tariff defined in the meter) and there are no ―Friendly Credit Days / Friendly Credit Hours then meter automatically disconnects the supply at load side.

5.1.9 Respondent's willingness to use prepayment metering system to conserve energy and save money

The study revealed that 76.9% of the respondents said that they are willing to use prepayment metering system to conserve energy and save money, 14.9% of the respondents said that they are not willing to use prepayment metering system to conserve energy and save money while 8.2% of the respondents said that they do not know. The study results depicts that the respondents are willing to use prepayment metering system to conserve energy and save money. In their earliest form, prepayment meters consisted of coin operated mechanical meters. From the late 1980's forward, electronic meter technology combined with card encoding and various telemetering communication techniques have been used in prepayment meter design (Measurement Canada, 2006). In recent years, there has been a growing interest amongst government departments and industry stakeholders to identify new methods for managing and conserving energy to meet rising demand at the residential and commercial/industrial trade levels. In the electricity industry, the use of prepayment applications combined with time-of-use is being closely reviewed as a viable means for reducing overall demand in the electricity marketplace.

5.2 The effectiveness of the Prepayment Metering Implementation in Ghana

5.2.1 The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality

The study shows that 53.4% of the respondents affirmed that the Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality is the great improvement and saving potential in promoting end use efficiency in the residential and commercial sector, 31.3% of the respondents said that the use of

prepayment metering system saves money while 15.3% of the respondents said that prepayment metering system conserve energy. This finding contradicts with the research conducted by Ariel and Luciana (2008), who asserted that consumers switching from the conventional to the prepayment system face two types of cost. One refers to the direct monetary cost, while the other refers to differences in habits that result from replacing a post-consumption and single monthly payment with more frequent payments, which occur prior to consumption. The main direct monetary effect is the cost of the new meter and its associated opportunity cost, which we proxy using the interest rate for savings accounts deposits, which was estimated relating consumers‘ average expenditure to a rate capturing the opportunity cost of money.

5.2.2 Benefits of the prepayment metering system

According to the study conducted, 54.2% of the respondents said that even though there are other benefits of the prepayment metering system, they do not find the prepayment metering system to be of any benefit to them, while 45.5% of the respondents said that they find the prepayment metering system to be of benefit to them. This means that majority of the respondents had a negative perception that even though there are other benefits of the prepayment metering system, they do not find the prepayment metering system to be of any benefit to them. This however agrees with Ariel and Luciana (2008), consumers switching from the conventional to the prepayment system face two types of cost. One refers to the direct monetary cost, while the other refers to differences in habits that result from replacing a post-consumption and single monthly payment with more frequent payments, which occur prior to consumption. The main direct monetary effect is the cost of the new meter and its associated opportunity cost, which we proxy using the interest rate for savings

accounts deposits, which was estimated relating consumers‘ average expenditure to a rate capturing the opportunity cost of money.

The study indicates that 59.3% of the respondents disagreed that that the prepayment metering system made it easier for you to pay the bills and clear debts however 40.7% of the respondents affirmed that the prepayment metering system made it easier for you to pay the bills and clear debts. According to Mr. Fred Enninson of the ECG, in charge of the pre-paid meter faults, the introduction of the prepaid meter, though having problems in the initial stages, people will soon get abreast with how it operates. The ECG's main concentration is the easiness that the prepaid meters has brought to their workers and not to the normal Ghanaian. Moreover he said ―customers of ECG are now free from monthly billing‖ He used the phrases free very nicely to my understanding but this might not be well understood by a well-resourced economist who knows the difference between his opportunity cost for prepaid meters and a mere free word as he used it.

In some jurisdictions, regulators and consumer advocates have expressed concerns that utilities might force prepayment onto customers in low-income areas, thus stigmatizing customers whose positive history of bill payment may equal or frequently exceed those of their wealthier neighbours. This concern has faded as prepayment has become the payment method of choice for mobile phone and similar services (Oracle, 2009). A different fairness issue has arisen recently in the U.K. There are reports that retailers in this fully competitive market will agree to serve prepayment customers only at excessively high rates.

Over the years, the VRA-NED and ECG have used the conventional credit metering and billing system in their revenue collection efforts. Measures such as termination of service of defaulters, use of bonded cashiers, private debt collection

companies, threat of prosecution and raffles did not result in a significant reduction in the debtors' position of the utility service providers. Rather, the debtors' position of these companies worsened. Prepayment metering was seen as a better option for improving the cash flow position and reducing the level of debts owed to these companies by customers. Between 1994 and 1995 ECG ran the prepayment programme on a pilot basis in Accra, Tema and Kumasi for residential and non-residential customers with small loads. Areas where the meters were installed were Adenta SSNIT flats and surrounding areas, Sakumono Estates, some communities in Tema, Asuoyeboah SSNIT flats, Kwadaso, Patase and Danyame areas of Kumasi (Chartwell, 2008). Based on the implementation in Ghana, there were some improvements these being;

- Improving revenue collection
- Creating awareness on the need for customers to conserve energy and reduce wastage
- Reducing costs associated with meter reading, billing errors, bill production and delivery of bill.

5.2.3 Respondent's satisfaction with the prepaid metering system

The study portrays that majority 51.1% of the respondents are not satisfied with the prepaid metering system, 40.7% of the respondents were satisfied while 8.2% said they do not know. The study concluded that majority of the respondents are not satisfied with the prepayment metering system. This contradicts with the research conducted by the Power Division of the Ministry of Power, Energy and Mineral Resources, Republic of Bangladesh, who summarized the benefits of prepaid meter as follows;

Customers like the system because (Power Division, 2011):

It is transparent, easy to add credit to the meter through smart card, they can control their own consumption, they can control their budget, no hassles with bill payment, disconnection or reconnection, there is no minimum charge, require no deposit, no more disputed bills, warning for low credit, abnormal voltage protection, automated record keeping. The power company also benefits in the following way (Power Division, 2011):

Upfront payment, improved cash flow, decreased non-technical losses, lower overheads expenses (no meter reading or billing), increased revenue, no outstanding debt, tamper protection, non-allowance of over sanctioned load, better load management, better customer services, automated record keeping and create power saving attitude to the consumers.

The study depicts that 52.6% of the respondents said that the prepayment metering system has not made it easier for them to budget on how to spend on electricity because sometimes the units purchased get exhausted and they have to purchase more before the month ends, 42.2% of the respondents affirmed that the prepayment metering system made it easier for them to budget on how to spend on electricity while 5.2% of the respondents said that they do not know. Taylor mentions that the early prepaid meters were called Budget Energy Controllers (BECs), and were promoted as a way to put the consumer in control (of their electricity expenditure). Cosmetic approaches were also taken – BECs would not be black because black clothing and drove black cars). Neil Ballantyne notes that during the Cape Town City Council‘s prepayment pilot project in Hanover Park in 1993, township unrest was affecting the electricity department: that‘s why when we started with installation of the meters we actually branded our vehicles to support those

meters completely differently. In other words, it was almost like the good guys and bad guys situation. The trucks for the disconnections, people knew what they looked like, and they were the bad guys, we were the good guys going in with cars with ―energy dispenser support written on the side, and the guys didn‘t really have trouble because they were seen as the guys helping them‘ (Ballantyne, 2013).

According to Measurement Canada (2006), Prepayment metering is the trade measurement of electricity or gas which is required to be purchased by a consumer in advance of the consumption of electricity or gas. Generally, in a prepayment application, a consumer must prepay for electricity or gas in order to activate their load through the meter. The types of prepayment applications for electricity and gas may vary and can range from a simple advance monetary payment for electricity or gas to the pre-purchase of a fixed quantity of electricity or gas. In principle, under a prepayment application, the consumer may not receive a subsequent bill as payment is made in advance for electricity or gas. The terms and conditions for prepayment are established by the electricity and gas contractors (also referred to in the industry as suppliers or energy providers), and are subject to regulation. The design, construction, performance, installation and usage of meters intended for prepayment applications are subject to regulation in most countries. Prepayment Electric meters now come in various types.

5.3 The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality

The study indicates that majority 97% of the respondents affirmed that saving electricity at home is important while 3% said that they do not know. The study concluded that saving energy is important. This agrees with the study conducted by

Karen (2006), who asserted that energy conservation refers to efforts made to reduce energy usage. Energy conservation can be achieved through increased efficient energy use, in conjunction with decreased energy consumption and/or reduced consumption from conventional energy sources. Because of the limited amount of non-renewable energy sources on Earth, it is important to conserve our current supply or to use renewable sources so that our natural resources will be available for future generations (Karen, 2006). Energy conservation is also important because consumption of non-renewable sources impacts the environment. Specifically, our use of fossil fuels contributes to air and water pollution. For example, carbon dioxide is produced when oil, coal, and gas combust in power stations, heating systems, and car engines. Carbon dioxide in the atmosphere acts as a transparent blanket that contributes to the global warming of the earth, or "greenhouse effect." It is possible that this warming trend could significantly alter our weather. Possible impacts include a threat to human health, environmental impacts such as rising sea levels that can damage coastal areas, and major changes in vegetation growth patterns that could cause some plant and animal species to become extinct (Karen, 2006).

5.3.1 The advantages of the prepayment metering system

The study shows that 37.7% of the respondents said that the advantage of the prepayment metering system is that they can buy units according to their earnings and available budgets. This means that monthly bills are no more needed, 28% said that prepayment metering system help the country to conserve energy, 17.5% said that it can protect energy and environmental conservation while 16.8% said that it saves money. A Prepayment Meter is an easy way to pay for your gas and electricity. It allows you to pay for your energy supply before you use it. If you would like to pay

for your gas and electricity in this way, it can be easily fitted into your home, providing it is safe and practicable to do so. A Prepayment meter will charge for any gas or electricity as you use it. It may also be used to recover any outstanding debt from you at an agreed weekly rate. Some electricity Prepayment Meters may also take a weekly amount to cover fixed unit charges as part of our two-tier pricing structure. When we install a Prepayment Meter, we will provide you with details of our gas or electricity charges. Where there are any additional charges in connection with your Prepayment Meter, we will always tell you what they are beforehand (Edison Electric Institute, 2016).

According to UK Power Limited (2012), Prepayment meters work in exactly the same way as their name would suggest; instead of paying for your electricity after you have used it, you pay before. UK Power Limited (2012), also noted that, there are two main types of prepayment meters. The first, standard prepayment meters may either display one or two readings and these should simply be read as above like other meters. The second type is meters connected to the Pay-point network. This system works by accepting tokens, usually in the form of plastic keys which can be bought and then your supply topped up.

The study results holds it that 89.6% of the respondents said that the disadvantage of using the prepayment metering system is that they are unable to purchase units on Sundays and holidays while 10.4% said that sometimes they are able to buy units on odd days. The concepts were further developed in a conference on the electrification of developing communities which was held by the South African Institute of Electrical Engineers in 1991, in the ANC‘s national Meeting on Electrification held in February 1992, and in the work of the National Electrification Forum (NELF), which met between 1992 and 1994. From 1990 onwards, Eskom

developed the NRS009 standard, which allowed for standardization of prepayment technology and therefore the ability to make units sourced from different vendors interoperate. This was initiated from 1993 onwards (Eskom, 2007), eventually leading to the creation of the Standard Transfer Specification (STS) to which all South African prepaid meters comply. (The STS was later developed into an international specification by the International Electro-technical Commission with the result that STS-compliant prepaid meters are now in use throughout the world).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

The main purpose of the study was to evaluate the perception of the consumers of electricity regarding the use of prepaid metric system in the Koforidua Municipality. This study employed quantitative and descriptive research design to collect data and analyze data. The population for this study encompasses individuals who consume electricity in the Koforidua Municipality in the Eastern Region of Ghana. The population for the study was two thousand six hundred (2600). The random (probability) sampling technique was used to sample three hundred and thirty five electricity consumers within the study area to collect data in order to predict and generalized the whole research population. The main instrument used for the study were structured questionnaires. Furthermore, out of 335 questionnaires sent out for primary data, 268 questionnaires were retrieved and 68 questionnaires were not retrieved. Therefore, the analysis of the study was based on 80% response rate. This figure was considered adequate 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 18.0) 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. The data gathered were presented using tables and charts. The data presented was analyzed using percentages and frequencies.

6.2 Major Findings

6.2.1 The Perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality.

The study findings revealed that 52.2% of the respondents affirmed that they used the old type metering while 47.8% of the respondents used the prepayment metering system. The study results holds that majority of the respondents still used the old type of metering. This means that the implementation and the migration of the old type metering to prepaid metering should be intensified. Moreover, the study shows that 58.6% of the respondents preferred the prepaid metering system, 25.7% of the respondents preferred both the prepaid and old metering system, 7.8% preferred the old metering system. Furthermore, 49.3% of the respondents said that they have not made any changes in their electricity usage because of increasing electricity prices while 22% of the respondents said that they have made big changes. The study depicts that 48.5% of the respondents had a fair opinion regarding the prepayment system, 29.1% had a good opinion on the prepayment system, 16% had excellent opinion while 6.3% had poor opinion on the prepayment metering system. The study shows that 42.5% of the respondents affirmed that they think the use of prepayment metering system could help them to reduce the cost of electricity tariffs while 48.1% of the respondents said that prepayment metering system could not help them to reduce the cost of electricity tariffs. The study results holds it that 76.5% of the respondents said that the ECG has not done enough to educate consumers on the implementation of the prepayment metering system. The study shows that majority 50.7% of the respondents said that they are aware of link between price and conservation measures. The study findings revealed that majority 90.3% of the respondents said that they are always aware of electricity price increases in Ghana.

The study revealed that 76.9% of the respondents said that they are willing to use prepayment metering system to conserve energy and save money.

6.2.2 The Effectiveness of the Prepayment Metering Implementation in Ghana

The study shows that 53.4% of the respondents affirmed that the Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality is the great improvement and saving potential in promoting end use efficiency in the residential and commercial sector, 31.3% of the respondents said that the use of prepayment metering system saves money while 15.3% of the respondents said that prepayment metering system conserve energy. The study revealed that 54.2% of the respondents said that even though there are other benefits of the prepayment metering system, they do not find the prepayment metering system to be of any benefit to them. To add more, 59.3% of the respondents disagreed that that the prepayment metering system made it easier for them to pay the bills and clear debts while 40.7% of the respondents affirmed that the prepayment metering system made it easier for them to pay the bills and clear debts. The study shows that majority 51.1% of the respondents are not satisfied with the prepaid metering system while 40.7% of the respondents were satisfied. The study depicts that 52.6% of the respondents said that the prepayment metering system has not made it easier for them to budget on how to spend on electricity because sometimes the units purchased get exhausted and they have to purchase more before the month ends.

6.2.3 The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality.

The study indicates that majority 97% of the respondents affirmed that saving electricity at home is important. The study revealed that 37.7% of the respondents said that the advantage of the prepayment metering system is that they can buy units according to their earnings and available budgets. This means that monthly bills are no more needed, 28% said that prepayment metering system help the country to conserve energy, 17.5% said that it can protect energy and environmental conservation while 16.8% said that it saves money. The study revealed that 89.6% of the respondents said that the disadvantage of using the prepayment metering system is that they are unable to purchase units on Sundays and holidays while 10.4% said that sometimes they are able to buy units on odd days.

6.3 Conclusions

The study results concluded that majority of the respondents still used the old type of metering. This means that the implementation and the migration of the old type metering to prepaid metering should be increased to improve customer's perception and knowledge regarding the prepayment metering system. Furthermore, most of the respondents preferred the prepayment metering system but they still used the old metering system due to the disadvantages involved in the use of the prepayment metering system. The respondents had a fair opinion regarding the prepayment system. This means that electricity service providers should intensify the public education regarding the benefits of the prepayment metering system in order to enhance the customer's opinion and adoption of the new system. The study concluded that the use of prepayment metering system could help to reduce the cost of electricity

tariffs. The ECG has not done enough to educate consumers on the implementation of the prepayment metering system. This has generated some misconception in the minds of the consumers and has affected the adoption of the new metering system. The study concluded that majority of the respondents were willing to use prepayment metering system to conserve energy and save money.

The study further concluded that the effects of prepayment metering on customer energy usage in the Koforidua Municipality is the great improvement and saving potential in promoting end use efficiency in the residential and commercial sector, saving money and energy conservation. The study further concluded that even though there are other benefits of the prepayment metering system, the respondents did not perceive the prepayment metering system to be of any benefit to them. Majority of the respondents were not satisfied with the prepaid metering system because they claim that the prepayment metering system has not made it easier for them to budget on how to spend on electricity because sometimes the units purchased get exhausted and they have to purchase more before the month ends.

The advantages of the prepayment metering system are that respondents can buy units according to their earnings and available budgets. This means that monthly bills are no more needed, prepayment metering system helped the country to conserve energy, it protect energy and environmental conservation and save money. The disadvantage of using the prepayment metering system is that respondents are unable to purchase units on Sundays and holidays.

6.4 Recommendations

According to the major findings and the conclusions remarks of the empirical research conducted, the following recommendations are made with the belief that they will go a long way to assist and improve the implementation of prepayment metering the Koforidua Municipality and Ghana as a whole.

1. The Management of the Electricity Company of Ghana (ECG) and Volta River Authority (VRA) should organise periodic intensive educative and informative programmes through the available media platforms like the Television and Radio stations to inform and educate the electricity consumers regarding the benefits of the prepayment metering system in order to enhance implementation of the new metering system in the Koforidua Municipality.
2. The implementation and the migration of the old type metering system to prepaid metering system should be increased as well as the quality of service should be enhanced to improve customer's perception, acceptance and knowledge regarding the prepayment metering system.
3. According to the study most of the respondents had a fair and poor opinion regarding the prepayment system. This means that electricity service providers should intensify the public education regarding the benefits of the prepayment metering system in order to enhance the customer's opinion and adoption of the new system. This will reduce the misconception in the minds of the consumers and improve the acceptance and adoption of the prepayment metering system.
4. There is the need to encourage electricity consumers to use prepayment metering system to conserve electricity energy and save money. This is a great

improvement and saving potential in promoting end use efficiency in the residential and commercial sector, saving money and energy conservation.

5. The Government of Ghana through the Ministry of Energy should put all necessary administrative measures in place to ensure the successful implementation of the prepayment metering system in all government agencies, department and educational institutions in Ghana.
6. The Ministry of Energy and Ghana Standard Board should ensure that all the energy meters that come into the country meet the international standards to improve customer satisfaction.
7. According to the study, the respondents said that the disadvantage of using the prepayment metering system is that respondents are unable to purchase units on Sundays and holidays. Therefore, there is the need to provide sales agents who can operate on Sundays and public holidays to sell units to electricity consumers.

6.5 Suggestions for Further Study

The study conducted was limited in scope to the Koforidua Municipality in the Eastern Region of Ghana this could affect the generalizations of the findings. Therefore, the researcher suggested that a similar research should be undertaken to investigate the same situation using the whole ten regions of Ghana as case study.

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APPENDIX A

QUESTIONNAIRES FOR THE ELECTRICITY CONSUMERS IN THE KOFORIDUA MUNICIPALITY

The researcher is a product of UEW, Kumasi Campus. She is conducting a piece of research to **ASSESS THE EVALUATION OF PREPAID METRIC SYSTEM OF CONSUMERS – CASE STUDY OF KOFORIDUA MUNICIPALITY** in the Eastern 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 of the Respondents.

Please tick [√] in the box where appropriate

1. Gender: Male [ ] Female [ ]

2. Age: Below 18 years [ ] 19-29 years [ ] 30-39 years [ ] 40-49 years [ ] 50-59 years [ ] 60-69 years [ ] above 70 years [ ]

3. Education background:

Never [ ] BECE [ ] SSSCE/WASSCE [ ] Diploma [ ] Bachelors' degree [ ] Masters' degree [ ] PhD [ ]

Section B: The Perception of the electricity consumers regarding the use of prepaid metric system in the Koforidua Municipality.

Please tick [√] in the box where appropriate

4. What kind of metering do you use at home?

Old type metering [ ] Prepaid metering [ ]

5. Do you prefer a prepaid metering or the old metering?

Prepaid [ ] Old metering [ ] Any of them [ ] Can't tell [ ]

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

Yes, big changes [ ] No, the same [ ] Haven't taken notice [ ] Don't know [ ]

7. What is your opinion on the prepayment system?

Excellent [ ] Good [ ] Fair [ ] Poor [ ]

Please tick [√] in the box where appropriate

The Perception of the electricity consumers regarding the use of prepaid metric system	**Yes**	**No**	**Don't know**
8. Do you think the use of prepayment metering system could help you to reduce the cost of electricity tariffs?			
9. Do you think ECG has done enough to educate consumers on the implementation of the prepayment metering system?			
10. Are you aware of link between price and conservation measures?			
11. Are you always aware of electricity price increases in Ghana?			
12. Are you willing to use prepayment metering system to conserve energy and save money?			

Section C: The effectiveness of the Prepayment Metering Implementation in Ghana.

13. What are the Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality? Please tick [√] in the box where appropriate

The use of prepayment metering system saves money [ ] Conserve energy [ ]

Great improvement and saving potential in promoting end use efficiency in the residential and commercial sector [ ]

Section C: The Benefits of switching to the prepayment metering system. Please tick [√] in the box where appropriate

14. Do you find the prepayment metering system to be of any benefit to you?

Yes [ ] No [ ]

15. Has the prepayment metering system made it easier for you to pay the bills and clear debts?

Yes [ ] No [ ]

16. Are you happy or satisfied with the prepaid metring system?

Extremely satisfied [ ] satisfied [ ] not satisfied [ ] Do not know [ ]

17. Has the prepayment metering system made it easier for you to budget on how to spend on electricity?

Yes [ ] No [ ] Do not know [ ]

Section D: The Effects of Prepayment Metering on Customer Energy Usage in the Koforidua Municipality. Please tick [√] in the box where appropriate

18. Do you think using prepayment metering system and saving electricity at home is very important?

Very important [ ] Important [ ] Not important [ ] Do not know [ ]

19. What do you think are the advantages of the prepayment metering system?

Saving money [ ] Protect environment [ ] Help the country to conserve energy [ ] buy units according to my budgets [ ]

20. Are you able to buy units on Sundays and holidays?

Yes [ ] No [ ] Sometimes [ ]

21. With the prepayment metering system are you able to use electricity without paying?

Yes [ ] No [ ]

22. What do you think are the disadvantages of the prepayment metering system?

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23. In general what do you think of the prepayment metering system?

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