KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

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DEPARTMENT OF GEOMATIC ENGINEERING

GIS WEB-BASED SOLUTION FOR ECG ASSET TRACKING AND BILLING

(A CASE STUDY AT ADENTAN MUNICIPALITY)

A Thesis submitted to the Department of Geomatic Engineering, Kwame Nkrumah University of Science and Technology in partial fulfilment of the requirements for the degree of Master of Science in Geomatic Engineering.

BY

TOTIMEH, DAVID TEYE (BSc. Geomatic Engineering)

SURPERVISORS

PROF. DR. - ING. COLLINS FOSU

MR. GEORGE ASHIAGBOR

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DECLARATION

I declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all materials that are not orignianal to this work

TOTIMEH, DAVID TEYE (PG2233614) …… ……..

(Student Name and ID) Signature Date

Certified By:

PROF. DR. - ING. COLLINS FOSU …… ……..

(Lead Supervisor) Signature Date

MR. GEORGE ASHIAGBOR …… ……..

(Second Supervisor) Signature Date

DR ISAAC DADZIE …… ……..

(Head of Department) Signature Date

DISCLAIMER

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ABSTRACT

Today, the world is fast moving in the area of Information and Communication Technology (ICT). With the use of Spatial Technology and subsequent development of Web GlS evolving, the operations, services and management of several industries in the world over are flourishing.

Electricity as utility is inimical to the socio-economic development of any country. The generation, transmission and distribution of power electricity come with lots of challenges. This study aimed at using Spatial Technology to enhance ECG business. Adentan Municipality was used as a study area and data on user requirement was gathered.

Geomatic measurement techniques were employed in spatial data acquisition. The task of development of ECG-GlS Customer Information System was put into data acquisition, data processing, geo-database development and system design phases respectively. A user friendly ECG-GlS Customer Information System comprising of four modules, Customer Activity, Customer Database, Geo-database and System settings was developed and deployed. The system is centrally web based, dynamic and has the ability to track ECG customers' information on billing with ease.

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LIST OF ACRONYMS AND ABBREVIATIONS

AM - Amplitude Modulation

BSP – Bulk Supply Points

BST – Bulk Supply Tariff

CAD – Computer Aided Design

CIS – Customer Information System

DBMS – Database Management System

DSC – Distribution Service Charge

ECG - Electricity Company of Ghana

ER – Entity Relational

ESRI – Environmental Systems Research Institute

EUT – End User Tariff

FM – Frequency Modulation

GDB – Geo-data base

GIR – Geographic Information Retrieval

GIS – Geographic Information System

GRIDCo – Ghana Grid Company

GUI – Geographic User Interface

ICT – Information and Communication Technology

ID – Identity

IIS – Internet Information Services

IPP – Independent Power Producers

IRCA – International Register of Certificated Auditors

IREA – International Renewable Energy Agency

IT – Information Technology

LMP – Locational Marginal Pricing

LPGL – Lesser General Public License

MOE – Ministry of Energy

MYTO – Multiple Year Tariff Order

NED – Northern Electricity Department

NLC – National Liberation Council

NREL – National Renewable Energy Laboratory

NSLT – Non-Special Load Tariff

PHP - Personal Home Page

PSEC – Power System Energy Consulting

PURC – Public Utility and Regulatory Commission

RDBMS – Relational Data Base Management System

RMS – Root Mean Square

SDLC – System Development Life Cycle
SMS – Short Message Services

SQL – Structured Query Language

UML – Unified Modeling Language

VB – Visual Basic

VRA – Volta River Authority

XML - Extensible Markup Language

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Electricity as utility is of much value and potency in the life of mankind (Piepmeier 1995). The generation, transmission and distribution of Electricity on both commercial (industry) and domestic (household) levels is inimical to the socio-economic development and growth of any country and the world over (Bergasse 2013). The demand and supply of electricity comes with a cost element. The Electricity Company of Ghana (ECG) whose core mandate is to distribute Electricity is as well responsible to generate revenue to finance its services (ECG Annual Report 2010). One of the major challenges that affect the delivery of reliable supply of Electricity by ECG is their inability to mobilize revenue efficiently (ECG Annual Report 2012). The act of illegal connection, toppled with power theft is a huge burden that affects ECG revenue mobilization.

According to the International Energy Agency (2013), nations like; Russia, Brazil and South Africa will need huge investment for global electricity supply in terms of production to overtake in the world industry of oil between the duration of 2010-2035 in order to keep pace with the increasing demand.

Africa has vast energy resources, far above its own needs (Bergasse, 2013). However, Scott (2015), has revealed that majority of the population in Africa do not have any supply of electricity, and the power producers are unable to meet the high call for power.

GIS can be applied in spatial analysis to determine load of electricity on transmission lines to find out location feasibility, and study resource market dynamics in Africa (ESRI, 2005).

In a comparative analysis of two blocks within the African continent, the International Renewable Energy Agency (2012), have noted that almost all countries at the North of Africa are fully electrified but the rate of electricity distribution in sub-Saharan Africa is only 35% and much lower in the remote areas. Fabini *et al.* (2014), narrowed the argument by establishing that easiness and availability of electricity still remains uneven as it has been estimated that close to 550 million populace need electricity in sub-Saharan Africa. For about 48 countries in Africa, majority of the population have limited or no access to electricity at all and as a result, about 30 out of 48 countries experience daily blackouts (IRCA, 2012).

ESRI (2005), have outlined that, the Republic of South Africa was the seventh largest electric company in the world per its generation capacity and sales. In further explanation, South Africa's electrical requirements provide its citizens with more power which is close to 50 percent of the electricity produced in Africa.

In Uganda, it has been established that the ever-growing demand for electricity has exceeded real consumption. This is due to limited supply which has exasperated the current load shedding that is imposed almost daily on urban consumers in Kampala and its environs where demand is deemed greatest (Kaijuka, 2006).

Many methods to reduce high demand predictions, originally used social science methods such as research, longitudinal studies and stated preferences for critical assessment and willingness to pay (Fabini et al., 2014).

ESRI (2010), has outlined GIS functions to aid in electricity conveyance from the source production to the final destination. In Ghana, the Volta River Authority (VRA) produce power as utility. Eskom is a company in South Africa which engages in the production and distribution of electricity in the country. Kaijuka (2006), has reiterated that Ghana's Akosombo dam, is one of Africa's largest hydropower plants and its

contribution to the economy is very great. Similar in Uganda, the electric power supply system is hydro dominated which is nearly 100 times greater than any other source of power generation (Kaijuka, 2006). This ensures efficiency in electricity consumption.

This project is needed to assist administrators to establish effective policies and plans to enable them find out the possible alternative means in case of emergency (Brenner, 2014). The transmission and distribution are controlled by operations in these areas in order to meet the goal of making electricity accessible and affordable to all of Ghanaians by 2020 (Soumonni, 2013).

1.2 Problem Statement

The power sector in Ghana has been in difficulties in terms of production and distribution for a very long time. The high rate of increase of people has increased the consumption of electricity in the country. According to World Bank report of 2013, ECG had registered a down turn in revenue of US$ 16 million in 2011, US$ 44 million in 2012 and US$ 60 million in 2013. Due to the huge characterized falls in the revenue level, losses in the energy sector is great and also huge (Nawaz-ul-Huda *et al*., 2012). The re-occurrence of problems in the power sector are mostly seen in the distribution of electricity. These problems have led to economic depression crippling business men and women in the industry (Morimoto & Hope, 2004). Indeed, the major problem or challenge faced by ECG in their power distribution and supply are system losses. These systemic losses are due to commercial and technical losses. Commercial losses are fundamentally unlawful connections, metering challenges, problems in cost allocation as well as collection difficulties. Also, technical losses are mainly due equipment operating inadequacies, old and out of date gadgets.

All these problems can be attributed to lack of access maps of the area and up to date information on customers, assets and their locations. Considering the problems

enumerated above, it therefore warrants for a study to be conducted to find a lasting solution to the menace.

1.3 Justification

Revenue collection rather seems to be a major challenge for ECG. A critical perusal of the ECG historical record, 2012 shows that system loss increased from 20.72% in 1996 to 26.49% in 1999 and decreased to 22.64% in 2000. It increased sharply from 22.64% in 2000 to 26.54% in 2004. In 2009 ECG incurred a system loss of 26.0% and decreased to 23.47 in 2012. These show that quite a little has been done to curtail the situation. The major causes of these system losses are illegal connections, metering problems, billing challenges, collection challenges, inadequate equipment capacity, and old and obsolete cables (Energy Commission, Ghana, 2013). This has shown in Ghana's energy producing companies, including the Volta River Authority (VRA) and Independent Power Producers (IPPs). This project proposes the implementation of spatial technology to provide web application for ECG to track customers and assets to reduce system losses. Also, spatial technology in the form of a web based application will provide efficient billing and collection system or platform for revenue mobilization. This system will enable ECG the ability and ease for financial accuracy and growth.

1.4 Research Questions

To be to arrive at the objectives of the study, the underlisted research questions will be answered:

- Which factors account for revenue loses to the Electricity Company of Ghana?
  - What are the impacts of these loses to the Electricity Company of Ghana?
- How do ECG locate their assets such as; meters, substations, transformers and poles?

- How do ECG track their customers?
- By which mode do customers asses their bills?
- How do ECG maintain their revenue stream?

1.5 Aim and Objectives

The aim of the study is to enhance ECG Business using GIS as a tool with the application of spatial technology. This spatial technology was developed via a web based platform for effective and efficient operation of ECG business in relation to revenue mobilization.

The objectives of the study are to:

- Produce a web based application to help ECG locate and track their assets such as, meters, substations, transformers and poles with ease for routine maintenance.
- Produce a web based application to help ECG locate and track customers and their bill information easily for efficient revenue mobilization.

1.6 Scope of the Study

Geographically, the scope of the study looks at the evaluation of the current ECG operating system at Adentan municipality in the Greater Accra region of the Republic of Ghana. But thematically, it seeks to develop a web based application for efficient and effective revenue mobilization.

1.7 Organization of the Thesis

This research is structured into six chapters. Chapter one touches on the background of the study, problem statement, aim and objectives of the study, scope of the study and the organization of the study.

Chapter two reviews literature about the organogram of ECG, their functions as well as their revenue mobilization strategies. The third chapter reviews literature about spatial and technical studies related to the research topic.

Chapter four outlines the methodology and conceptual design of the web based application, ethical considerations, shortfalls and assumptions of the study. Chapter five outlines analysis, discussion of findings and the web based application system design. Chapter six finally gives out the recommendations and conclusion on the research study.

CHAPTER TWO

2.1 The Electricity Company of Ghana (ECG)

This section of the document is retrieved on 12th May 2016 from http://www.ecgonline.info/

The Electricity Company of Ghana is a limited liability Company entirely belonging to the Government of Ghana and is managed under the Ministry of Energy. According to ECG, the Company was embodied under the Companies Code, 1963 in February 1997. It began as the Electricity Department on 1st April, 1947 and subsequently the Electricity Division in 1962. It later became a corporate entity and was named Electricity Corporation of Ghana by NLC Decree 125 in 1967.

Until July 1987, ECG was responsible for the distribution and supply of power in the country. The Government created the Northern Electricity Department (NED) as a supplement to Volta River Authority (VRA) in 1987 which took over from ECG the responsibility of managing electric power distribution in Brong-Ahafo, Northern, Upper East and Upper West Regions. The Company (ECG) is however responsible for the distribution of electricity in the southern part of Ghana namely, Ashanti, Central, Eastern, Greater Accra, Volta and Western Region.

2.1.1 Mission and Functions of ECG

The mission of ECG is to supply quality, reliable and safe electricity to Ghanaians. This power is supposed to support socio-economic growth and development of the country. The company has the responsibility to:

1) Buy huge power from the Volta River Authority or any other supplier and distribute it to consumers.
2) Establish, install, gather, maintain, reconstruct, use or abandon transmission machines when they become obsolete.

3) Embark on country wide electricity provision.

4) Carry out any activity to provide superb, stable and accident free electricity services.

2.1.2 Structure of ECG

ECG is categorized into Head Office, Regions and Districts. There are nine departments who work hand-in-hand with the Managing Director forming the top management that sees to the running of key functional areas in the head office. These areas are;

- Accounts
- Finance
- Operations
- Legal
- Engineering,
- Audit
- Material & transport
- Human resources
- Customer services

On record, ECG works in six administrative regions of Ghana. These are Ashanti, Central, Eastern, Greater Accra, Volta and Western Region. In each operational region, there is a regional office and in each District a district office. There are seventy-seven district offices scattered over the ECG operational regions.

2.2 The Distribution of Electricity in Ghana

Institutions that produce, convey or distribute electricity are called power utilities. They have the ability to serve fundamental human needs for a better lifestyle. In Ghana, power production, transmission and distribution are performed by different organizations. The Volta River Authority (VRA) is responsible for the electricity

production. Ghana Grid Company (GRIDCo) is also responsible for electricity transmission. Electricity Company of Ghana (ECG) and Northern Electricity Department (NED) are responsible for the distribution of electricity. The Northern Electricity Department (NED) is however directed by the VRA. The electric power market forms the wholesale and the retail market. VRA and GRIDCo dominate the wholesale market whilst the ECG and NED dominate the retail market. ECG is the major national distributor and retailer of electricity power in Ghana. It has been authorized to provide quality electricity services to support socio-economic development of Ghana. It is responsible to give its customers quality and reliable services.

2.3 Billing Process, Revenue Mobilization and Methods Employed by ECG

2.3.1 Billing Process

One major criterion in the billing process of electricity is the metering and meter reading system. According to Raikar et al. (2014), electronic energy metering is the straight billing interface between power grid and users. It has undergone many improvements in the past years. However, in postpaid system, there is no restriction in the use of electricity from the consumer's side. This results in wastage. Menasha *et al*. (2014), have established that in advanced countries, a budget payment plan is offered to all current and potential residential customers. The commercial accounts are established monthly in order to accurately budget payment plan that will match closely with the customer's actual consumption.

The metering system in billing can be improved by a mobile phone with a direction map called Walk Order Map. This has the path of houses covered in a day and whenever a meter is read, the particular meter is embossed with a mark confirming that the reading is already captured (Rathnayaka et al., 2013). The exact bill is however, delivered at the

end of the month. Expatiating on this point means, manual calculation are not done by Meter readers rather the calculation is done in the system.

A two-part tariff for residential and single tariff for non-residential customers is another system of billing proposed by the Electricity Company of Ghana. According to the Electricity Company of Ghana (2013), for easy tariff execution and an effective way of solving the compound house problem, houses have been put together as one. This ensures equity and fairness of billing users.

Ghana's Public Utility and Regulatory Commission (PURC) sets another billing process called electricity tariffs. This is in line with major stakeholders including producers, distributors, and final user representatives (Power System Energy Consulting, 2010).

Antmann (2009), has established that connection delays in India were drastically reduced by the introduction of a spot billing system which allowed meter reading in the presence of customers. This stopped billing complaints. A different and more improved form of metering which is used by solar power producers is called the Net Metering. Reinstalling the financial and economic status of utility companies is always paramount. As it has been highlighted by the National Renewable Energy Laboratory (2002), grid-connected systems mostly use a billing process called "net metering" or "net billing in which power generated by the solar modules that is not used by consumers is immediately returned to the utility grid. If a household system produces enough energy in any given month so that the user does not have to draw from the grid, the customer will receive a small monthly bill.

On the other hand, system of Multiple Year Tariff Order (MYTO) have been practiced by Nigeria power producers and distributors. Ajayi et al. (2013), in their study across the Nigerian Power Sector found that the Multi Year Tariff Order (MYTO) is the tariff vehicle designed for the Nigeria Electricity Market. This is a blended way to form

efficient net industry revenue requirement, and deliver a 15-year plan for proper tariff in the sector.

Another electricity distribution and billing mechanism is by using geo-spatial consumer price indexing which is easy to get all the data about poles, distribution transformer & consumers (Govindara and Nailwal, 2013). Consumer indexing helps to reduce electricity theft. This is by performing energy auditing consumption to find out the maximum consumption area and set the different ways to collect the tariff or bills. Alagh (2010), has noted that India has developed a billing mechanism called Revenue Management and Monitoring module with an IT based application drafted to deliver a complete and centralized record of the billing and revenue recuperation from various consumers.

2.3.2 Revenue Collection

A sound revenue system for the Electricity Company of Ghana is an essential precondition for a strong and reliable service to its customers. In the delivery of electricity to final consumers, losses refer to the amounts of electricity that do not reach the final consumer. Antmann (2009), has identified two components of revenue loses to electricity companies as technical and non-technical. The former occurs as a result of power wastage in electricity system components such as transmission and distribution lines, transformers, and measurement systems.

The latter is seen to consist mostly of electricity theft, non-payment by users, and errors in accounting vis-à-vis record-keeping. The Ghana power sector is combating huge problems of reduced revenue. Energy thefts and network losses are causes of this situation. The Electricity Company of Ghana is made up of two parts in terms of collecting revenue from customers or consumers. It has been revealed that these are;

the Bulk Supply Tariff (BST) and Distribution Service Charge (DSC) which are summed up to be termed End User Tariff (EUT) (Power System Energy Consulting, 2010). The End User Tariff is seen as the retail price charged to the end user by the ECG. The value and structure of tariffs however, regulate not only market entry, but also how much power is created by existing plants. Utility costs for infrastructure and customer service are largely fixed, whereas commodity costs are variable to the ECG. According to the National Renewable Energy Laboratory (2009), decoupling is one rate adjustment mechanism that can be employed by power companies to maximize the quantity of electricity a utility sells and the revenue it generates. This is to retrieve the fixed costs for provision of services to customers. It is noted that a utility's revenue from fixed costs remains at the level regulators determine. A fair in-coming return is expected on power distributed to customers. Technical or engineering method is one important way to increase revenue collection by stopping electric theft.

The necessary steps as indicated by Smith, (2004) are to reduce losses and improve collection. These steps include; improving power lines, cables and transformers. Information technology is key in the monitoring systems as well as installation and maintenance of modern metering systems. ECG interface for both the organization and its consumers is another important factor. In furtherance, Ajayi et al. (2013), have reiterated that the Multi Year Tariff Order (MYTO) is a convenient revenue collection mechanism which is used to mark wholesale and retail prices.

Certainty, cost recovery, and stability are the principles in which Nigeria electricity market is based.

Govindara and Nailwal (2013), have found that a web based application using ASP.Net 2008 with C Sharp (C#) is efficient to calculate the energy consumption by the households. This enables consumers to know how much units their equipment and gadgets consume in a month to allow for correct bill calculation tariffing. Another

mechanism for tariff collection has been stream lined by the ECG from 75 to 85 to enhance customer relations as well as service quality (Resource Center for Energy Economics and Regulation, 2005). This will entice consumers to pay their bills regularly and correctly. Alagh (2010), has indicated that the National Grid and a Power Trading Corporation in India have shown growth of the power market, power trading organization and power exchanges. This is because the revenue collected were huge and have enabled availability of power sending signals to market participants for bigger returns in terms of tariffs and bills.

Rathnayaka et al. (2013), have opined that the problems associated with the major loses in terms of revenue related to the Manual Billing process is suggested to use a mobile device and Web based system. This will eliminate most of the errors prone to manual revenue collectors in their calculations and manual data entering.

To meet the increasing demand for electricity by ensuring fuel diversity and reliability, power firms must invest in new power plants to help maximize revenue (Edison Electric Institute, 2006).

2.3.3 Methods of payment

Adequate and efficient transmission and distribution of power in developing economies with high growth of electricity demand are important. High and scientific methods are employed nowadays by power companies as a measure to effectively and efficiently collect their utility bills. It has been postulated by the Electricity Company of Ghana (2013), that prepayment metering, a strategy to tackle challenges that come up with revenue collection across its operational areas. This has been viewed as cost effective since it makes it easy to assess and quantify their revenue collected. But it has been difficult to install it to rural communities due to weak economic base and also, poor communication in terms of road networks. Antmann (2009), in his findings from India

noted that, more than 2 million information-technology (IT) and high-quality commercial meters have been installed to ensure convenience in payment.

To ensure financial viability of the electricity industry, Ajayi et al., (2013), have established that a critical method in the revenue collection must be a modern and accurate meter systems with well-grounded communication facilities. This must be deployed across the industry production and supply chain to determine and measure energy production and usage with centers within proximity for collection of tariffs and bills.

The Resource Center for Energy Economics and Regulation (2005), have clearly stated that the automatic price adjustment formula is a method affecting the Bulk Supply Tariff (BST) and the Distribution Service Charge (DSC) for the end user tariff system on consumers.

However, Alagh (2010), has cautioned that trading of power at high rates has a distortion effect on consumers who will be paying very high prices for such purchased power.

Balancing this in the tariff charged to users will lead to large financial losses which will have negative ramification on the power companies.

Also, 'Time of Day" is a crucial method for collecting revenue from residents who possess more than one meter. Explanation of how to bill commercial and industrial accounts require the customer to meet certain criteria in order to be billed per one meter charge (Menasha et al., 2014).

Similarly, Rathnayaka et al. (2013), has noticed that people known as meter readers visit houses, read the meter, and then manually calculates the amount to be paid.

2.3.4 Types of revenue collectors

Revenue collectors for the power companies are mostly their employed workers who have been assigned for these activities. The private companies that produce or generate electricity in Ghana sell to VRA or ECG at the wholesale price which is in tend sold to the final consumers or users (Resource Center for Energy Economics and Regulation, 2005).

ECG collect their revenue through their specified workers designated for this duty. Alagh (2010), has posited that Utilities companies have involved the private sector in minimizing distribution losses and have resorted to giving authorization to companies to provide services such as metering and billing. This is to ensure higher revenue collection.

On the contrary, a sophisticated IT mechanism called the GIS based system have been used in India as a utility bill or tariff collector. GIS solution for analyzing and optimizing power revenue have been employed to detect network and commercial losses which computerizes spot billing for optimum revenue mobilization (Alagh, 2010).

Menasha et al. (2014), has revealed that for ECG revenue collectors to receive higher revenue, they should print out the tariffs on paper and route the document and distribute to customers to ensure there is assurance through review. The required notification of current of utility rates is, to review in detail to confirm that it matches the rate tariffs.

Adding to this, one technology ECG has introduced in place of its manual revenue collection practices is the use of data loggers for Non-Special Load Tariff (NSLT) customer billing in which it instantly validates meter readings and process bills for printing and distribution (ECG, 2013). This has come to end the challenge of the company over concerns of billing, revenue collection and debt management.

However, there are weird situations where people from different arena intervene in the revenue collection process. Smith (2004), has revealed that in 1998, the corruption menace in Pakistan degenerated to a level that, the government stepped in and employed 35,000 army men to recover utility bills and dues. They conducted house-to-house raids in inspecting for any tampering of power meters and illegal connections which boosted the revenue level of the power company.

2.3.5 Payment challenges

The power sector in Ghana has faced some serious problems in the past years due to insufficient electricity supply resulting to the passing of load to customers. Affordability is one major challenge faced by electricity consumers during payments. Fankhauser and Tepic (2005), has posited that affordability problems arise when there are no better improvements in the quality of infrastructure services to poor consumers.

These are only possible if the underfunded power is put on a sound financial footing whereby mitigating this problem will not lead to a high financial burden on low-income households. This is an important distinction, where coverage of electricity to these areas are low and connection charges are prohibitively high making most people unable to pay.

Customers are placed within the distribution network where residential and nonresidential customers are put on different lines (Power System Energy Consulting, 2010). This leads to dissipation of electricity on the part of the consumer. Due to improper planning in terms of consumer consumption, ECG has more than 2 million residential and commercial customers with 1,150 industrial customers (ECG, 2013; Raikar et al., 2014). The total cost of electricity to consumers higher than the existing revenue from tariff collections by the power providers. The economic cost is huge when we consider secondary issues as destruction of appliances, consumer costs from

alternative supply efforts and lost foreign direct investment (Power System Energy Consulting, 2010). These are passed on to consumers.

Again, electricity theft is another major challenge which burdens users who pay their bills correctly and in the long run reduces the revenue computation of the ECG (Antmann, 2009). The amount of theft may be small in terms of the electricity generated.

More so, corruption has been identified as a serious challenge of utility bill collectors. Smith (2004), has realized that corruption rises and becomes endemic as power sector employees favor consumers by issuing low bills and allowing illegal connections. This is encouraged by their political leaders who come in as shields to disallow prosecution of their followers. Other forms are when employees of the power company receive bribe and record the meter at a lower number than the actual. The consumer at this point pays lower bill and the meter-reader earns unofficial salary.

Due to the negative return on revenue, power sector companies have posted meagre net revenues, because of insufficient tariffs. Limited revenue collection has resulted in poor financial positions of the power organizations making it extremely hard to keep and expand the system infrastructure, leading to deterioration in quality supply (Ministry of Energy, 2010).

This according to the Resource Center for Energy Economics and Regulation (2005), a more evident challenge is that majority of the citizenry remain without access to electricity delivery. It is expensive to construct transmission lines to serve smaller communities especially when the people are relatively poor and cannot pay for their bills. This problem is purely a management inefficiency. The transmission and distribution systems do not deliver quality service to the users. The users do not realize the value of the power supplied to them find it very difficult to pay their bills. Alagh (2010), in his research found that losses to power companies are technically incurred in

transmission and distribution of electricity to the consumer. This represents cumulative inefficiencies that estimates commercial losses to the system. An established challenge identified by Menasha *et al.* (2014), is in the form of errors that occur in meter reading. These includes; missing intervals, high usage, no usage, outage reporting, meter tampering, meters without a corresponding billing account and water leak that represent huge inadequacies in the system.

Another major problem which have been recognized by Rathnayaka et al. (2013), was that customers complain about incorrect bills due to inaccuracies in manual calculation. Customers are dissatisfied with the services they are provided by ECG. Consistent power outages are damaging to businesses and households from both economic and social point of view. Also the number of outages per annum is the prime factor of poor service quality (Tallapragada, 2009). This is a great disincentive to consumers in the payment of utility bills and tariffs.

2.4 Features of MapGuide for mapping

MapGuide Open Source is a web-based platform that allows users to develop and deploy web mapping applications and geospatial web services (17 June 2016. Retrieved from https://mapguide.osgeo.org). MapGuide provides an interactive viewer that includes support for feature selection, property inspection, map tips, and operations such as buffer, select within, and measure. MapGuide includes an XML database for managing content, and supports most popular geospatial file formats, databases, and MapGuide can be deployed on Linux or Windows, supports Apache and IIS web servers, and offers extensive PHP, .NET, Java, and JavaScript APIs for application development. MapGuide Open Source is licensed under the LGPL.

2.5 Concluding Remarks

The ECG of Ghana is tasked to distribute power to six regions of Ghana namely, Ashanti, Central, Eastern, Greater Accra, Volta and Western Regions. A sound revenue system for the Electricity Company of Ghana is an essential pre-condition for a strong and reliable service by the organization to its customers. The two major components of revenue lose to electricity companies are technical and non-technical where the former occurs as a result of power dissipation and the latter is seen to consist mostly of electricity theft. The main billing system of ECG is the metering process where consumers either pay after using the power at the end of the month or buy credit on cards for use. The payment centers are located at the various offices and other places deemed appropriate by the company across its area of jurisdiction. However, affordability is one major challenge faced by electricity consumers during payments.

CHAPTER THREE

3.0 Geomatics and ECG Business

Gomarasca (2010), has defined Geomatics as a systemic, multidisciplinary and integrated way of picking instruments. Newcastle University (2009), has opined that

Geomatics is the study of the land using surveys, mapping and Geographic Information Systems (GIS) to develop a precise digital profile of our environment. GIS is a subset of Geomatics. It is a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes (Gomarasca, 2010).Geomatics impacts in realistic manner by the module Geographic information systems, which seek to give a thorough understanding of, and competence in ECG businesses.

GIS in Geomatics is composed of sets of data, hardware and software. Sharma et al. (2013) explained GIS to basically mean, a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data referenced to the Earth. GIS is

an essential tool of modern technologies. It considers growth opportunities for fault analysis. This is by optimization of networks, load forecasting, cost estimation and selection of suitable areas. GIS as a subset of Geomatic survey has been demonstrated to be a feasible system, which permits utility engineers to develop and concentrate on practical skills very much over only understanding data. It also, analyzes power system networks efficiently and accurately.

Database is a valuable ingredient in setting goals for ECG business. (Resource Center for Energy Economics and Regulation, 2005**)**. This can be grouped into two main types that is spatial and attribute data.

The spatial data describes the location and the shape of geographic features and spatial relationship of map features. Attribute data describes map features. The two main forms of spatial data are raster and vector (Resource Center for Energy Economics and Regulation, 2005**)**. In the vector data, geographic objects are shown by points, lines and polygon. Vector data are more acceptable for features that have discrete boundaries such as roads. Raster data is composed of a regular grid of cells or pixels where each cell has an individual value that in the coordinate system. The cell size indicates distance and geographical position of objects. The raster data is most appropriate format for arithmetic operations among cells. A mathematical procedure called topology is used for representing spatial relationships among the objects.

GIS in Geomatics software and hardware are used as tools for storing, analyzing, interpreting, updating, displaying information and maintaining the system (Gomarasca, 2010). Geographic Information System (GIS) in Geomatics is a computer designed to accept large volumes of spatial data derived from variety of sources. This data can be efficiently stored, retrieved, analyzed, modelled and displayed according to user defined specifications. GIS is described as a fundamental tool in the power utility companies. The areas are as follows; suitability analysis in construction of substations and high

voltage lines, the optimum route finding, the profile analyses, the engineering design of towers and wires, and the cost estimation, power outage and load study analysis.

3.1 Components of GIS

A functional GIS combines five key components: hardware, software, data, people, and methods (ESRI, 1998).

3.1.1 Hardware

Hardware is the computer on which a GIS operates. Today, Geamatics contain GIS software which runs on a vast range of hardware types, from centralized computer servers to desktop computers used in standalone networked configurations (ESRI, 1998).

3.1.2 Software

According to (ESRI, 1998), GIS software provides the functions and tools needed to store, analyze, and display geographic information. The key software components are:

- Geographic Information Input and manipulation tools A database management system (DBMS).
- Geographic query, analysis, and visualization tools.
- A graphical user interface (GUI) for easy access to tools.

3.1.3 Data

The essential part of GIS component is the data. Geographic data and related tabular data can be collected in-house or purchased from a commercial data provider.

3.1.4 Methods

A working GIS operates in geomatics according to a well-designed plan and business rules. These are the models and operating practices unique to each organization.

3.1.5 People

Geomatics technology with GIS is limited without the people who manage the system and develop plans for applying it to real-world problems. GIS users are different from technical specialists who design and maintain the system. Using GIS with Geomatics helps the users to perform their work accurately every day. This Chapter reviews the applications of GIS and Information technology in utility management.

3.2 Geomatics-GIS and ICT in Utility Management

Utility companies around the world are adopting new plans to operate and enhance their service provisions. ESRI (2005) has postulated that GIS holds great potential for generation and transmission organizations via quick process of influencing mapping, database information and automating work processes. In the competitive world today, the primary goal of every utility manager is to take utmost advantage over its resources to deliver quality services. The application of GIS stands unique to this work. According to ESRI (2013), GIS gives out more than a map. It uses geographic to deliver the underlying infrastructure for all the major happenings and components of a utility business.

Many utility managers have become more aware of the importance of GIS for enhancing day-to-day operations. GIS can be used closely to model utility networks and combine other related types of data, such as raster images and CAD drawings (ESRI, 2013). GIS spatial selection and display of tools allow users to visualize scheduled work, monitor ongoing activities, recurring maintenance problems and historical information (Meyers, 1999). GIS can be used to carry out many other operations and maintenance with the application of Geomatics.

In the competitive world today, a succeeded utility must take outmost advantage of each of its resources, combining geographic and other corporate data to increase revenue of the company.

If one pauses to consider the wide angle of utility operations, it is difficult to come across any practices that do not have a spatial element. Equipment, facilities, crews, customers, even system events have an aspect that can be associated with a physical location. In fact, Geomatics and GIS underlies almost all your information needs.

3.2.1 Enterprise GIS

Enterprise GIS is a growing discipline in the field of information technology which is giving better answers in the representation of geographical data. Enterprise GIS is explained as a platform which facilitates collaboration by unifying underlying data infrastructure. Workflows with other key utility information system are vital to control asset, work and outage management as well as field force automation (ESRI, 2007). An Enterprise Web GIS Solution combine the knowledge of complex GIS systems with the acceptable applications of information technology. This is a design that is done to implement an end-to-end system that deliver geospatial data services, tools and applications on the web (Rao and Vinay, 2009). ESRI (2005), continued to highlight that an enterprise ArcGIS for utility companies provides spatial query and geographic visualization to virtually every detail concerning their operations. The Enterprise GIS software enables the electricity company to have a peaceful business system that works in harmony by providing a wide range of corporate and integrated solutions.

3.2.2 Amplitude Modulation (AM)/ Frequency Modulation(FM)/GIS

In the early 1980's, GIS became popular where minicomputer-based systems replaced the mainframe-based technology. AM/FM systems which relied on hierarchical or network data models for representation and storage of facilities data began to exploit

this new platform. Meyers (1999), has established that there are three key components of AM/FM/GIS in terms of utility data model.

First is the exact picture of locations of all physical features, including lines, devices, and structures, which make up the network. The second characteristic is the ability to integrate the topology to determine a model of the utility which produces an accurate representation of how the system operates. The final crucial aspect deals with the ability to integrate a utility data model proportionally with spatial representation of facilities with other utility databases such as customer, accounting and work management systems.

According to Shamsi and Fletcher (2000), AM/FM places less emphasis on graphics detail or precision and more emphasis on data storage, analysis and reporting whilst GIS considers location and topology that is spatial relationships. This however, defines AM/FM as a high digital infrastructure management database.

3.3 Application of Geomatics-GIS in Electric Utility Company

Geomatics with GIS is used to make informed decisions about the best places to build roads, bridges, buildings and offshore oil rigs. The Power Distribution Companies continuously engage in updating their consumer data and the associated electrical network attributes where Geographical Information System (GIS) technology plays a significant factor. In the mapping of consumers and electrical network assets, a geographical base map helps to determine the consumer electrical connectivity vis-àvis the cost. Through Geomatics with GIS, a web based application that uses ASP.Net 2008 together with C-Sharp (C#) program have been designed. This is to measure the energy consumed by household per their equipment ratio for the consumer to know how much units an equipment consumed the past month (Govindaraj and Nishchay, 2013). In a similar fashion, Brisaboa et al., (2012) have proposed another form of GIS application called the Query Evaluation Service where electricity companies answer questions in

their billing system. This is done by using the index structure to the queries posed by the users. An AM/FM/GIS database is used by electricity companies for realtime trouble call for monitoring equipment. The reason is to identify the location of a problem, possible consequences and even the best method for restoring service to affected consumers (Meyers, 1999).

Also, GIS and AM/FM are different but both are very useful in specific applications and circumstances where the former can help locate the worst transmitting line whilst the latter helps to prioritize work required to bring the worst line up to a minimum operating standard (Shamsi and Fletcher, 2000). As a proof of the concept, ESRI (2005) have found in the Asian region that GIS has been used to show market data by using interpolated surfaces of actual Locational Marginal Pricing (LMP) in a view of the direction of grid affecting people in that area. Real-time operation characteristics for the system is an effective way to incorporate LMP into the pricing and market response of consumers.

GIS is playing a vital role in the field of planning and analysis with respect to the geographical dispensation of electric poles in an electric system and detailed information about each electric pole such as; age of pole, height of pole, if a street light is on the pole and the number of transformers attached to a specific electric pole (Sharma *et al*., 2013).

3.3.1 GIS in information retrieval

In a GIS process known as pole to building relationship, Govindaraj and Nishchay (2013), have recounted that information required concerning a low tension pole and the name of the consumer is then retrieved by clicking on a button. This shows the low tension pole, the building position as well as the owner or user.

Geographic Information Retrieval (GIR) system has been designed which proposes a new system of architecture, index structures, and other parts in order to retrieve documents and information both geographically and thematically important in answering queries input into it (Brisaboa et al., 2012). Another simplest form of application for information retrieval as proposed by Meyers (1999), is a query tool called FM, used by many utility personnel executives to customer service representatives which provides a link between spatial and attribute facilities for companies.

Again, GIS uses locational marginal pricing (LMP) mechanism to retrieve a unique price for each node or location on the transmission system. This method brings no congestion in the transmission of information to consumers, since a level LMP is ensured throughout the transmission grid or system. The web GIS server architecture has web server, application server, map server and data server as its four components. According to Rao and Vinay (2009), the web server responds to send requests from the web browser, the application server is a software that develops, deploys and manages large number of applications in a distributed system. The map server is described as the brain of any web GIS application whilst the data server manages data in both relational and non-relational database management systems.

3.3.2 GIS in maintenance and monitoring

Various monitoring and maintenance mechanisms have been developed from different manufacturers on this subject. A maintenance as well as a monitoring tool in GIS is the switchgear compartment which prevents leakages in the distribution of power to consumers. According to

Rayon et al. (2012), the modern monitoring steps in GIS authorizes much more reliable interpretations than previously conventional solutions because they are run by digital processes either than analogue.

The AM/FM/GIS applications are particularly important to power utility system managers in monitoring and maintenance. According to Shamsi and Fletcher (2000), this provides a basis for comparing the geographic patterns of probable transmitting deficiencies and actual management efforts for efficient control and operation.

Likewise, Bartelme (2012), has cautioned that a geospatial data framework should be well kept since it provides a basis for current and future GIS technology, for geospatial answers to be potentially implemented and applied. In addition to providing asset management for geospatial data, there is a file tracking application. This supports and creates documentation regarding low and high transmission grid for future safety in the monitoring and maintenance processes (ESRI, 2005).

3.3.3 Data Management in GIS and Geomatics

Data is the foundation of a utility Geomatics and GIS. According to Meyers (1999), GIS data may be categorized into three main types. These are; low, medium and high per average cost of acquisitions specifically in electricity companies or to the wider sense utilities companies. According to Shamsi and Fletcher (2000), a utility Geomatics/GIS database consist of graphic features and labels, with links or pointers related to features which are organized into a series of vector layers. In a base map; points, lines or polygons. They are identified with a geographically controlled network which serves as source information. A modern data base model in Geomatic GIS is described in a standard format called Unified Modeling Language (UML). This presents the data in a structured, object-oriented form with three essential components called attributes and relationships (ESRI, 2007).

Geomatic data is more or less basic structure, which are managed in GIS as points and lines for vector-based applications and as pixels and images for raster-based applications (Bartelme, 2012). These are basic data serving as the building blocks for

more complex ones to be built later into the model when the need arises. An exclusive GIS Data Server manages data. GIS in Geomatics spatial or non-spatial data creates a relational or non-relational database management system (Rao and Vinay, 2009). A Geomatic system will manage data by integrating spatial data with GIS data sources used by most organizations to organize, maintain and manage from the geographical setting (Sharma et al., 2013).

3.4 Concluding Remarks

Geomatics is one branch of earth survey and positioning which includes GIS. GIS has been noted to be one of the most important new technologies which considers growth opportunities for fault analysis, optimization of networks, load forecasting, cost estimation and selection of suitable areas for utility companies. GIS switchgear has a maintenance as well as a monitoring tool for the prevention of leakages in the distribution of power to consumers in order to increase rate. Also, GIS has been used in locational marginal pricing (LMP) mechanism to retrieve a unique price for each customer on the transmission system. Data management in GIS is by integrating spatial data with Geomatic data as used by most organizations to organize and maintain necessary for ECG setting. Geomatics and GIS spatial technology is key to rectifying the revenue loses in ECG.

CHAPTER FOUR

4.0 Methodology

This chapter introduces the methodology which was used in the development of the project.

The task of developing the ECG-GIS web based Customer Information System for the

Electricity Company of Ghana (ECG) was illustrated using the System Development Life Cycle (SDLC).

The cycle is made up of five phase models (Romney and Steinbart 2002) which are:

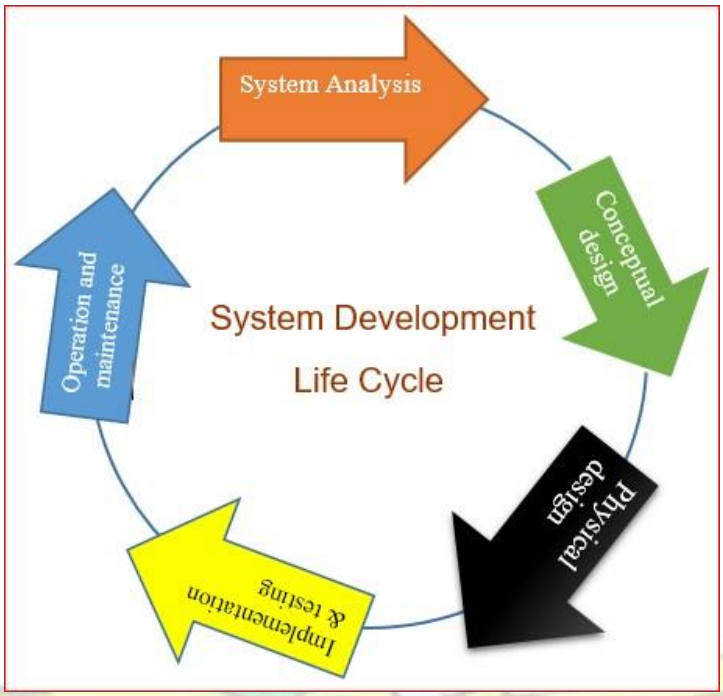

Figure: 4.1 System Development Life Cycle

SDLC is chosen as a methodology for the Customer Information System because it is a continuous process of creation, maintenance, enhancement and replacement of information system (Coronel and Rob, 2007). Rob and Coronel stated that successful information systems are subject to frequent evaluation and revision within this framework of SDLC (*ibid*)

4.1 System Analysis Stage

It more or less requires the accumulation of information on the existing system. A good knowledge on the system in place is rather relevant to put in changes to design the Customer Information System. (Khairina *et.al* 2009). The system analyst does more than solve current problems but also help handle planned expansions of the organization's business. The strengths and problems of the system are as well identified to shaping, improving performance and achieving objectives profitability and growth.

The general approach to understanding the system was to (Johnson and Walker 2001):

I. Interview key personnel and departments.

II. Map and Evaluate current customer processes and environment.

III. Determine data requirements, interfaces, and implications on the customer information.

The interviews were conducted in the case study areas as well as public utilities companies (ECG) and other government agencies and departments. The objective of these interviews was to identify customers and track their bill information easily for efficient revenue mobilization.

Mapping and Evaluation of the current customer processes and environment was also facilitated through interviews with key personnel. Key customer components such as: meters information billing, payments and complains were analyzed.

Sample data in terms of reports and other documents were retrieved from the departments for review.

The information and recommendations gathered in this stage provided a framework for the design structure of the customer information system. The information needs of system users are identified and documented. These needs are used to develop and document system requirements for the new system.

4.2 Conceptual Design Stage

Conceptual model describes business processes and are used to describe the new system to be developed. It illustrates the processes or activities that are performed and how data moves among them. The objectives of these models are:

1 To recognize the relevant requirements to be executed in the customer activities regardless of the level of technology in place.

2 To be able to track and locate ECG assets such as meters, transformers in the system.

3 To make quick analysis on customer bill information and support decision making.

4.3 Materials used

The materials used for the project ranged from computer software to the existing data on household meter connections to electricity grid. These were categorized into spatial and non-spatial data components. They included the following:

- A digital map of the study area.
- ArcGIS Desktop 10.3 Software
- Microsoft Office 2013 (MS Excel, MS Word, MS Access)
- Computer Hardware and peripherals
- Microsoft SQL Server 2014 Express Edition
- Microsoft Visual Studio 2015 Community Edition
- Entity Relation (ER) studio for data modeling

4.4 Flow chart of tasks

In undertaking the project, the various tasks and operations required were organized into a flow chart. It served as a guide in the course of the project and is captioned accordingly.

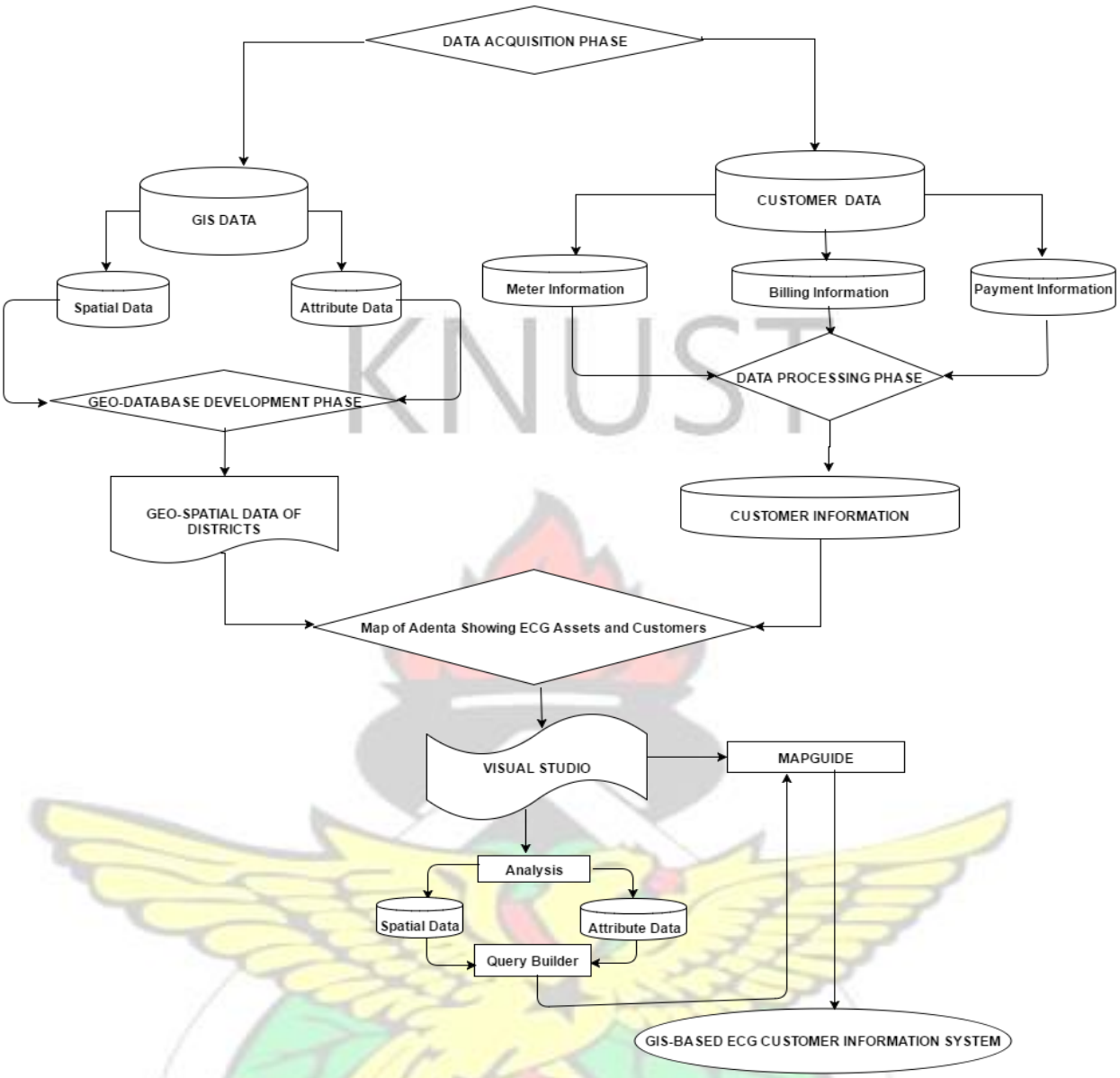

Figure 4.1: Flow Diagram Showing Methods Employed

4.5 Study Area

The study area for this project is Adentan Municipality. The Adentan Municipality is one of the districts in the Greater Accra region. It shares borders with Ga East Municipality to the west and Tema Metropolitan Assembly to the east.

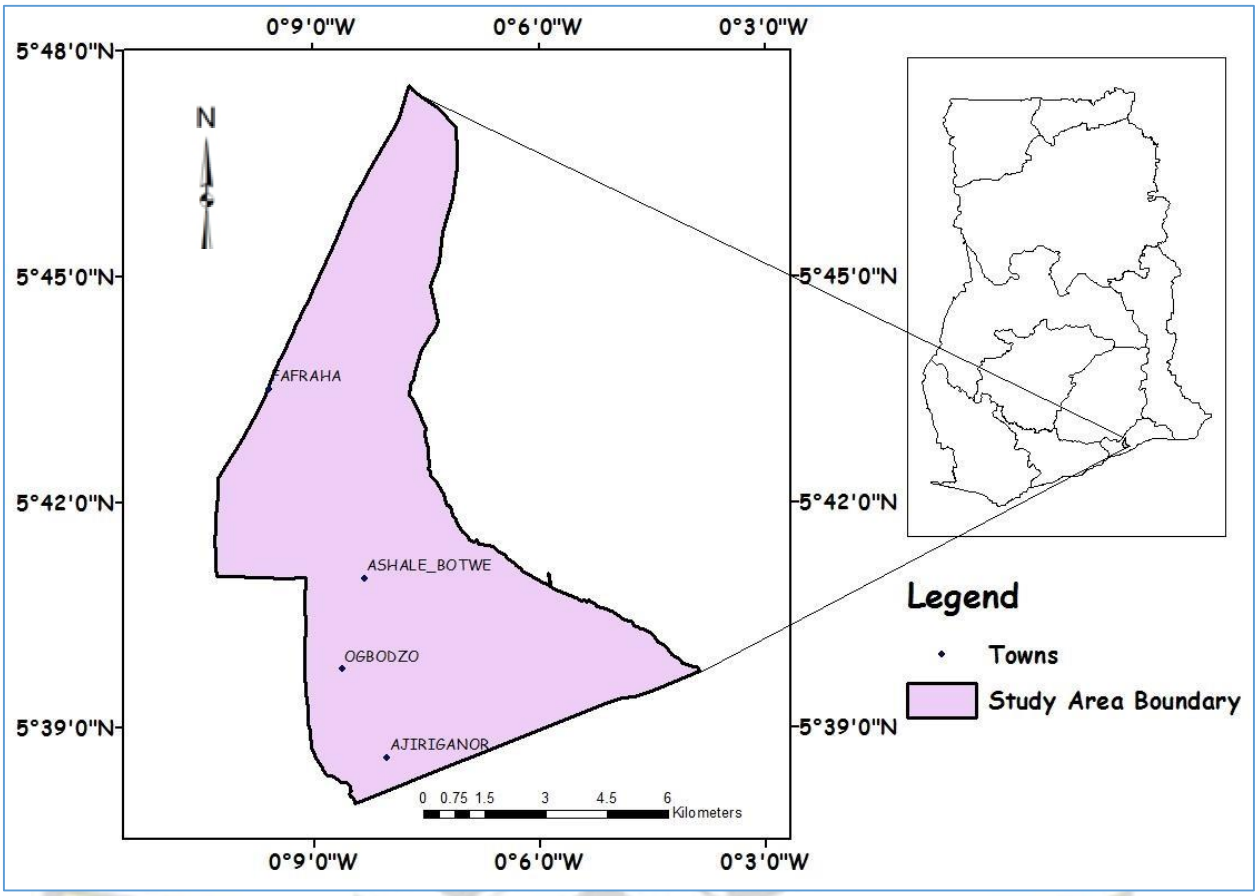

Figure 4.2 Study Area

In acquiring data for the project visits were made to the Electricity Company of Ghana (ECG) head office in Accra, Kumasi, the Adentan Municipal Assembly and other local level district offices. Adenta is the capital of the Adentan Municipality. It is about a 29 minute drive from Accra covering a distance of about 21Km (distanceform, 2013). It is a residential area with few commercial activities with a well-planned nucleated settlement pattern. It has a population of about 78,215 with density of 795.7 inh/km square and a land area of about 98.3 square km, (Ghana Statistical Services, 2010).

4.6 Data Acquisition Phase

The data acquisition for ECG asset mapping is made up of spatial and non-spatial data which form the basic foundation for the developed web-based application.

1. Spatial data

A Global Positioning System (GPS) Leica instrument was used for spatial data collection in the Real Time Kinematic (RTK) mode. Detailed information was acquired on the following:

1. Road networks
2. Structures (metered and unmetered structures, transformers, poles and substations)
3. Walls
4. Drains
5. Watercourse
6. Railway lines
7. Telephone poles

2. Non- spatial data

These are attributes associated with the spatial data. The non-spatial data include meter ID, customer name, meter type, phase usage class, activity name, telephone numbers, remarks, easting and northing coordinates for structures (centroid). These are recorded in excel and are linked with the CAD drawings with a common layer called structure ID.

4.6.1 Data requirement

The data used for modeling the Geo-database were grouped into four (4) categories: (i) Structures with meters

(ii) Structures without meter supply

(iii) Structures without meter connected from a meter.

(iv) Structures with supply but no meter direct

4.6. Data Processing phase

In this phase, the main software used was ArcGIS Desktop 10.3. ArcGIS Desktop which consists of a suite of integrated applications, including ArcMap, ArcCatalog, and ArcToolbox. The manipulation and integration of the software and tools in GIS environment results in the task of mapping, geographic analysis, data editing and compilation, data management, visualization, and geo-processing.

4.6.3 Attribute data entry

In ArcMap, new attribute values were entered when new districts were created. During spatial data entry, default attribute values which included automatically generated identity (ID) were observed. The attributes entered in the various columns include Region name, District name, Community name, Population, Electrification.

4.7 Geo-Database Development Phase

Under this phase, a relational geo-database (RGDB) structure was used. A geodatabase is the primary data storage and management framework for ArcGIS. Much simply identified as a household of spatial and attribute data. This phase handles all the various data in the ArcGIS as well Global Positioning System (GPS) coordinates.The main Software used to manage the geo-database was Microsoft SQL

Server Studio 2015 Express Edition and selected programming language was Structured Query Language (SQL). The data were stored in tables. Each table contained item of data called fields about a particular object (feature). The objects properties were arranged along the rows and the field (attribute values) arranged along the column. The entities identified were; Regions and district name then communities.

The entities identified constituted the ECG access geo-database.

4.7.1 The Logical Design

In order to implement the database design, it is necessary to map the logical data model in the schema. Each entity in the list was represented into table thus forming the database schema; the schema described how real world entities were modeled in the database. Figure 4.7 illustrates the database schema for the ECG access database.

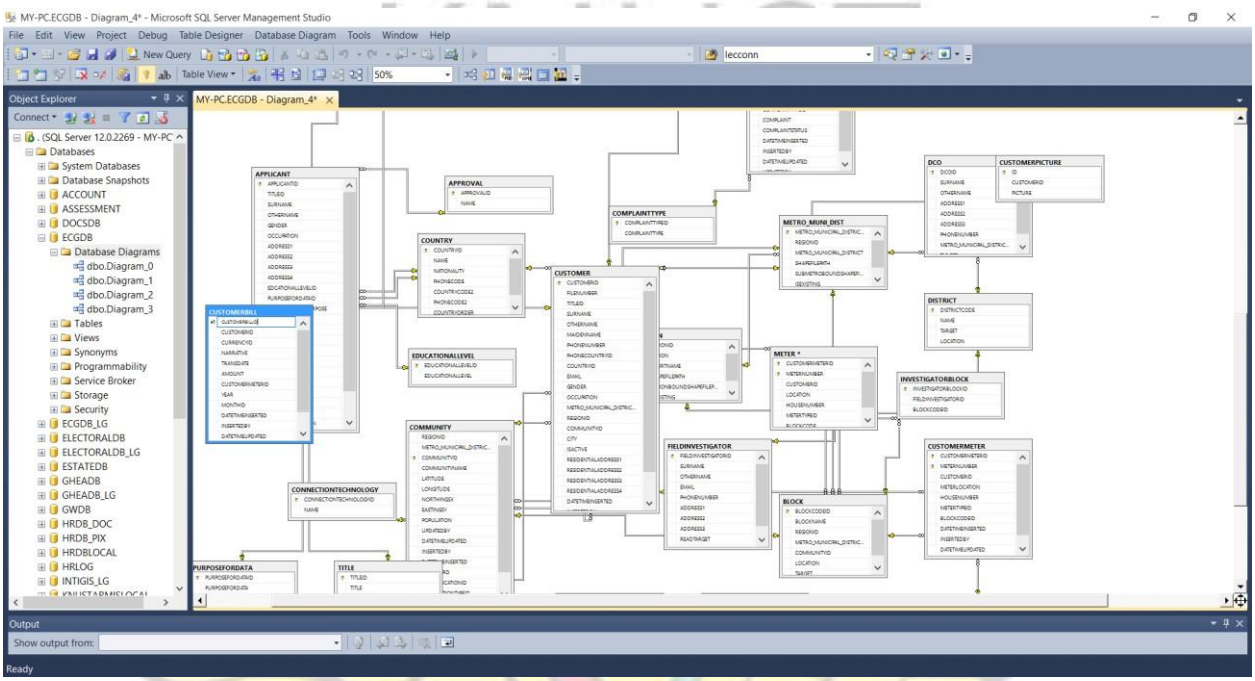

Figure 4.7: Database schema

4.8 ECG-GIS CIS Design Phase

The primary designed architecture conceived was to develop a web-based application for ECG Customer Information System. Four modules such as Customer Activity, Customer Database, Geo-database and System settings were developed and displayed in the dashboard or control panel. The system employs Main Menu, Toolbar, Legend Window, main Map Display and a Cadastral database page. The Map Display will always be opened, the Legend Window displaying all of the features, active and inactive, concerned with the map in the current project. The Main Menu and Toolbar contain functions to manage system and manipulate queries to be executed by the

system. The main Software used was Microsoft Visual Studio 2015 and selected programming language was C sharp.

4.9 Concluding Remarks

The ECG-GIS web based Customer Information System (CIS) was developed for effective revenue mobilization and reduction of system losses. The ECG-GIS CIS was constructed with standard units and allows for flexibility and variety in its use. It is a dynamic system, can be updated to accommodate additional information and also allows for editing.

The application is user friendly and incorporates various spatial utility maps including road network which will increase its acceptability and utilization among ECG officials

CHAPTER FIVE

5.0 Results and Discussion

Many companies all over the world understand the relevance of Information Technology (IT) in their operation. Over the past decade or so, millions of businesses have adopted the use of web application as a cheap channel to communicate and conduct transactions with prospective customers. In particular, the internet provides a way for entrepreneurs to get to know the people visiting their sites and start communicating with them.

According to Almanac Computer Industry (2006), the web is also a profitable sales channel for a great number of organizations, large or small, with over one billion Internet users today. US e-commerce spending accounted for $102.1 billion in 2006 (ComScore Networks, 2007).

All the data must be captured, stored, processed and transmitted to be used immediately or at a later date. Web applications, in the form of submit fields, enquiry and login forms, shopping carts, and content management systems, are the website widgets that allow this to happen.

They are, therefore, fundamental to businesses for leveraging their online presence. Thus, creating long-lasting and profitable relationships with prospects and customers.

No wonder web applications have become such an ubiquitous phenomenon. However, due to their highly technical and complex nature, web applications are widely unknown. It is therefore, seen as a grossly misunderstood fixture in our everyday cyber-life.

The internet has become the most common way to distribute applications to end users, whether they are web based applications, or mobile device based applications. Many startups are focused on mobile devices, and the technology to develop mobile applications has progressed rapidly to the point where one does not have to be a heavy duty programmer.

The ECG-GIS web based application system has been designed to reduce system loss and to enhance productivity of the company. This Chapter describes comprehensively, the functionalities of the ECG-GIS web based application designed under this research for ECG revenue mobilization.

5.1 ECG-GIS Customer Information System

- The web application system has so many interfaces. Figure 5.1 is a user registration form where ECG officials are registered and login credentials are generated.
- The user registration form requires that basic information about the user be captured into the system.

- The required information of the user that needs to be captured in the system are title, name, gender, phone number, email, district, address of the user and the purpose of using the system.
- The optional information that should be captured about the user are education, position and description of duties.
- The final step is to submit to save details in the system. The account registration process is done by the system administrator. User roles are defined based on the position of the user. An email is sent to the user to complete the registration process and to choose a password to his or her account. This ensures confidentiality and uniqueness of the system. This information is retrieved any time needed.

5.1.1 User Registration Form

The user registration form is used to register new users and update existing users in the system. A background validation is done to validate all information and the data is saved to the database.

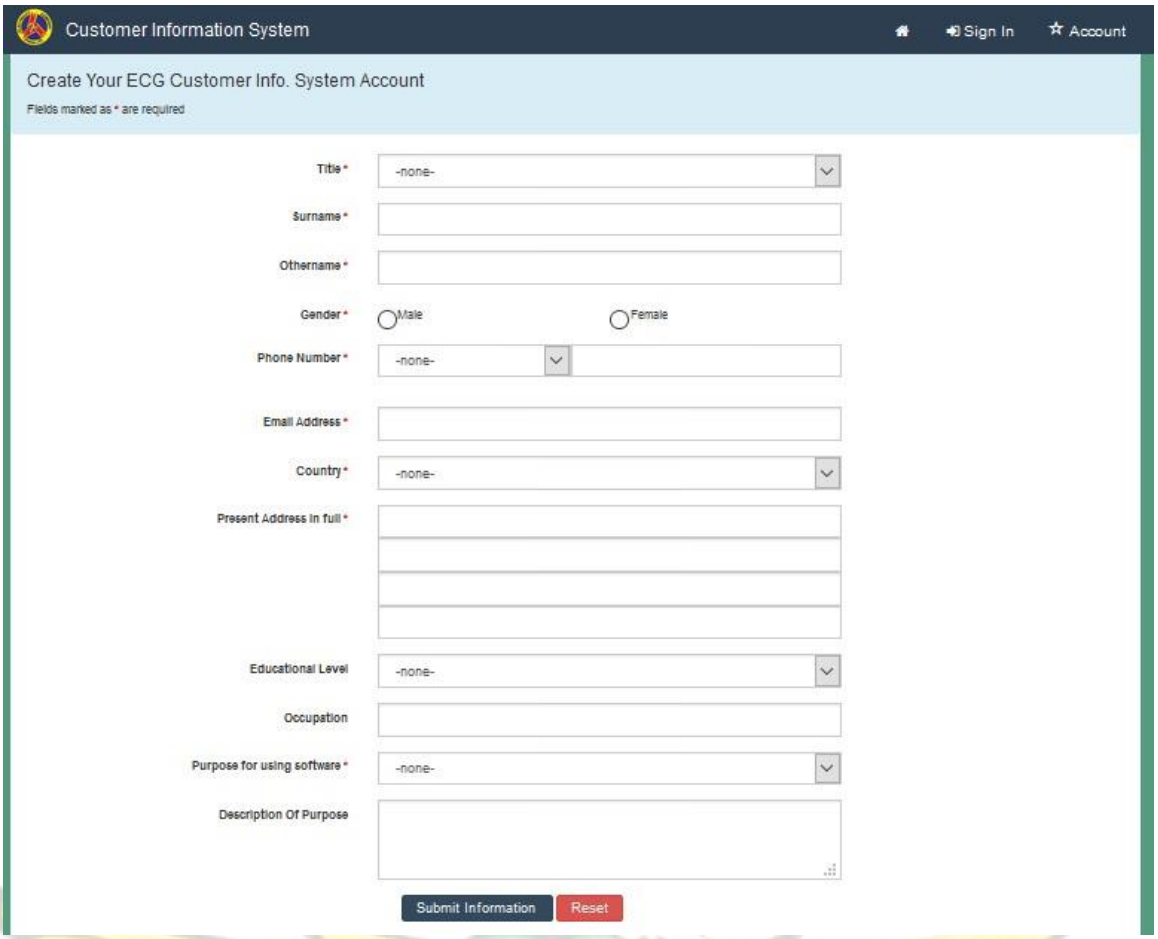

Figure 5.1: User Registration Form

5.1.2 The Login Interface:

After a successful user account registration, a username and password is created. These credentials are used anytime the user wants to log into the system. The login interface provides a secure interface were users are validated before they are given access into the system On the log in interface, there is an option to view the account you have registered. The system has been created in such a way that, when you wrongfully enter your username and password, you will not be able to enter into the system. The system validates any user to verify whether the user is allowed into the system. Two individuals cannot have the same credentials. Anytime you forget your username and password, you are allowed to request an email to be sent to you to change the credentials.

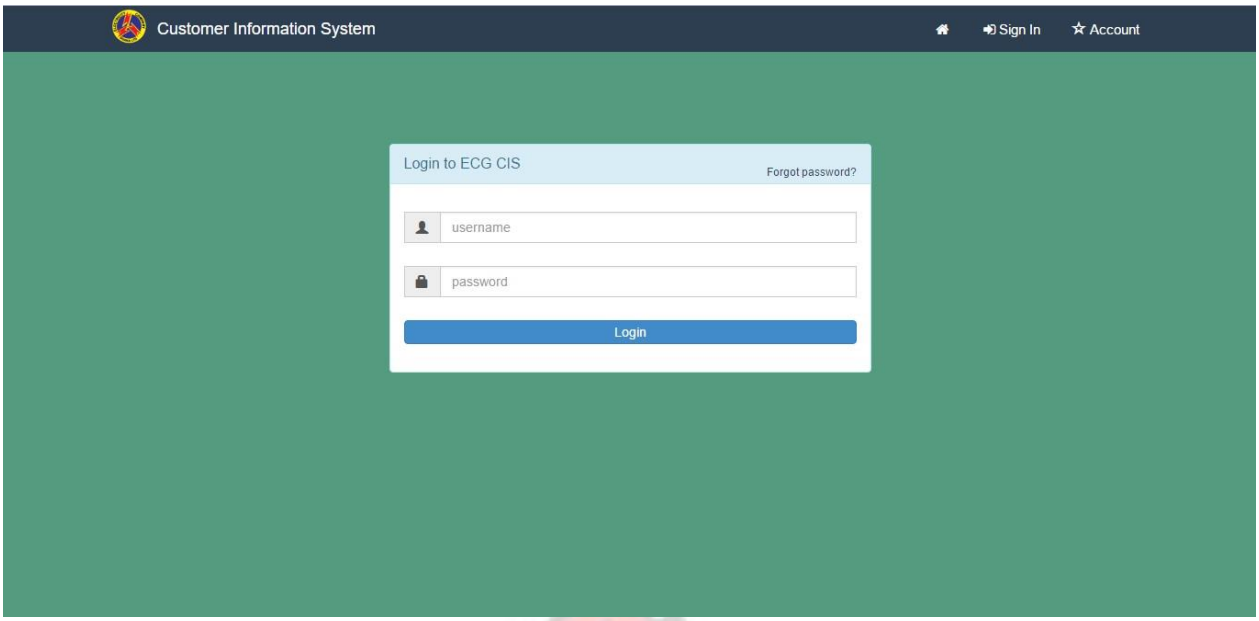

Figure 5.2: Login Interface

5.2 System Modules

The ECG-GIS Customer Information System consists of four modules where a valid user can perform every activity per the user rule that has been assigned.

5.2.1 Customer information system dashboard

After a user has been successfully logged in, he or she is taken to the system dashboard or control panel based on the user role assigned to him or her by the system administrator. The modules that appear on the dashboard are Customer Database, Customer Activities, Geographic Database and System Settings.

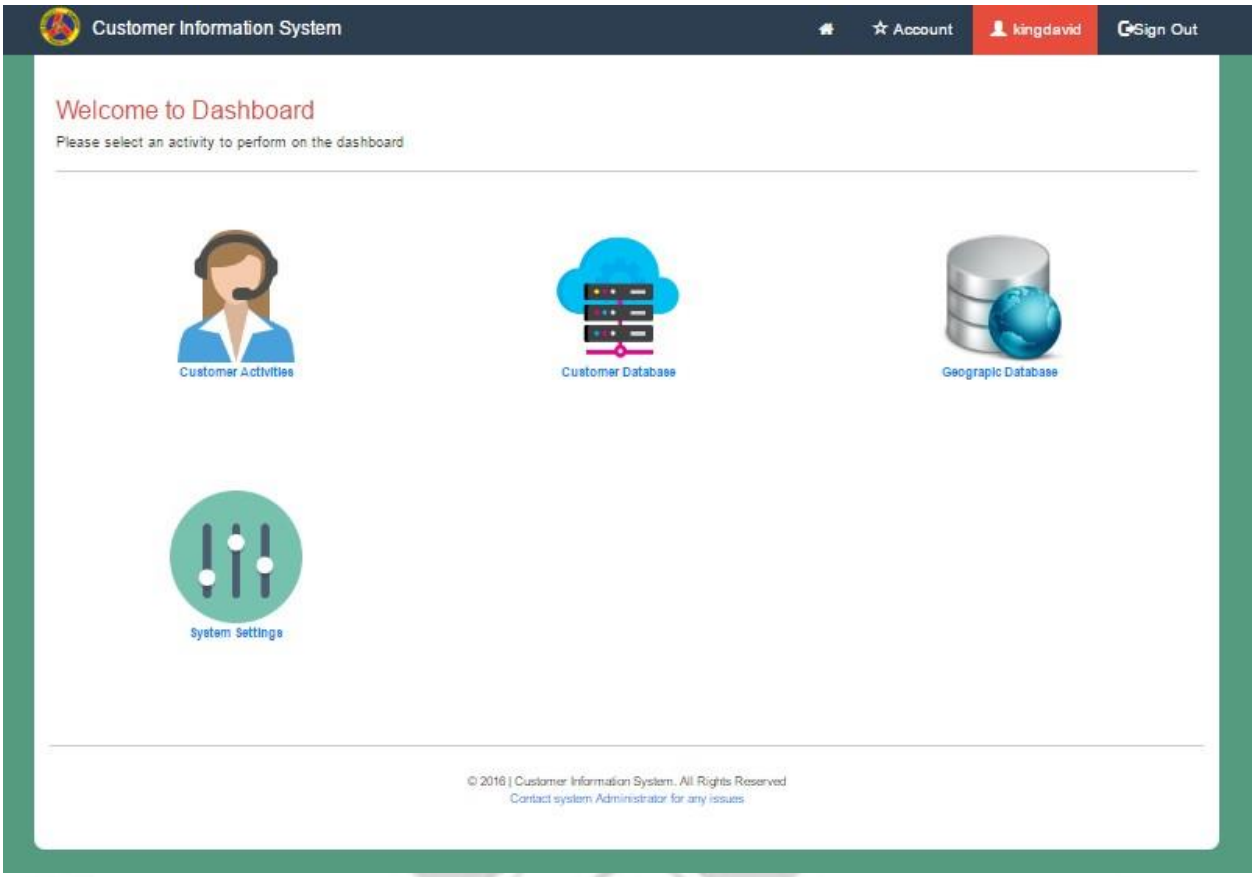

Figure 5.3: Customer information system dashboard

From the customer data center, every customer information is displayed. This place allows for adding or creating of new customers. It gives opportunity for editing and deleting of old information of customers when the need arises. From figure 5.5 below, the data center shows; customers ID, name of customer, region, district located and status of consumer. All these items are found on the customer database system. The options of signing out is on this customer data center. Users can decide to sign out on this platform. In short, the customer data center is a place to manipulate customer data.

5.2.2 Customer Database

The customer database is the module that contains crucial information about the ECG customers. The information that are captured in the customer database are done by ECG officials. The relevant information about the customer that are captured into the system

are Customer ID, which is the meter number of the customer, name, region, district, phone number and status of the customer. In the customer database, the following actions can be performed by the user:

1. You can add a new customer to the database.
2. You can edit information about a customer in the database
3. And you can delete a customer from the database depending on the user role assigned to the user

Also, a search can be performed for a user in quick search button using their customer ID as the key.

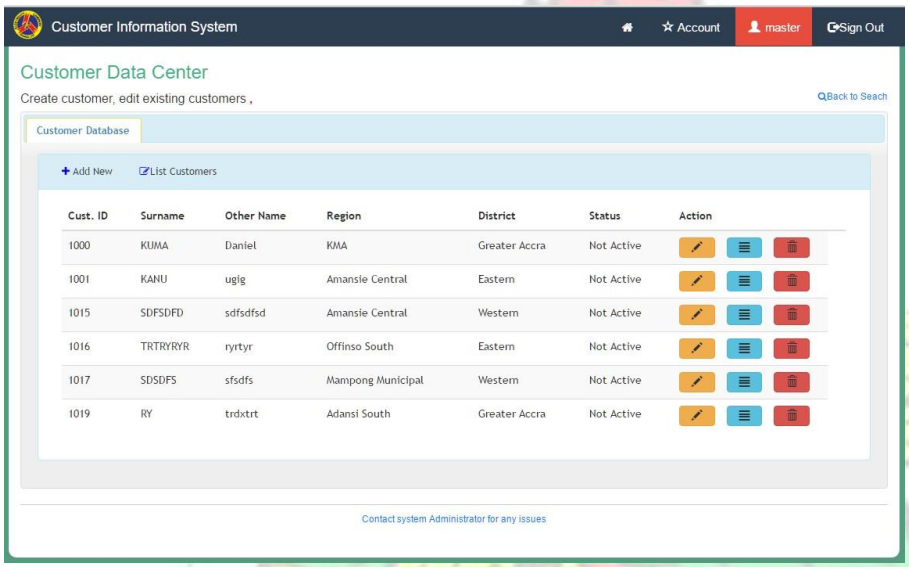

Figure 5.4: Customer database

5.2.3 Customer Activities

In the customer activities module, several activities can be performed on a specific customer. A customer can be retrieved by searching for the customer ID from the search engine. This module displays one customer at a time. The module contains information about the customer meter number, location, meter type and service type. This is where a customer bill is produced and payments made are updated. Basically, the meter number becomes the Customer ID.

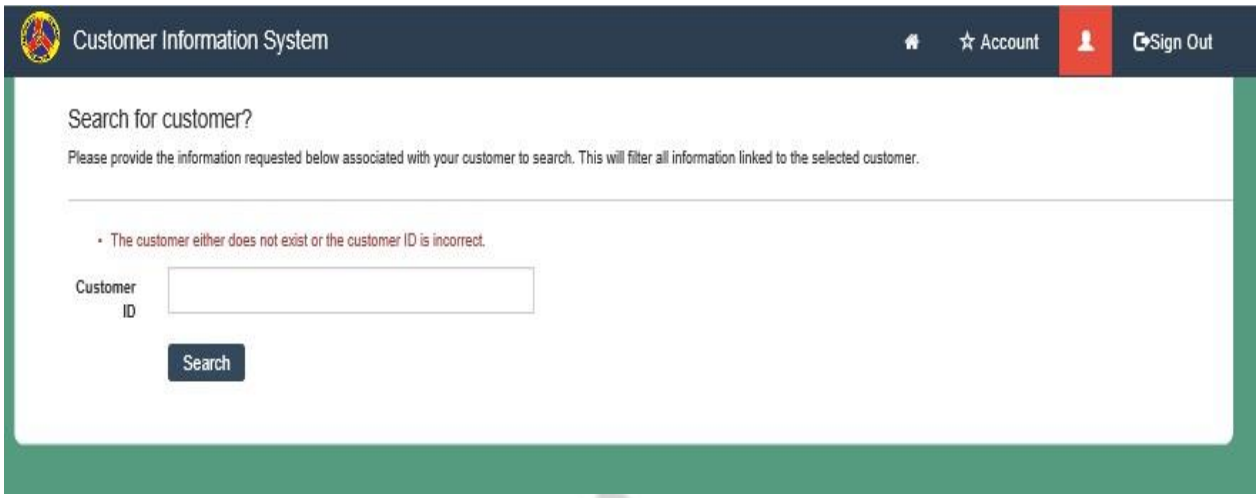

Figure 5.5: Customer search on Customer Information System

5.2.4 Geographic Database

The geographic database contains access map of the Adentan district. Items found on the map are ECG assets including transformers, poles, electrical lines and meters in various households. Road networks are also found in this map. Activities that can be performed in this module are identifying road networks, identifying ECG assets and access and measuring distances from specific places on the network.

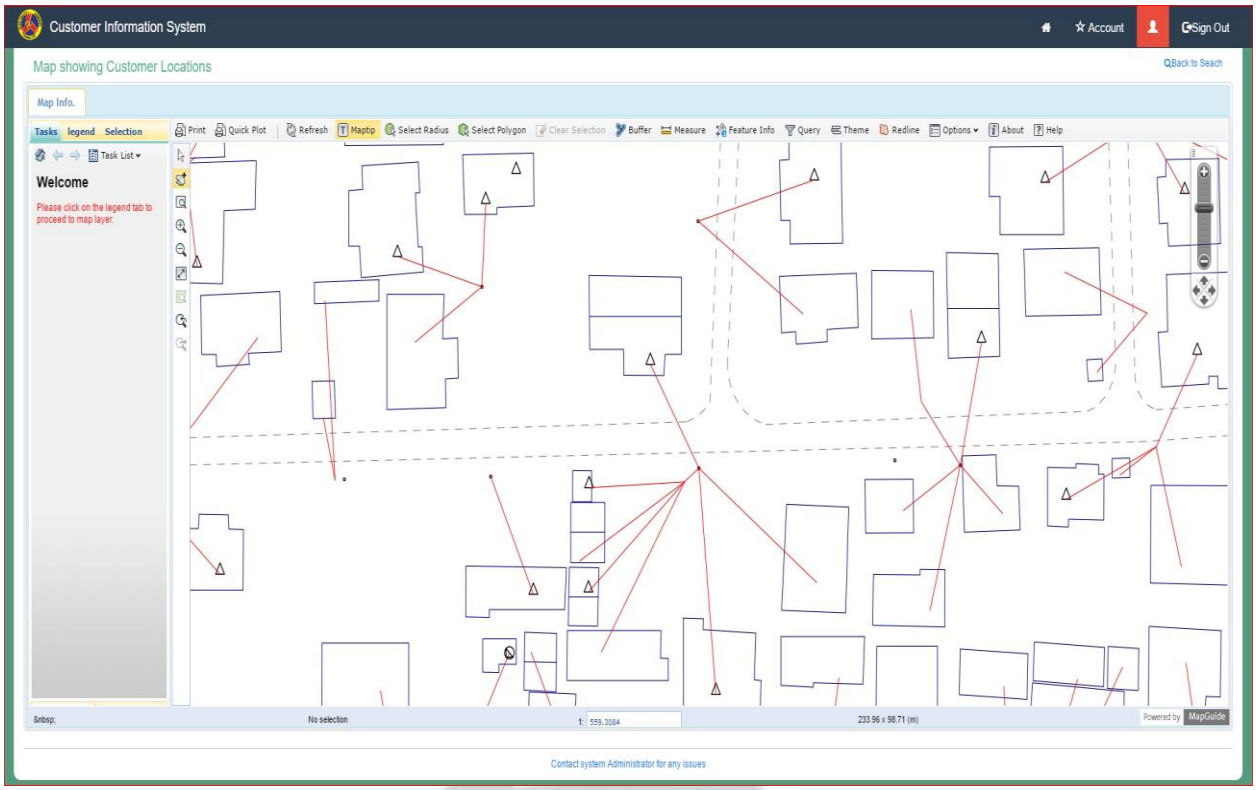

Figure 5.6: Geographic Database

5.2.5 System Settings

This module of the application is being controlled by the system administrator. All the modules are controlled in the system settings. Some of the features that can be found in this module is the title of the user. It needs to be set by the system administrator but will be predefined to the user. Constraints are placed on some of the fields and it is not every user who can view this information on their dashboard. The other fields that can be seen in this module are region settings, district settings, country settings, currency settings, month name, payment location, payment type, complaint type, education, meter type, purpose of data and approval. The System administrator can add more fields, edit, and delete fields.

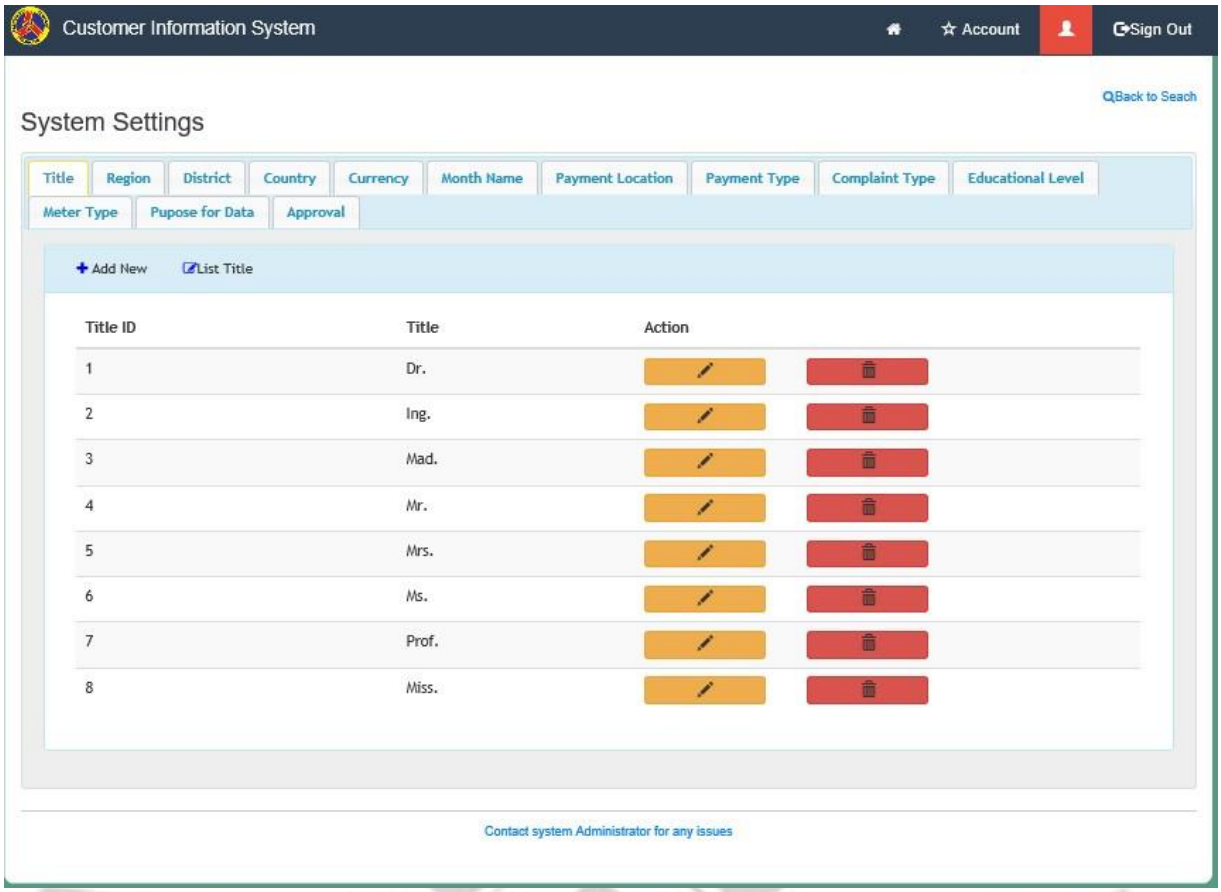

Figure: 5.6: System settings being displayed

CHAPTER SIX

6.0 Summary, Conclusions and Recommendations

6.1 Introduction

The study examined the role of Geomatics-GIS in ECG business of the Adenta Municipality in the Greater Accra Region of the Republic of Ghana.

6.2 Summary of the study

The research has been structured into six parts or chapters.

The first chapter was referred to as the general introduction. It contained the background of the study, problem statement, justification, research questions, research aim and objectives as well as the scope of the study.

Profile of ECG was the title of chapter two. This was made up of the definition of ECG, mission and functions of ECG, structure of ECG, distribution of electricity in Ghana. The second part of this chapter considered, billing process, revenue mobilization and methods employed by ECG in the mode of payment of bills. Payment challenges were also addressed in this section.

The third part of the research looked at Geomatics and ECG business. This chapter concentrated on how to use Geomatics and GIS to effectively run Electricity Companies for profit. Geomatics-GIS and ICT in Utility Management, application of GeomaticsGIS in Electric Utility Company, GIS in information retrieval, GIS in maintenance and monitoring and data management in GIS and Geomatics.

Chapter four of the research dealt with methodology and materials used in conducting the survey. The methodology for the study was categorized into four (4) phases namely; data acquisition phase, data processing phase, geo-database development phase and design of the ECG-GIS Web Based ECG Customer Information System. Also, the materials used for the project ranged from computer software to the existing data on household meter connections to electricity grid.

These were;

- A digital base map of Adentan Municipality.
- ArcGIS Desktop 10.3 Software
- Microsoft Office 2013 (MS Excel, MS Word, MS Access)
- Computer Hardware and peripherals
- Microsoft SQL Server 2014 Express Edition

- Microsoft Visual Studio 2015 Community Edition
- Entity Relation (ER) studio for data modeling

Analysis and discussion formed the chapter five of the project. The summary of findings were based on the discussion and analysis.

The following were the parameters of analysis and discussion in the study:

- Examine ECG-GIS Base Application System
- Analyse the various System Modules

6.3 ECG-GIS Base Application System

The web application system had user registration form and log in interfaces. This aided in the registration of a new customers and also logging on to an already registered customer portal. It provided a platform for creating customer data base. This enabled information of users to be retrievable.

6.3.1 System Modules

The modules were found as Customer Database, Customer Activities, Geographic Database and System Settings.

The customer database was the module that contained crucial information about the ECG customers. The information that are captured in the customer database are done by ECG officials.

It was also realized that customer activities module contained information about the customers' meter number, location, meter type and service type. This was where a customers' bill was produced and payments made are updated.

The geographic database contained the base map of Adenta Municipality with items such as transformers, poles, electrical lines and meters in various households as well as road networks. This showed the specific property location of the Electricity Company.

All the modules were being controlled in the system settings by an administrator. This brought regularity in management and flow of information.

6.4 Conclusion

The ECG-GIS web based application system housed two important interfaces. These were the registration and log in or off interfaces. They provided the platform for officials to enter in new information of customers and also log on after registration. The system modules were also responsible for handling data bases. The data were used for manipulation of the established system to ensure effectiveness and efficiency. In conclusion, the ECG-GIS web based Customer Information System is capable of helping the organization to manage, handle and mobilize its finances effectively.

6.5 Recommendations

First, ECG should start doing research into modern trends in revenue collection. This is because it was seen from the study that modern methods of revenue mobilization such as electronic means of billing was lacking, therefore the need for its integration to ease the burden of revenue collection and mobilization.

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APPENDIX

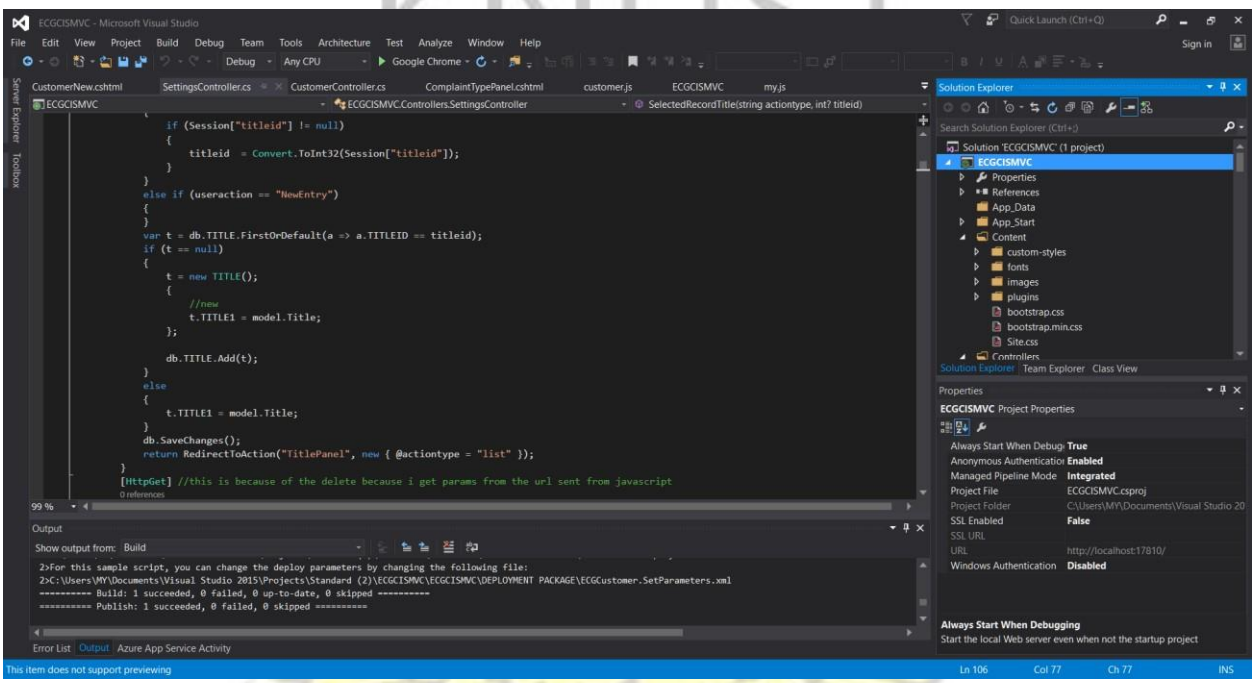

Figure 4.8: Application Design in Visual Studio