Mobile Application for Renewable Energy Information Dissemination (Go Renewable)

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Nassolo M. Assumpta

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DEDICATION

I dedicate this work to The Almighty God for His favor bestowed upon me throughout this research and the entire course.

I would also like to dedicate this work to my parents for their continuous encouragement and support, emotionally, physically, financially and spiritually.

To my daughter Angella Grace who had to take some time without me, for understanding, endurance, and prayers during my studies.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

FARI: Fieldstone Africa Renewables Index

GHGs: Green House Gases

IDS: Information Dissemination System

JICA: Japan International Cooperation Agency

MEMD: Ministry of Energy and Mineral Development

NGOs: Non-government Organizations

PV: Photovoltaic

REA: Rural Electrification Agency

REB: Rural Electrification Board

RETs: Renewable Energy Technologies

SDLC: System Development Life Cycle

SHS: Solar Home System

SMS: Short Message Service

SSA: Sub-Saharan Africa

UNCCC: United Nations Climate Change Convention

UDRES: Uganda Domestic Renewable Energy Solutions

MW: Mega Watt

ABSTRACT

Despite the so many different sources of Renewable Energy (RE) in Uganda, little has been done to inform the public. The existing systems used to disseminate RE information in Uganda have a number of limitations which include not being able to provide answers to what if questions for individuals who wish to inquire about different sources of RE and as well get timely response, not providing for visual presentations on the different sources of RE and not facilitating peer to peer learning.

The objective of this research is to develop a mobile application to enhance the dissemination process of RE information to the public anytime, anywhere. The application was developed using Eclipse IDE, Tom Cat Server, MySQL as the backend database and SQLite the front-end database.

To achieve the objectives of this project, the user-centered design (UCD) was used with interview guides to conduct the research. UCD approach supports the entire product development process with user-centered activities. The Agile Systems Development Life Cycle (SDLC) model was used in particular, because the product is tested very frequently, through the release iterations, minimizing the risk of any major failures in future.

The application prototype was evaluated by 20 users on different platforms to determine the user's satisfaction and willingness to use the designed application, to acquire more information on RE technologies and make informed decisions. The majority of the interviewees revealed positive results for the all the questions and a few that were negative mentioned that they don't have much interest in using mobile applications.

CHAPTER ONE: GENERAL INTRODUCTION

1.1 Introduction

Nowadays, the development of Internet has revolutionized the way we communicate with each other. Communication helps us better share knowledge, ideas and beliefs, thus influencing people behaviors. Sam (2000), states that the rapid growth of the World Wide Web (WWW or Web) in particular, provides highly customized, accessible and interactive sources of information to a widely distributed user base.

The rapid development of computer and Internet technologies has dramatically increased the ways of teaching and learning. Among these new approaches, online Web based education has become a promising field (Bude et al., 2005). As technology becomes a key tool for good teaching (Adonis, 2006 as cited by Rex and Roselle, 2011), academic institutions promote and encourage optimization of the Internet technology for information dissemination. Anton (2004) describes Information Dissemination Systems to describe systems that deliver individual copies of the same data from one source computer or a cluster of computers to client computers (subscribers) via the Internet.

Yun, Wang and Yanqing (2016) discussed seven models used in information dissemination which include Web Portal, Voice based service Text (SMS)-Based Service, Self-Support Online Community, Interactive Video Conferencing Service, Mobile Internet Based Service and Unified Multi-Channel Service Model.

During recent years the usage of mobile devices has increased greatly as new mobile technology allows the users to perform more tasks in a mobile context (Nidhi and Pankaj, 2013). At least 52.3 per cent of Ugandans have access to mobile phones, according to the Uganda Communications Commission (UCC) 2014 Access and usage of communication services across Uganda study. This, as per the study means that more than 19.5 million Ugandans are connected to different mobile telecommunications networks. With the growth in number of people using smart phones and the internet in emerging economies like Uganda, information can easily be accessed by the use of phones. This means that it’s easier for people to access any type of online information through use smart phones.

Currently, there are few existing mobile based applications that are used in dissemination of information about renewable energy and most of these are not fully functional in a way that they don't support decision making in our local settings. Therefore, a need for mechanisms to enable the growing population to access more information about renewable energy over the internet.

1.2 Background to the Study:

The Ministry of Energy and Mineral Development (MEMD, www.energyandminerals.go.ug) is responsible for overall management of the country's energy sector, dealing with policy formulation, implementation and monitoring.

The mandate of the Rural Electrification Agency (REA), is to facilitate provision of electricity in rural areas. The REA was established as a semi-autonomous Agency by the Minister of Energy and Mineral Development through Statutory Instrument 2001 no. 75, to institute the Government's rural electrification function under a public-private partnership. It functions as the secretariat of the Rural Electrification Board (REB), which carries out the Minister's rural electrification responsibilities, as defined in the Electricity Act of 1999.

According to the Energy Policy report of 2002, the major aim is to meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner. To achieve this aim, Uganda completed an inventory of its greenhouse gas emissions to meet its commitment as a signatory to the United Nations Climate Change Convention (UNCCC) as per the international perspective and as a result, a lot of efforts are underway to develop projects which are able to benefit from the Global Environment Facility and the clean Development Mechanism.

The nation's goal for 2050 is to greatly develop supplies of energy in Uganda based on renewable sources and they propose a modern renewable energy system that is resilient and has low impacts on environment and climate (The Energy Report for Uganda, "A 100% Renewable Energy Future by 2050", 2015). The report further states that whereas most developed countries already have 100% electricity access, only 15% of the Ugandan population currently has access to electricity. Secondly, as per capita electricity consumption in Uganda is extremely low compared to the rest of the world, massive increases in energy and electricity supplies are needed. Thirdly, the discovery of, and investment in, fossil fuel resources in the country has the potential to defer investment in RE infrastructure and put the country on an unsustainable and carbon-intensive path. This report is about ensuring that Uganda makes best choices today to assure its clean energy future. This research is one way through which the nation's 2050-energy goal in regard to creating public awareness of the available RE sources can be achieved.

1.3 Statement of the Problem

Despite the so many different sources of renewable energy in Uganda, little has been done to inform the public. As a result, people are mainly concentrating on only one major source of energy that is Biomass, which has had a great impact on the human health, climate and social status. More so, even the existing systems used to disseminate renewable energy information have a number of limitations. They don't provide answers to what if questions for those who may wish to inquire about the different sources of renewable energy and as well get timely response, they don't provide for visual presentations on the different sources of renewable energy and they don't facilitate peer to peer learning. The proposed system is to improve upon RE information dissemination to the Ugandan population, which will enable them utilize the various sources of RE that are currently unknown, rather than just Biomass.

1.4 Objectives of the study

1.4.1 Main objective of the study

The main objective of this study is to improve the dissemination process of renewable energy information by designing a mobile application that can avail RE information to the public any time it's needed anywhere.

1.4.2 Specific objectives of the study

1. To review literature of the current systems used in dissemination of renewable energy information.
2. To design a model for the mobile application that will provide information about Renewable energy and allow clients to interact with suppliers of these technologies
3. To implement the designed model for the Go Renewable mobile application

4. To evaluate the usability, efficiency, and effectiveness of the Go Renewable mobile application

1.5 Scope

The scope of this report is divided into geographical and functional scope.

1.5.1 Geographical Scope

The study was carried out in Kampala City, Kawempe division in particular. Kampala is the capital city of Uganda with 5 divisions, and Kawempe is of them.

1.5.2 Functional Scope

The study aims at designing and implementing a mobile application that provides renewable energy information to individuals' and communities' so as to improve the decision to acquire different types of energy from renewable energy sources. The study's main emphasis was on educating people about sources of RE, providing them with market prices, basic information on what RE source is suitable given the one's location and ability. The study did not put so much focus on technicalities of RE generation. The study acts as a guide for the policy makers in RE development. It benefits those who are computer literate and have access to internet services using mobile phones.

1.6 Significance of the study

1. The study will contribute to the nation's goal for 2050 of having a modern renewable energy system that is resilient and has low impacts on environment and climate.

2. The study will educate the population about benefits of renewable energy compared to the non-renewable energy sources and guide those who are currently using renewable sources like electricity but are not aware of alternative sources, like solar which can actually be cost saving.
3. The study will ease the process of identifying the type of renewable energy to use or to buy as well as its advantages in comparison to other energy sources.
4. The research study will contribute to the health of Ugandans by minimizing the use of non-RE sources such as fossil fuels that may lead to illnesses, since access to information

regarding the pros and cons of these different energy sources will be readily available with the designed application.

5. This study will serve as a platform for users to suggest ways of improving RE awareness to the public.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

Literature review presents elements that help the researcher understand the problem under investigation better. As stated in the first objective of this research, which is to review literature of the current systems used in dissemination of renewable energy information so as to identify requirements for the new system.

The diffusion of renewable energy technologies (RETs) has been progressing very slowly globally, mainly in developing countries, where the diffusion challenges for renewable energy are greater. Among potential actors in the promotion and diffusion of rural-based renewable energy innovations, NGOs and NPOs have been mentioned as promising actors. However, empirical studies that show the role of the actors and the way they can be system builders by diffusing existing technologies have been very rare (Kassahun, Toshio and Mohammad, 2013).

Mohammed, Mustafa, and Bashir (2013) mention that the Sub-Saharan Africa (SSA) region is at the moment engrossed in the mesh of an energy crisis and undisputable socio-economic deficits. They further state that the region accommodates 13% of the human population in the world, yet access to modern energy in the region has been time after time ranked underprivileged and the region was said to have occupied the last position in terms of growth in gross domestic product GDP) and contemporary developmental strides. They further mention that SSA is the least developing sub-region of the world with a very high number of dispersed rural settlements and the scattered nature of the rural settlements is responsible for the sub-region being technically and economically weak in achieving substantial grid connection development in the power sectors of many countries in the region despite the continuous increase in electrical energy demand. Mohammed, Mustafa, and Bashir (2013) finally state that all forms of development can be achieved sustainably provided there is interaction among energy sources, human beings and society. These researchers however, did not suggest ways the interaction could be achieved. This research is not only concerned with energy sources that require grid connection but also other sources of energy that the public is not aware of, yet they could afford the prices given the necessary information. With this system, alternative sources can be explored, not only by public but even authorities in energy sector.

2.1 Renewable Energy Resources in Uganda

Uganda received global recognition as the best in Africa in attracting renewable energy investigation by Fieldstone Africa renewables at the Africa Energy Forum 2016 in London, (Sanya, 2016, p.4). He further states that according to the latest Fieldstone Africa Renewables Index (FARI), Uganda only came behind South Africa and Morocco in Africa. Fieldstone Africa is the leading independent financial advisor and provider of related financial services in energy and infrastructure.

The Energy Policy for Uganda (2002), states that Uganda is richly endowed with a variety of renewable energy resources which include plentiful woody and non-woody biomass, solar, wind, geothermal and hydrological resources. Presently, with the exception of biomass, only a meagre fraction of the country's renewable energy potential is exploited. It is estimated that other renewable sources of energy, excluding large hydropower, contribute less than 2% of Uganda's total energy consumption (Energy Policy for Uganda, 2002). The energy resource potential of the country includes large hydro (2000MW), minihydro (200MW), geothermal (450MW), 460 million tonnes of biomass standing stock with a sustainable annual yield of 50 million tons, 5.1 kWh/m2 of solar energy. Much of the potentials for renewables have so far not been exploited. This endowment of renewable energy resources has the potential to help the country diversify its energy mix by making the system less exposed to climate vulnerabilities affecting its hydro resources and meeting a considerable share of its energy needs.

According the Energy Policy for Uganda (2002), the GoU is committed to the sustainable development of renewable energies in the country to address energy access issues, contribute to the fight against climate change, resolve environmental problems and create sustainable green jobs.

2.1.1 Biomass

Biomass is energy generated from organic material that comes from plants and animals (COMESA, 2012). Biomass contributes over 90% of the total energy consumed in the country and provides almost all the energy used to meet basic energy needs for cooking and water heating in rural areas, most urban households, institutions, and commercial buildings. Biomass is the main source of energy for rural industries. Limited availability of electricity and high prices of petroleum products, constitute barriers to a reduction in the demand for biomass. Trade in biomass especially charcoal is a large contributor to the rural economy. The per capita consumption of firewood in rural and urban areas is 680kg/yr and 240kg/yr respectively. Per capita charcoal consumption is 4kg and 120kg in rural and urban areas respectively. Current charcoal consumption in Uganda is estimated at 580,000 tons per annum the biomass equivalent is about 6 million tons of wood, based on the conversion efficiency of 10% for the charcoal kilns in use. While it is believed that biomass will continue playing a key role in the country's energy mix, the strategy moving into the future is to sensitize people to the importance of preserving forests and to provide access to modern productive energy services. Thus, the need for this system to support the government of Uganda in a struggle to sensitize its people, since it provides real time information about the various RE sources and can be accessed from anywhere by anyone.

2.1.2 Hydropower

Hydropower is power that is derived from the force or energy of moving water, which may be harnessed for useful purposes – mainly that of generation of electric power (COMESA, 2012). Hydropower output varies depending on rainfall. Currently, hydropower supplies 85% of grid electricity in the country, though variations in water flow cause significant variations between installed capacity (683 MW) and actual generation (300-350 MW). Hydropower stations on River Nile include Bujagali (250 MW), Nalubaale (180 MW) and Kiira (200 MW).

Umeme Uganda's primary power company, operates, maintains and expands UEDCL's distribution network under a 20 year concession agreement. Umeme is fully-privatized and publically traded on Uganda's stock exchange (Gustavsson et al, 2015).

2.1.3 Geothermal

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is energy that determines the temperature of matter. Earth's geothermal energy originates from the original formation of the planet, from radioactive decay of minerals and from volcanic activity (COMESA, 2012). Fissures in the earth's crust allow water heated by geothermal energy to rise naturally to the surface at hot springs and geysers. Wells drilled into the earth allow steam or water to escape to the surface in a controlled manner to operate steam turbines and to generate electricity. The geothermal potential is estimated at 450MW in three areas of Katwe, Buranga and Kibiro, on the western boundary of the country because of their volcanic and tectonic features that indicate a powerful heat source and high permeability. Geothermal technology is the most viable diversification alternative to large hydro power in Uganda since it can deliver large scale, base-load power at relatively low cost, stemming from its 24 hour availability (high capacity factor).

2.1.4 Solar

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic, or indirectly using concentrated solar power. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic convert light into electric current using the photoelectric effect (COMESA, 2012). When converted to thermal energy, solar energy can be used to heat water for use in homes, buildings, or swimming pools; and to operate turbines that generate electricity.

Solar energy can be converted into electricity in two ways:

Photovoltaic (PV devices) or solar cells change sunlight directly into electricity. Individual PV cells are grouped into panels and arrays of panels that can be used in a variety of applications ranging from single small cells that charge calculator and watch batteries, to systems that power single homes, to large power plants covering many acres.

Solar thermal/electric power plants generate electricity by concentrating solar energy to heat a fluid and produce steam that is then used to power a generator.

Solar energy from Photovoltaic is subdivided into two categories PV on grid and off grid as follows:

Solar PV On grid is an electricity generating solar PV system that is connected to the utility grid. A grid-connected PV system consists of solar panels, one or several inverters, a power conditioning unit and grid connection equipment. They range from small residential and commercial rooftop systems to large utility-scale solar power stations.

Solar PV Off-grid are stand-alone power system that provide a smaller community with electricity. Off-grid electrification is an approach to access electricity used in countries and areas with little access to electricity, due to scattered or distant population.

The main benefits of solar energy is that solar systems do not produce air pollutants or carbon dioxide, and also when located on buildings, solar energy systems have minimal impact on the environment.

The GoU has been actively promoting the use of solar PV to provide basic electricity services to remote populations through the World Bank-financed Solar PV Targeted Market Initiative-subsidized private sector implemented program. Some 18,000 solar home systems (SHS) and solar lanterns have been disseminated thus far. Solar PV systems have also been installed in rural schools, health centers and other social institutions.

There is less experience in Uganda with Solar PV mini and micro-grids, which are small centralized solar PV systems serving several households and small businesses. Two pilot projects in this category are being carried out in Western Uganda financed largely by the GoU and bilateral donors. The 5 kWp (Kilowatt peak specifies the output power achieved by a Solar module under full solar radiation) project in Kasese by a Danish company is currently operational and benefiting 94 customers. The charge is a monthly bill of UGX 5,000 (about USD 1.5) for 1 bulb, and, UGX 7,000 (USD 2) for 2 bulbs. The micro-grid project at Kyenjojo by the University of Southampton is for 13.5kWp and is still under construction. The experience with these two pilot projects, particularly with subsidy and cost recovery schemes poses a good example for rural electrification planners and policy makers. Despite their high cost, solar home systems and isolated solar PV mini and micro-grids are undoubtedly still the least cost solution for providing basic electricity services in the most remote areas, including Ugandan islands in the Lake Victoria. Therefore, the need for this system to easily reach out to the Ugandans who may have interest or need to access this information.

2.1.5 Wind Power

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, windmills for mechanical power, wind pumps for water pumping or drainage, or sails to propel ships. Wind power, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, clean, and produces no greenhouse gas emissions during operation (COMESA, 2012). Wind speeds across the country as generally understood have been estimated to be low on the whole, with more promising sites in the areas of Kabale, on Lake Nalubaale islands and in Karamoja. This region is widely considered as one of the windiest locations in Uganda. Even though detailed feasibility studies have not been undertaken so far, preliminary assessments have shown that there could be potential for medium-scale generation of electricity.

Recently, the MEMD has procured wind measurement equipment which is being installed at high altitudes in the Napak and Kotido districts of the Karamoja region. The objective is to collect consistent and relevant wind data to determine the best delivery method for this technology in the region.

The GoU plans to implement a systematic wind mapping program, starting at areas that are considered endowed with the resource. If the wind potential is proved to be sufficient for commercial on-grid generation, then wind technologies can become an important large-scale diversification option for the country.

2.1.6 Biofuels

Biofuels are transportation fuels like ethanol and biodiesel that are made from biomass materials. These fuels are usually blended with petroleum fuels (gasoline and diesel fuel), but they can also be used on their own. Using ethanol or biodiesel means less gasoline and diesel fuel is burned, which can reduce the amount of crude oil imported from other countries. Ethanol and biodiesel are also cleaner-burning fuels than pure gasoline and diesel fuel. Ethanol is an alcohol fuel made from the sugars found in grains like corn, sorghum, and barley. Other sources of sugars to produce ethanol include Sugar cane, Potato skins, Rice, Yard clippings, Tree bark.

Biogas on the other hand is another form of biofuel, which is gaseous, especially methane, produced by the fermentation of organic matter.

Since 2009, SNV has provided support to Uganda’s biogas efforts under the Africa Biogas Partnership Program that targets the construction of 70,000 biogas digesters in 6 African countries, including Uganda, benefiting about half a million people. (SNV-Uganda 2015-2016, Report). With this support, Uganda has carried out a multi-pronged approach to the promotion of biogas utilization in the country. The scope of activities covers not only the construction of digesters in rural areas but also the training of construction companies and individual masons, implementers, financial institutions and Non-Government Organizations (NGOs). By the end of 2013, a total of 2,085 biogas systems had been constructed as per the report. Almost all are for onsite cooking and lighting, with only a few instances of electricity generation for domestic and institutional users. GoU through MEMD has piloted a project constructing bio latrines in 10 schools across the country for cooking purposes which will be expanded. Institutions such as schools are known to use significant quantities of firewood, which negatively impact the forest assets of the country.

The same report states that the challenges faced in promoting wider use of biogas in Uganda include the high upfront costs for installing a digester, thus becoming unaffordable to many households in-spite of significant subsidies. In addition, limited accesses to affordable financing coupled with high interest rates have affected marketing efforts. A major constraint to more widespread adoption in Uganda, as in many other countries, is the reduced number of families who own a sufficient number of livestock to support the operation of a domestic digester. However even those with livestock may not be aware of this source of energy.

2.2 Why Renewable Energy

2.2.1 Ever increasing cost and uncertainty of non-renewable energy

Throughout the world, concerted efforts are being made to make renewable energy replace non-renewable energy sources in the future (Renewable Energy Policy for Uganda, 2007). According to Renewable Energy Policy for Uganda (2007), the driving forces for investments in renewable energy include the ever increasing cost of fossil fuels that makes them too expensive for developing countries and uncertainty in future of these fuels. In the same policy, experts show that if the world continues to consume energy at the current rate, the non-renewable sources will be exhausted in the near future because if no more oil were to be found and we carried on using oil at existing rates, then the reserves would last for less than 40 years. Although more oil fields are being discovered, the future of oil is bleak. The proven global coal reserve was estimated to be 984,453 million tonnes by the end of 2003. The USA had the largest share of the global reserves (25.4%) followed by Russia (15.9%), China (11.6%) and India with 8.6%. In the year 2004, the World's coal consumption was 2775.8 Mtoe representing 0.28% of the estimated reserves. At this rate of consumption, it is estimated that the global reserve can last for only the next 250 years.

2.2.2 Environmental conservation and economic development

Renewable energy has become a top priority for the governments in all the European countries due to the increasing global concerns about climate change and scarcity of fossil fuels (Smith, 2013; Krupp, 2007). Concerns about energy security and climate change are enforcing significant changes in how energy and electricity specifically, is generated, transmitted and consumed. Since then, a series of formal and informal policies, directives, legislations, etc. have been developed to encourage use of renewable energy in order to reduce emissions of greenhouse gases, to decrease the energy consumption throughout the European Union (Tol, 2012; European Parliament and Council, 2010), and to increase the energy efficiency (Moula *et al*., 2013).

Small-scale renewable energy solutions can play a vital role in poverty alleviation, environmental sustainability and economic development. Such systems can provide energy that is affordable to the poor and can be a source of employment and enterprise creation for both the rural and urban poor. There is a growing evidence to suggest that investment in small and medium-scale renewable energy projects may have strong impacts in improving the energy services for the majority of the population, especially the rural and urban poor. These projects can also play a vital role in minimizing fuel imports by providing viable alternatives to thermal-based electricity (Byakola et al, 2009).

2.2.3 Irrigation in dry regions

Uganda Solar Irrigation is a project that examined the feasibility of a solar pump installation in the village of Ewavio, Uganda (http://piet1.ucdavis.edu/projects/uganda-solar-irrigation/uganda-solar-irrigation-final-report/view). Ewavio is a small rural village with a population of approximately 200 people, or 25 families. The families currently gather water from a variety of sources, including shallow- and deep-wells that are manually pumped, surface rivers and springs, and a few houses have rain water catchment and storage tanks. The proposal submitted to D-Lab at UC Davis was for a solar pumping system that would help the village address their water needs. The villagers would like to increase the volume of water available to them during the dry season, so that they may expand their agricultural activities. Dry season farming of leafy green vegetables would provide nutrition to agricultural households and income through the local market. The market is well-established and accessible, but the water scarcity makes dry season agricultural activities difficult. In addition, the current year-round water supply, the deep-well, is manually pumped from a depth of 14 meters, and the villagers would like an automated pumping option to save hours of labor. The village has a small, portable solar pump brought by Gloria Androa from UC Davis and they would like to expand the local use of that technology. (http://piet1.ucdavis.edu/projects/uganda-solar-irrigation/uganda-solar-irrigation-final-report/view) This case was cited as one of the so many uses of RE sources, particularly solar.

2.3 Current status of Renewable Energy Information dissemination in Uganda

Japan International Cooperation Agency (JICA) carried out a study on Dissemination of RE in Rural Communities to examine the current status and future prospects of photovoltaic (PV) and small-hydropower utilization in East Africa, rural Uganda in particular, from various viewpoints, the aim was to propose a sustainable development model of PV and small hydropower applications in rural communities. Among the key issues wanted to find out was the reason as to why the dissemination of the PV systems was slow in remote communities and it was discovered that due to lack of consumer education about Solar Home System (SHS). The study further reveals that in most cases, it was conducted briefly and poorly, so the SHS users were never able to fully understand what to do for the operation and maintenance of their SHS. (Japan International Cooperation Agency, 2008). With this research, having a component of real time interaction amongst users, consumer education can be easily conducted.

2.4 The need for Renewable Energy information dissemination in Uganda

Kandpal and Broman (2014), in their review of published literature on renewable energy education initiatives across the globe mention that RE education is expected to play an important and effective role in promoting sustainable development and also contribute towards improvement in quality of life of a large section of global population. They further mention that it is necessary that policy makers are aware of the latest advancements in the field of renewable energy and appreciative of their merits and potential towards providing sustainable energy supply options to meet increasing global energy needs. Similarly, educating common public about energy and climate change related issues and exposing them to the state of the art renewable energy technologies is also of immense importance. Awareness generation among potential users is necessary for enhancing the adoption of a new emerging technology. Public awareness campaigns, demonstration exhibitions etc. are expected to be of great help in this regard. Some such attempts concerning renewable energy technologies have been made in the past and reported in literature. It is also important that both the policy makers as well as the common public appreciate the relevance of having appropriate institutional arrangements for imparting renewable energy education. There is an urgent need to provide proper training to end users on operation and maintenance aspects of renewable energy technologies. Such training is critically important for success of renewable energy promotion initiatives, particularly in rural areas. There is a need for educating and training villagers, particularly women, in the use and management of renewable technologies. Efforts to educate farmers, specialists, small scale manufacturers, communities and tribal population mid-career professionals and common public have also been reported in the literature. Use of press and television for providing renewable energy education have also been considered and reported.

According to a report by Haselip et al., (2011), a third and a half of the world's population rely on solid fuels for the majority of their energy needs. These fuels include a range of unprocessed biomass like firewood, crop residues and dung, as well as processed fuels like briquettes and charcoal. A number of negative consequences arise as a result of reliance on solid fuels. Cooking represents the largest use of energy in the household, and most cooking appliances tend to be relatively inefficient both in the way they combust fuel and in how they transfer the heat from the stove to the food. Many families cook indoors, either seasonally or year-round. Inefficient combustion releases harmful pollutants, which concentrate in the kitchen, leading to pollution levels far in excess of international standards (Smith, Edwards et al., 2007). As a result, the WHO estimates that smoke from solid fuels contributes to nearly 3% of the global burden of disease (Smith, Mehta et al., 2004), rivaling malaria and tuberculosis as a source of illness and death in developing regions. Many pollutants also act as heat-trapping greenhouse gases (GHGs)

(Bailis 2005; Smith, Uma et al., 2000) as stated in the same report by Haselip et al., (2011). Finally, in some locations wood is harvested unsustainably, leading to a net loss in tree cover, which further exacerbates climate change and contributes to environmental degradation.

In Uganda, close to 100% of rural households use dirty biomass energy for cooking, and less than 5% of rural households report using electricity for lighting. The majority of the population in Uganda depend on unsafe, dim kerosene lamps for light and have no source of power to charge mobile phones or other small appliances. The significant use of firewood and charcoal for cooking puts pressure on the ecosystem, degrading forests with negative consequences to environment and ultimately the food chain for all Ugandans. The use of dirty, inefficient cook stoves and burning kerosene lanterns, contributes to unhealthy households, causing an increase in respiratory illness and other poor health conditions for families. (SNV-Uganda 2015-2016, Report). With this system in place, people will be able to use other alternatives of RE sources other than concentrating on those that threaten their lives due to lack of knowledge.

SNV Uganda, designed and implemented the Uganda Domestic Renewable Energy Solutions (UDRES) programme, and through this inclusive business initiative reached over 150,000 people in 2015. UDRES included the promotion and distribution of improved cook stoves and home solar solutions in Eastern Uganda. The designed application, if used, would reach out to a bigger number of people as well make the promotion much easier.

2.5 Related Systems and models used in Information dissemination

According to Ommani & Chizari (2008), the main challenge of our age is not producing information or storing information, but getting people to use information because it is a critical resource in the operation and management of organizations and timely availability of relevant information is vital for effective performance of managerial functions such as planning, organizing, leading, and controlling. These designed an Information Dissemination System (IDS) based e-learning to be used the agricultural sector of Iran, and the reason for designing this system was due to lack of expert/scientific advice regarding crop cultivation not reaching farming community in a timely manner, a wide information gap existing between the research level and practice, and traditional methods for Information Dissemination that are inappropriate.

The government of India, under its Ministry of New and Renewable energy, has an Information and Public Awareness Programme whose objective is to disseminate information on new and renewable sources of energy (NRSE) systems/devices through variety of media like electronic, print & exhibition as well as outdoor media, thereby popularizing and creating awareness about such systems and devices. It also brings to the fore benefits, technological developments and promotional activities taking place in the renewable energy arena from time to time. The role of Information and Public Awareness Programme for inculcating the importance of renewable energy amongst masses has been assuming increasing significance in recent times. The Programme is implemented mainly through State Nodal Agencies, Directorate of Advertising & Visual Publicity (DAVP), Doordarshan, All India Radio (AIR), and Department of Posts. (http://mnre.gov.in/schemes/support-programmes/). In this project, the researcher's main focus was electronic due to its various benefits.

Yun, Wang and Yanqing (2016) carried out a research to review and identify the ICT based information dissemination models in China and to share the knowledge and experience in applying emerging ICTs in disseminating agriculture information to farmers and farm communities to improve productivity and economic, social and environmental sustainability. They reviewed and analyzed the development stages of China's agricultural information dissemination systems and different mechanisms for agricultural information service development and operations. They finally identified and discussed seven ICT-based information dissemination models that are believed to provide a useful direction for researchers and practitioners in developing future ICT based information dissemination systems. They further mention that with the rapid development of information technology, the agriculture information dissemination models are constantly evolved and improved. Currently, the agricultural information dissemination models in China can be classified into the following types:

1. Web Portal is a platform hosting a collection of relevant websites. It is an important and fast information dissemination channel. Web Portal is created with a large number of linked sites. All the websites follow unified styles, standards and regulations. The

establishment of Web Portals promotes the sharing and utilization of information resources, reduce overall investment and maintenance costs, and increase the service coverage and site visits.

2. Voice based service is the use of the call center technology to provide users with expert advice and automated voice services.
3. Text (SMS)-Based Service is information dissemination through text message of mobile phones. This service is normally jointly operated by agriculture sector and telecom service providers, e.g. Hunan Agri-Telecom Platform.
4. Self-Support Online Community is information services provided by a community to its members. This is a membership based system involving all stakeholders. Members share experience and exchange information through interactive service platforms, e.g. farmers Mailbox in Zhejiang Province.
5. Interactive Video Conferencing Service is using online multimedia technology to facilitate information service, e.g. Shanghai Farmers ‘‘One Click and Go” service, or Intelligent Farmers service.
6. Mobile Internet Based Service is information dissemination through smart phone service, e.g. Agribusiness price information, E-news, etc.
7. Unified Multi-Channel Service Model is utilizing multiple methods to effectively disseminate information through telephones, computers, and mobile phones, e.g. ‘‘3 in 1” 399service in Fujian.

A review of the above models helped the researcher in selecting most appropriate model for the project.

Memon et al., (2015) state that an information exchange tool for knowledge transfer can exist in two ways, the first is performed in the form of a question answer system in which a person readily answers all the queries that one might have and the other is use of a social forum. They designed a notification system titled Electronic Information Desk System for Information Dissemination in Educational Institutions specifically for students/employees in a university, which is capable of automatically sending information about results, circulars, schedules and time tables to the users on request. The basic idea of the system is to employ an automated notification and information counter and it uses a GSM module to provide remote connectivity, and it allows users to interact with system using SMS messages. When the system receives an SMS, it determines the sender and the information required and replies the sender with the requested information.

The major advantage of this system is the use of GSM for communication, therefore the user does not need to be present in institute, he/she can get information from anywhere and at any time not necessarily during campus timings & even there is no need of internet to deliver information to the users. Another feature in this system is quick information broadcast to all employees, in case if the Head of Department or any employee wants to convey any important information to all employees on urgent basis, he/she has to send a message to that system with specified format to broadcast that information to all employees automatically. The challenge with this kind of system is that it uses SMS which limits the number of characters the user can send and or receive.

2.6 Mobile Applications Development

Mobile applications (commonly referred as "apps"), are considered to be one of the fastest growing trends in Information Systems industry (Eddy, 2011 as cited by Njunjic (2012) According to Njunjic (2012), users enjoy the variety of features that mobile apps can provide quickly and without introducing unnecessary complexity into their designs. As a result, mobile apps present a more popular interface for interaction with business systems than using web applications via Web Browser.

Flora et al. (2014) defines Mobile Application Development as a process by which applications are developed for small low-power handheld devices. Though the mobile application development process is similar to software engineering, it also presents some additional requirements for which the traditional software development process has to be customized (Williamson, 2012 and Wasserman, 2010 as cited by Flora et al 2014). Therefore, the design approach as well differs and it is mostly User Centered.

2.7 User Centred Design approach

The aim of user-centred design (UCD) is to support the entire product development process with user-centred activities. This is done in order to create applications that are easy to use and fulfil the needs of the intended user groups (Nivala et al., 2005)

2.7.1 The User-Centred Design Cycle

According to ISO 13407 (1999), Human-centred design processes for interactive systems' gives instructions to achieve user needs by utilizing a UCD approach throughout the whole life cycle of a system. The study starts with planning the project, at which point a decision must be taken on what kind of information is needed with regard to the usability of the product: information about the usability of an existing product, ideas for developing a new product, or information for comparing products already on the market. The factors affecting the project planning process are strongly related to the amount of resources: money, time, people, etc. In addition, it is preferable to decide during the early stages of the project by whom, how, and when the usability evaluation will be carried out, i.e. usability experts or users, with usability tests or questionnaires, and at which stage of the project (Nivala et al., 2005). The design is an iterative process as in Figure 1

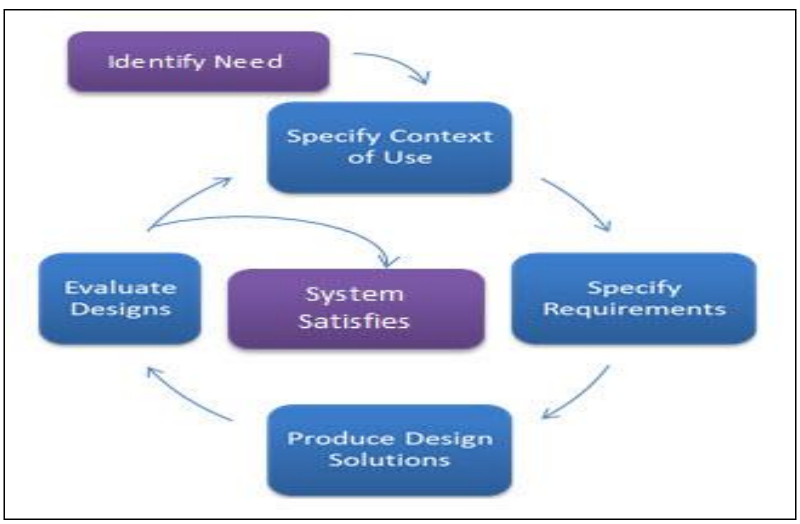

Figure 1: The User-Centred Design Cycle

The first step is to ascertain the user requirements. These can be analysed by studying potential users and the context in which the application will be used. A decision must also be taken on which usability criteria are to be emphasized in the study: effectiveness, efficiency, satisfaction, memorability, and/or minimal errors? The first design solutions and preliminary mock-ups can be designed on the basis of the user requirements. The following stage must analyze whether the defined user requirements have been met. Evaluation can be carried out using various usability methods, and if the results indicate that the user requirements have not been achieved, the iterative process goes back to redefining the user requirements.

2.7.2 System Development Life Cycle Model

The study used the System Development Life Cycle (SDLC) for the development of the system. The SDLC is a conceptual model that describes the stages involved in an information system development project, from an initial feasibility study through maintenance of the completed application. The SDLC model for this research project was Agile. Agile SDLC model is a combination of iterative and incremental process models with focus on process adaptability and customer satisfaction by rapid delivery of working software product. Agile Methods break the product into small incremental builds. These builds are provided in iterations. Each iteration typically lasts from about one to three weeks.

Agile was used because it is an adaptive approach where there is no detailed planning and there is clarity on future tasks only in respect of what features need to be developed. There is feature driven development and the team adapts to the changing product requirements dynamically. The product is tested very frequently, through the release iterations, minimizing the risk of any major failures in future.

This model was used because it is follows the UCD approach and involves bringing in people who are not part of your mobile app team to test and evaluate your prototype. Observe them as they interact with the app and ask for honest feedback on the application’s overall functionality and ease of use. Below is a graphical illustration of the Agile Model:

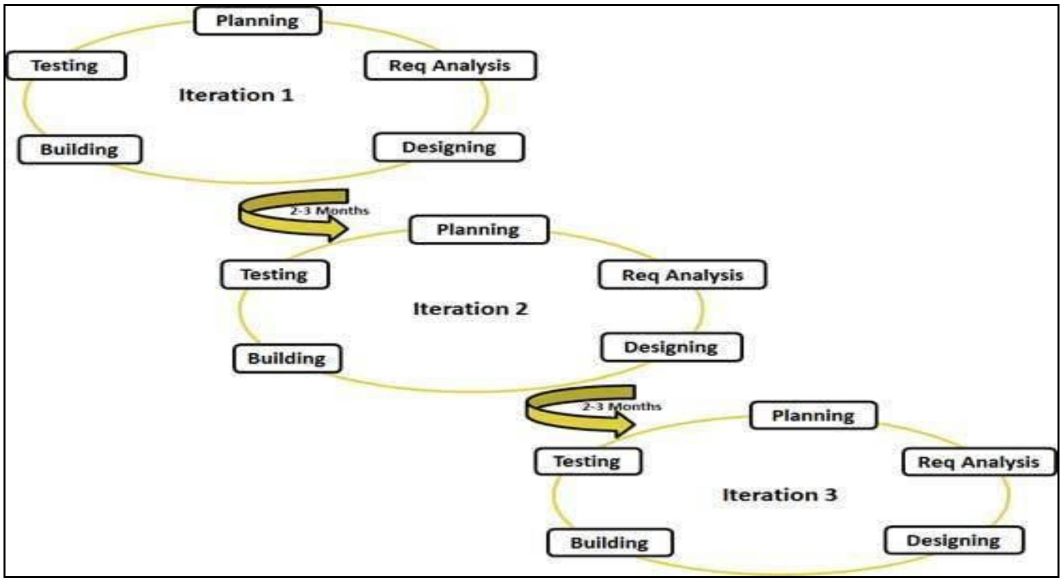

Figure 2: Agile SDLC Model

2.7.3 Models used to evaluate the Go Renewable mobile application

Usability evaluation (UE) is an important step in software development in order to improve certain aspects of the system. Bernhaupt as cited by Nidhi and Pankaj (2013) classified Usability evaluation (UE) methods as User testing (in the laboratory and the field), Inspection oriented methods (like heuristic evaluation and cognitive walkthrough), Self-reporting and inquiry oriented methods (like diaries and interviews) Analytical modeling (task model analysis and performance models) as in Figure 2.3 below

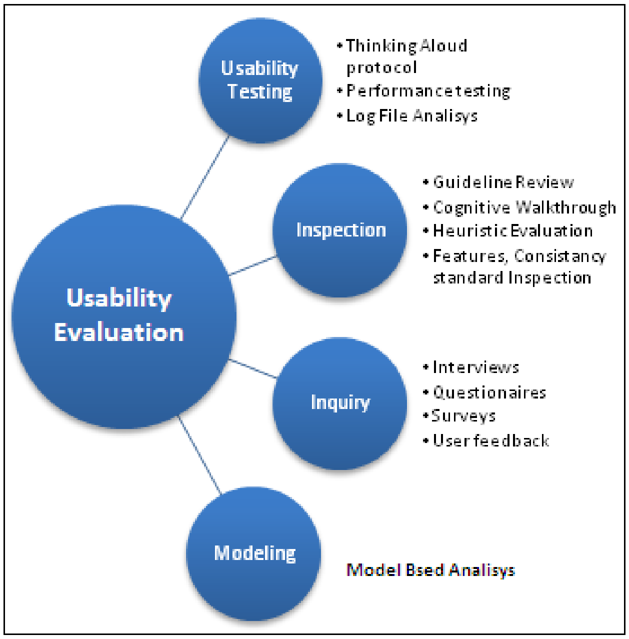

***Figure 3*: Summary of Methods used for UE**

Nidhi and Pankaj (2013) state that while in traditional usability studies a common assumption is that the user is performing only a single task and can therefore concentrate completely on that task. The mobile usage context users will often be performing a second action in addition to using the mobile application. For example, it is quite possible that user is walking while using application on mobile. This makes the user give less attention for using application as it requires the user to perform cognitive processing. Rachel (2013) as cited by Nidhi and Pankaj (2013) suggested a new Usability Model – PACMAD Model. The PACMAD model incorporates cognitive load, which is overlooked in existing usability models and cognitive load directly impacts the usability of mobile applications. The cognitive load refers to the amount of cognitive processing required by the user to use the application. The process of selecting appropriate usability attributes to evaluate a mobile application depends on the nature of the mobile application and the objectives of the study. The PACMAD usability model for mobile applications identifies three factors (User, Task and Context) of use shown in Figure 2.4.

Factors	Attributes
User	Effectiveness
	Efficiency
Task	Satisfaction
	Learnability
Context	Memorability
	Errors
	Cognitive Load

Figure 4: PACMAD Usability model

These factors are to be considered in designing mobile applications for improvement of usability. The word context refers here to the user environment. The context refers to a physical location and also includes other features like the user's interaction with other people or objects and other tasks. The model identifies seven attributes - Effectiveness, Efficiency, Satisfaction, Learnability, Memorability, Errors and Cognitive load. Each of these attributes has an impact on the overall usability of the application. These can be used to assess the usability metrics

2.8 Technique for computing power consumption

According to the Electricity Act (1999) the Electricity Regulatory Authority (ERA) has the mandate to review and approve a schedule of electricity End-user Tariffs to be charged by Umeme to the consumers for the supply of electrical energy in each Billing Period for the year. Every quarter, Umeme submits its power tariffs to the Uganda Electricity Authority for approval before being released to the public. These tariffs are always adjusted (Mostly upwards) due to various factors like global fuel prices, foreign exchange rates specifically the US dollar and the inflation rate of the economy.

The computations were based on the current tariffs set by UMEME at the time the research was being conducted that is the base tariff at Ugx 150 shillings for the first 15 units and Ugx 520 shillings for any units above 15 and the researcher based on this to calculate the power consumption.

2.9 Conclusion

In this chapter, the different RE sources were discussed in detail, current status of RE Information in Uganda, the need for RE information dissemination, Related Systems and Models used in information dissemination, Mobile Application Development.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This chapter includes the research methodology of the dissertation. Research methodology is a scientific and systematic way of finding a solution to a problem. Essentially, the procedures by which researchers go about their work of describing, explaining and predicting phenomena are called research methodology. It is also defined as the study of methods by which knowledge is gained. Its aim is to give the work plan of research. Easterbrook et al (2010) as cited by Franklin and Anselimo (2011) define a research method as a set of organizing principles around which data is collected and analyzed.

The chapter focuses on the methods that were used in developing the Go Renewable mobile application. It involved exploring issues surrounding the current RE information dissemination systems and methods that were used to achieve the specific objectives. The Structured System Analysis and Design Methodology was used which involved analysis of the current information dissemination systems, logical data modelling, data flow modelling and systems implementation. The analysis phase defined the project goals into defined functions and operation of the intended application. This was followed by the design phase that described the features and operations in details including business rules and process diagrams. Finally, the implementation phase transformed the design into real code.

3.1 Research Design

The research design used was user-centred design (UCD) to support the entire product development process with user-centred activities as discussed in chapter two.

In order to satisfy the objectives of the study, both qualitative and quantitative research methods were used. The purpose of Qualitative method was to gain an understanding of the way people access RE information. Its basic advantage, which also constitutes its basic difference with quantitative research, is that it offers a complete description and analysis of a research subject, without limiting the scope of the research and the nature of participant's responses (Collis & Hussey, 2003). The quantitative approach was used to attain a comprehensive understanding of the current dissemination systems in place and RE sources being used and the challenges faced with those while trying to access RE information.

3.2 Study Population

The study population included Clients (people living in Kampala City, particularly Kawempe division) and Suppliers of RE sources. These were considered key entities on which the system implementation was based.

Research purpose and research questions are the suggested starting points to develop a research design because they provide important clues about the substance that a researcher is aiming to assess (Yin, 2012). A research method that facilitates a deep investigation of a real-life contemporary phenomenon in its natural context is a case study (Yin, 2012). Case study research is an increasingly popular approach among qualitative researchers (Thomas, 2011). Several prominent authors have contributed to methodological developments, which has increased the popularity of case study approaches across disciplines.

3.3 Sampling and Selection technique

This study used purposive sampling techniques. Purposive sampling is a form of non-probability sampling in which the subjects selected seem to meet the study's needs.

3.3.1 Why Purposive Sampling technique was used

It gives the researcher freedom to select a sample based on judgment towards a specific purpose. This method was used by the researcher to identify the key stakeholders who participated in the design of the system.

In order to get the right information for this project, there was need to center on the key actors of the proposed system and people living around selection city division were selected because the researcher lives around that area and it was easy to get data from them. More so many of the city dwellers have access to internet services and many of them are owning smart phones which makes it easy for the designed application to be utilized. The researcher also needed to get data from suppliers of RE technologies to get to know how they disseminate information regarding their products.

3.3.2 Sample size

This summarizes the number of respondents to include in a statistical sample. The number of people to gather information from was about 50. These include the clients or people using the RE technologies, and suppliers of these technologies.

3.4 Requirements determination

One of the most critical and first activities for developing a new system is to determine the system requirements. Therefore, incomplete and inaccurate information requirements determination may result into system failures. In this project information was collected on what kind of information the users needed from the new system and how it should be presented and delivered to the end user.

3.5 Data collection methods

Qualitative data collection methods vary using unstructured or semi-structured techniques. Some common methods include focus groups (group discussions), individual interviews, and participation/observations. The sample size is typically small, and respondents are selected to fulfill a given quota. A couple of data sources were used to collect data for this research.

3.5.1 Primary data sources

Primary data sources were direct observations, and interviews,

3.5.1.1 Observation

The researcher observed the renewable energy sources in use for the selected study population. This method was used in order to allow the researchers to develop a keen understanding of the topic of interest necessary for developing relevant and meaningful semi-structured questions for the interview.

3.5.1.2 Interviews

This method was chosen because interviews provide an opportunity to explore or clarify topics in more detail. Interviewing involves asking questions and getting answers from participants in a study. Interviewing has a variety of forms including: individual, face-to-face interviews and face-to-face group interviewing. Interviews can be structured, semi-structure or unstructured. The semi structured interview guide was used for this study because it provides a clear set of instructions for interviewers and can provide reliable, comparable qualitative data and also the researcher did not have the chance to go to the field more than once to interview someone.

3.5.2 Secondary data sources

Secondary data sources involve the researcher using other people's research to collect information usually referred to as document review. These data sources were peer reviewed journals, articles, textbooks and the internet. The secondary data sources helped the researcher to gather information about the research problem in the required area of the study. Secondary data helped the researcher to avoid reinventing the wheel, which could not have been possible given the timeframe for carrying out research.

3.6 Usability Evaluation

The researcher reviewed literature on various methods of user evaluation and zeroed down to self-reporting and inquiry oriented methods in which tools like interviews, questionnaires, surveys and user feedback are used for evaluation.

The researcher generated questions for the interview guide basing on the PACMAD model usability model for mobile applications which identifies three factors (User, Task and Context) discussed in Chapter two. Appropriate usability attributes to evaluate the application were selected depending on its nature and the objectives of the study and these were effectiveness, efficiency and satisfaction.

3.7 Requirements Definition

Primary data helped the researcher to get the user requirements for the new system. The strength and weaknesses of the existing systems were also identified. The analysis led to the generation of user requirements, functional requirements, non-functional requirements and data requirements for the proposed system. The analysis provided the researcher with new systems specific requirements that were used for the design and development of the new system.

3.8 System Design Phase

Unified Modeling Language (UML)

It is a language for specifying, visualizing, constructing, and documenting the artifacts of software systems, as well as for business modeling and other non-software systems. The UML has a number of models which in turn form part of the models for information systems development, such as the systems requirements. The researcher used some models available in UML. This phase included the use of tools such as Data Flow Diagrams, (DFDs) and Entity-Relationship Diagrams (ERDs)

Data Flow Diagram (DFD) is a pictorial way of showing the flow of data into, outside and around the system. DFDs were used to model the system's data processing. These show the processing steps as data flows through a system. DFDs were used because they are simple and intuitive notation that anybody can understand as compared to textual descriptions. Data flow diagrams graphically represented functions or processes that capture, manipulate, store and distribute data between the system and its environment and among system components.

Entity Relationship Diagrams (ERD) is a detailed logical presentation of data and related business rules in an organization. The ERD is was used during data modelling to show the relationship between the entities involved in the system. The ERD was used in the design of the entity relational model to show the relationship between the entities involved in the system together with their attributes and indicates the number of occurrences an entity can exist for a single occurrence of the entity. The ERD was used as a communication tool between the database designer and the end-users; it was the main tool for the data modelling.

3.9 System Implementation

The technologies used in the implementation of the mobile app involved; Eclipse IDE, Tom Cat Server, MySQL as the backend database and SQLite the front end database. Eclipse IDE hosted the Android Emulator that simulates how the application runs on different platforms that is to say; different models of Android operating system phones e.g, SAMSUNG, HTC, and Sony. Eclipse IDE is the platform that supports the building of the program. Tom Cat server is a server that hosts the database which mobile application uses.

3.10 System Testing

System testing is the type of testing to check the behavior of a complete and fully integrated software product based on the software requirements specification (SRS) document. The main focus of this testing is to evaluate the functional /end-user requirements. A test case matrix was used to effect this.

Table 3.1: Test Case Matrix

ID	Test Case Name	Purpose	Type
1	Account Login	This was to ensure that account users are able to access the Go Renewable app after logging in	Functionality
2	Account logout	This test was to ensure that account users can log out after accessing the resources of the Go Renewable app	Functionality
3	Add User Account	This test was to ensure that the Admin can create accounts for different users (Supplier) who may want to access the resources of the Go Renewable Energy app.	Functionality
4.	Add, Modify, Delete RE Source	This was done to ensure that the Admin is able to modify information of different RE sources	Functionality
5.	Compare costs of installation RE sources	This test was done to ensure that a user can compare 2 different energy sources, by capturing number of appliances and how much time they are used in a day	Functionality

6	Comments and Suggestions/Questions	This was done to ensure that the user can send their comments in case of any query and get response from the system on their smart phone	Functionality

3.11 Project Management Plan

The project was conducted in four phases as follows; planning, systems' analysis, systems' design and development. The project activities and deliverables are as listed in the table below:-

Table 3.2: Activities and Deliverables of the Go Renewable app

Objective	**Activities**	**Deliverables**	**Time**
Planning	Identify the need for the project Determine the scope Develop data collection tools	Project proposal Detailed work plan for the project Specification of system	September – November 2015
Analysis	Determine requirements Determine design of system Identify the business processes, actors and roles Requirements and object model designs	Description of current System Challenges and Strengths Recommendation on how to improve current system Business process lists and models Information and IT infrastructure models	January 2015 - February 2016

Objective	Activities	Deliverables	Time
Design	Logical design Physical design	Requirements specification document Detailed specifications of system elements Entity Relationship Diagrams	March– May 2016
Construction	Programming Linking interfaces to the database	Code and documentation	June 2016
Testing	Testing	Test plan and results Working system	July 2016
Report Writing	Drafting, editing and formatting of the report	Research Report	Aug – September 2016

3.12 Conclusion

The research methodology chapter is basically explaining the methods that this research used in the designing and implementation of Go Renewable app. The researcher, in this chapter explained research methods, study population, selection of the sample, requirements determination, methods of data collection, system analysis, design, implementation, testing and Project Management plan.

CHAPTER FOUR: CURRENT SYSTEMS ANALYSIS AND NEW SYSTEMS DESIGN

4.0 Introduction

This chapter was essential in identifying the functional requirements of the system that could meet the end user needs. The design phase helped to derive deductions from the findings of the research and suggested solutions of the proposed system.

4.1 Responses attitude and acceptance

From the interviews carried out it was discovered that majority of the interviewees have heard about a few sources of RE through a word of mouth and but don't have in-depth knowledge of the different sources. Many of the interviewees admitted that they only know about Hydro. Those who have heard about Solar energy, don't know the details, yet they would like to get more information about this source of energy.80% admitted that the application would help increase awareness of these of Renewable energy.

The functionalities that respondents would like to include on the application are as follows:

1. Basic information about RE, the different types and how what is required to have these installed
2. Information on suppliers of RE, how to contact them
3. Information on prices

4.2 Study of the current system

The current systems used in dissemination of renewable energy (RE) information are mainly through mass media, and company websites, poster campaigns, mobile marketing where marketers move door to door looking for clients, email address for comment and suggestions for the different companies, and company newsletters.

4.2.1 Strengths of the current system

The current system requires less information technology skills, and does not suffer from system failures.

4.2.2 Weakness of the existing system

The current system is mainly paper based, meaning it is expensive in terms of costs involved in printing tools used in information dissemination and transport charges involved. The company must allocate financial resources for both the cost of the materials and the labor power of managing them, including printing, collating and filing costs. This could mean employing additional workers who require salaries and benefits. More so it is time consuming, when it comes to updating of information and retrieving what has been stored. There is limited information access by users, in a way that if a company is to use printed material for dissemination may not be in position to distribute individual copies to all clients.

4.3 Requirements

This involved interacting with the users of the system to know what they would like the system to do for them. These were grouped into user, functional and non-functional requirements.

4.3.1 User requirements

These are requirements that state what the user expects the application to be able to do for them. These were acquired during the interview carried out with the users of the system.

4.3.2 Functional requirements

Functional requirements define what the application is supposed to accomplish. A function is described as a set of inputs, the behavior, and outputs. Generally, functional requirements are expressed in the form system must do requirement. These are as listed below:

1. User being able to select Renewable source
2. Selecting of the item/technology under RE sources
3. Specification of quantity of Technologies
4. Enabling users to send comments and get responses to their phones/ email
5. Admin should be able to add, modify, delete items in the database
6. Comparing different energy sources

4.3.3 Non Functional Requirements

These are the quality requirements, which impose constraints on the design or implementation such as performance requirements, security, or reliability. For the Go Renewable application these include among others:

Accessibility which guarantees that the system is accessible from as many platforms as possible. i.e The application should be able to run on a Sumsung phone, HTC, well as running on android operating system.

Usability influences mostly the user interface and means the system is easy and intuitive to use without much background information.
Availability of the internet connection, to be able to fetch the most recent data.

4.4 System Requirements

The Go Renewable app required the following minimum system requirements to work effectively:

1. 32 MB of RAM
2. 200mhz processor
3. Android OS 4.4 and above
4. 32MB of storage and above

4.5 Context Diagram

This is the highest level DFD that defines the scope of the system and provides an "outward" view of the system. This diagram shows system boundaries and interaction with external entities and users. It also shows the groups of people that interact with the system and the main flows of data. The context diagram at the project level is the root of the functional decomposition at the conceptual model of detail. It shows the input and output data flows to a central process that represents the different business processes.

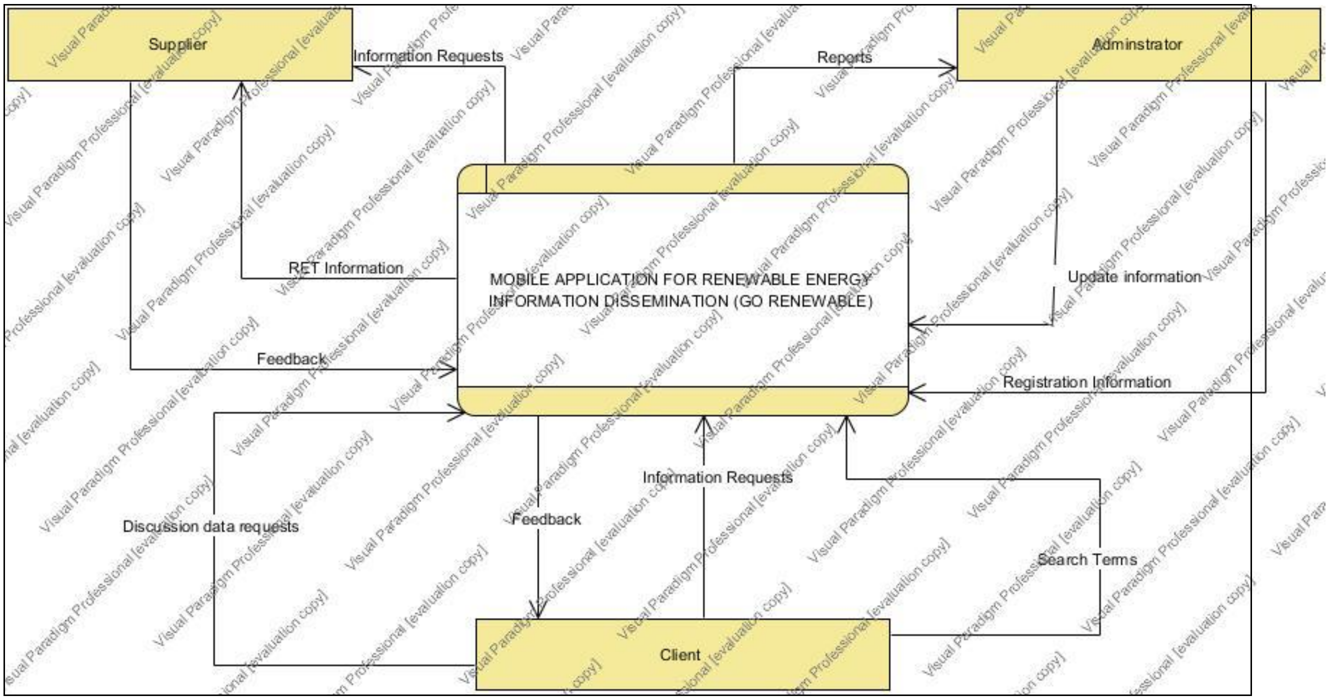

Figure 5: Context Diagram

4.5.1 Level one Data Flow Diagram

The Level one DFD illustrates the new system processes that are involved when users make use of the system. Each user has particular tasks to perform with the system

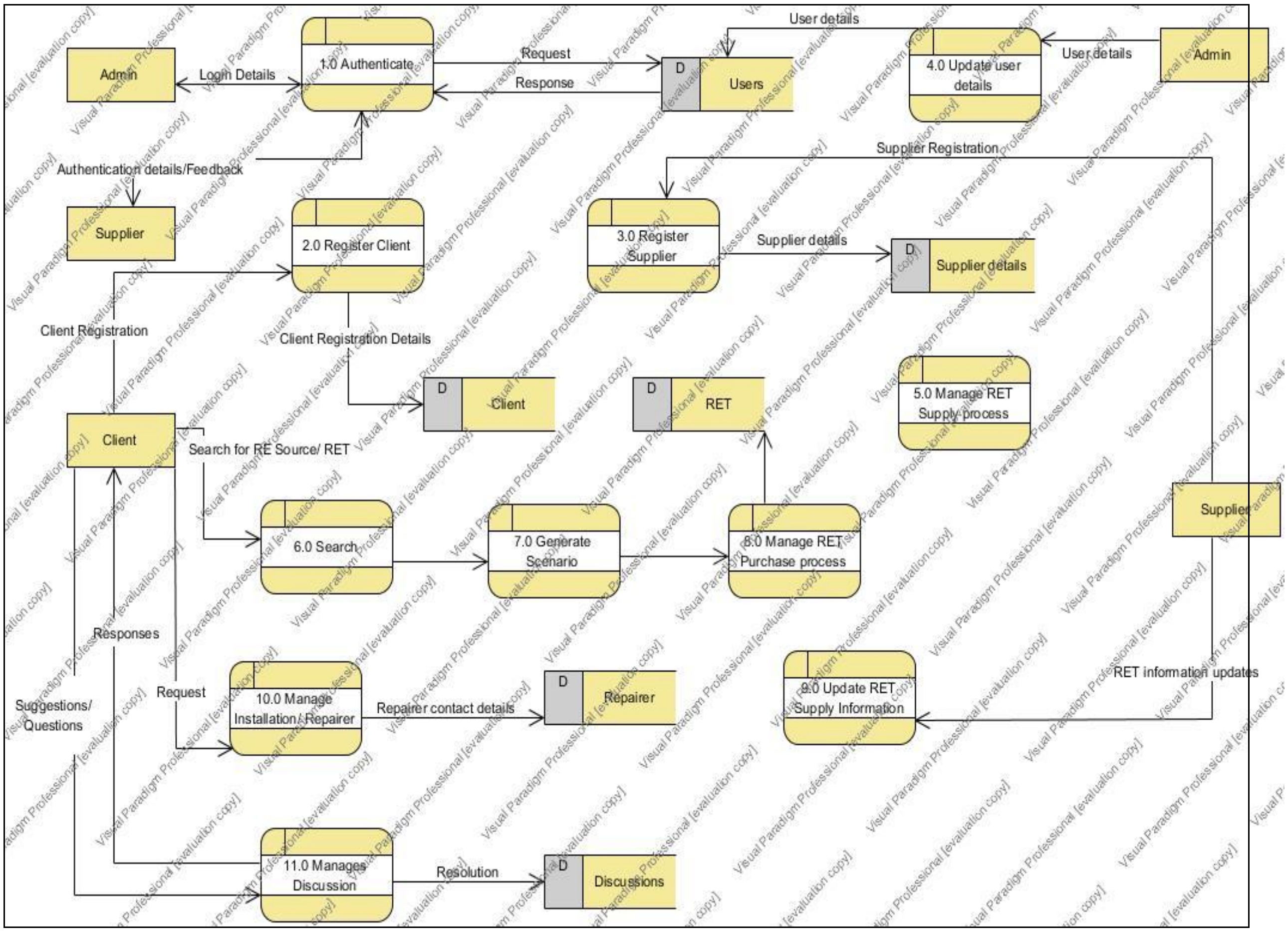

Figure 6: Data Flow Diagram

4.6 Entity Relationship Diagram

The Entity Relationship Diagram shown in the Figure: 4 below is a pictorial representation of the logical database design highlighting how the various entities connect and interact with each other. It was the main tool for back end data modelling. It shows the relationships between the entities as well as their attributes. Below are the different business rules applied in the entity relationship diagram above

1. A client searches for one (1) to many (*) RE information
2. RE information is searched by one (1) to many (*) clients
3. Supplier sells one (1) to many (*) RE Technologies
4. An energy sources is selected by one (1) to many (*) Clients
5. A client selects one (1) to many (1) Energy Source
6. An Energy Source is selected by one (1) to many (*) Clients

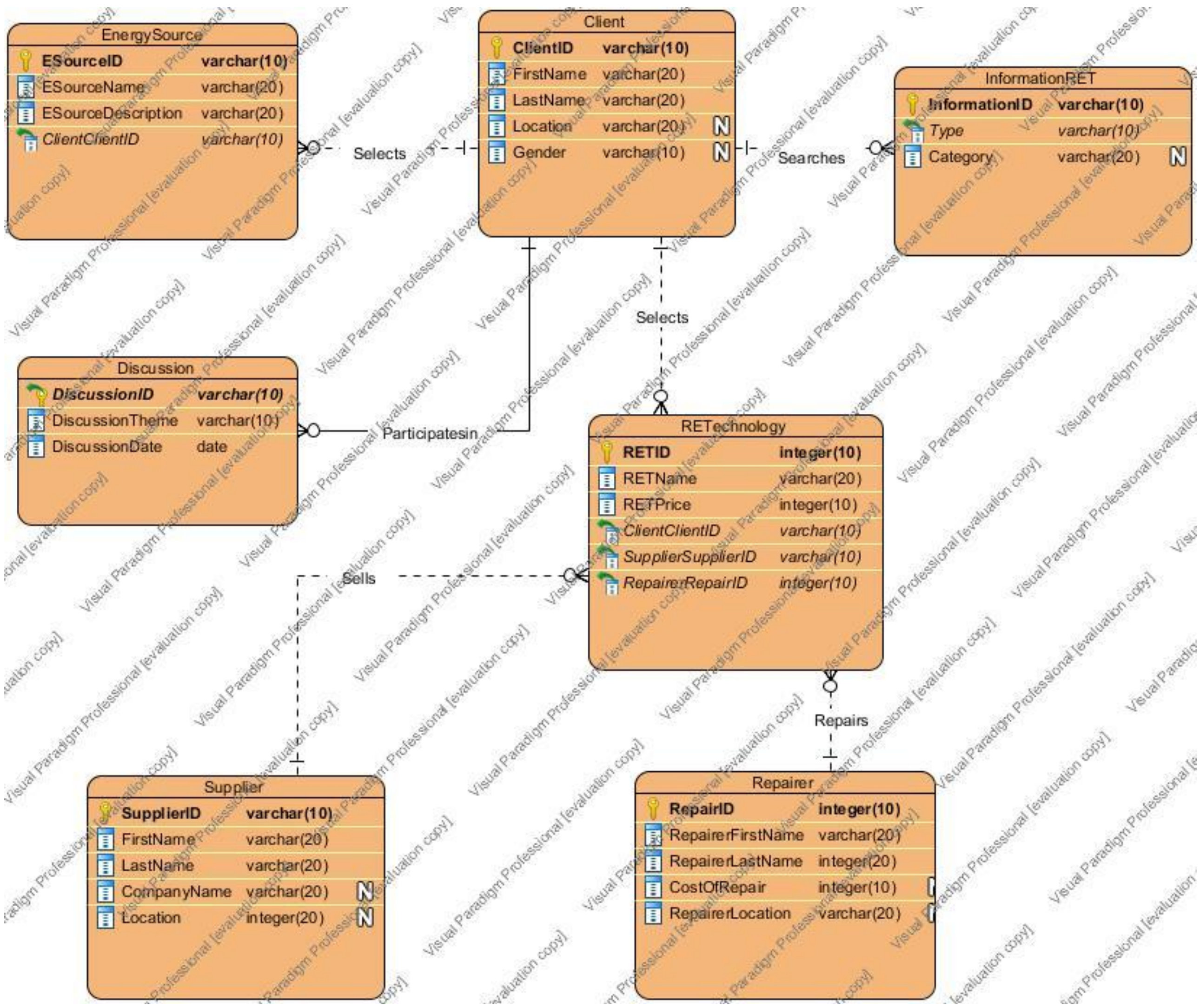

Figure 7: **Entity Relationship Diagram**

4.7 Data Dictionary

Table 4.1: Data Dictionary

Entity	Attribute Name	Data Type	Constraint
Client	**ClientID/Email**	**Varchar(20)**	**Primary Key**
	FirstName	**Varchar(20)**	**Not Null**
	LastName	**Varchar(20)**	**Not Null**
	Gender	**Varchar(20)**	**Not Null**
	Location	**Varchar(20)**	**Not Null**
Supplier	**SupplierID**	**Varchar(20)**	**Primary Key**
	FirstName	**Varchar(20)**	**Not Null**
	LastName	**Varchar(20)**	**Not Null**
	CompanyName	**Varchar(20)**	**Not Null**
	Location	**Varchar(20)**	**Not Null**
RETechnology	**RETID**	**Varchar(20)**	**Primary Key**
	RETName	**Varchar(20)**	**Not Null**
	RETPrice	**Int(10)**	**Not Null**
	ESourceID	**Varchar(20)**	**Foreign Key**

EnergySource	**ESourceID** **ESourceName** **ESourceDescription** **SupplierID**	**Varchar(20)** **Varchar(20)** **Varchar(100)** **Varchar(20)**	**Primary Key** **Not Null** **Not Null** **Foreign Key**
Discussion	**DiscussionID** **DiscussionTheme** **DiscussionDate**	**Int** **Varchar(20)** **Varchar(20)**	**Primary Key** **Not Null** **Not Null**
Repairer	**RepairID** **RepairerName** **RepairerLocation** **RETID** **CostofRepair**	**Varchar(20)** **Varchar(20)** **Varchar(20)** **Varchar(20)** **Int**	**Primary Key** **Not Null** **Null Null** **Not Null** **Not Null**

4.8 Logical Database Design

This was generated from the contextual design through stages of normalization. Normalization is a systematic approach of decomposing tables to eliminate data redundancy and undesirable characteristics like insertion, update and deletion anomalies. It is a multi-step process that puts data into tabular form by removing duplicated data from the relation tables. This was done to ensure that modifications made for an attribute in one table can be reflected in the entire Go Renewable app database.

4.9 Physical Database Design

The database was made using MySQL which had the ability of linking more than one table by creating relationships. Below is the sample code for the physical design.

CREATE TABLE IF NOT EXISTS ‘supplier’ (‘supplierID’ varchar(20) NOT NULL, ‘FName’ varchar(20) NOT NULL, ‘Lname’ varchar(20) NOT NULL, ‘Location’ varchar(50) NOT NULL, PRIMARY KEY (‘supplierID’));

CREATE TABLE IF NOT EXISTS ‘esource’ (‘esourceID’, varchar(20) NOT NULL, ‘esourceName’ varchar(40) NOT NULL, ‘esourceDes’ varchar(200) NOT NULL, PRIMARY KEY (‘esourceID’));

4.10 User Interface Design

The user interface design presented an easy to use layout for the technical personnel to demonstrate to users towards how the developed application would appear on completion.

4.10.1 Users Registration Interface

This would enable different users have access to the Go Renewable application after registration

4.10.2 Administrator’s Interface

The administrator’s interface would enable him/her update information in the database, create links to different suppliers, and manage users, frequently asked questions.

4.11 Conclusion

This chapter gave a detailed description of all aspects involved in Renewable energy information dissemination. DFDs were used to simulate the behavioral pattern of the Go Renewable app to the intended users.

CHAPTER FIVE: SYSTEM IMPLEMENTATION AND TESTING

5.0 Introduction

This chapter documents in detail the actual implementation of the Go Renewable Energy application. The user interfaces of the Go Renewable application and the database were constructed. Further, installation procedures for all the vital software and hardware are documented for further references whenever the need arises.

Tests were conducted to during system construction to verify that the system works according to the stated functional specifications.

5.1 Implementation plan for Go Renewable mobile application

The tasks followed during the installation of the Go Renewable application are listed in the table below

Table 5.1: Implementation Plan for Go Renewable app

Activity	**Deliverable**	**Tool**
Coding	Components of the application design that is login, main menu. Implement the system architecture	Eclipse IDE, Tom Cat Server, MySQL SQLite
Testing	User testing of the application with sample data to check for different errors, authentication and security testing	Smartphone, with data
Installation	Software installation Android studio, WAMP server Eclipse IDE, Tomcat server	Software CDs/Set up

Documentation	Technical, user and test Documentation	Microsoft Word
Training plan	User manual	Microsoft Word
Support plan	Online help	Frequently Asked Questions on the app side, Email
Security plan	Authentication Authorization	Passwords
Maintenance plan	Obtaining requests	Software patches

5.2 Coding and database implementation

Interfaces and physical design mentioned in the previous chapter were implemented into working code. Languages used in coding include MySQL as the backend database and SQLite the front end database. This was followed by sample data being entered to verify that there are no errors generated.

5.2.1 Print Screen Interfaces of Go Renewable application

The application is divided into 4 pages, namely: The Login Interface (Figure 5), About Renewable energy (Figure 6), Checking for prices of RE Technologies (Figure 7) and Compare energy sources (Figure 8).

The Login page enables one to access application, and leads user to the next page, which is About Renewable energy. The About Renewable energy page gives a list of all energy sources and their description. From the same page, there is a tab (How much power do you use) which enables user to compare 2 different energy sources, for example Hydro vs Solar. Here major appliances/Technologies like Flat Iron, TV, and Fridge were considered. The user enters the quantity, and number of hours an appliance is used and gets to know how much energy is consumed and also gets to know the expenditure if they are to use the different sources in order to make an informed decision.

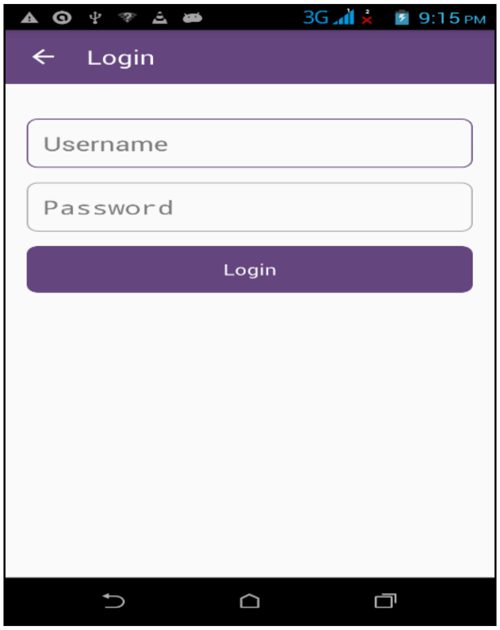

Figure 8: Login Interface

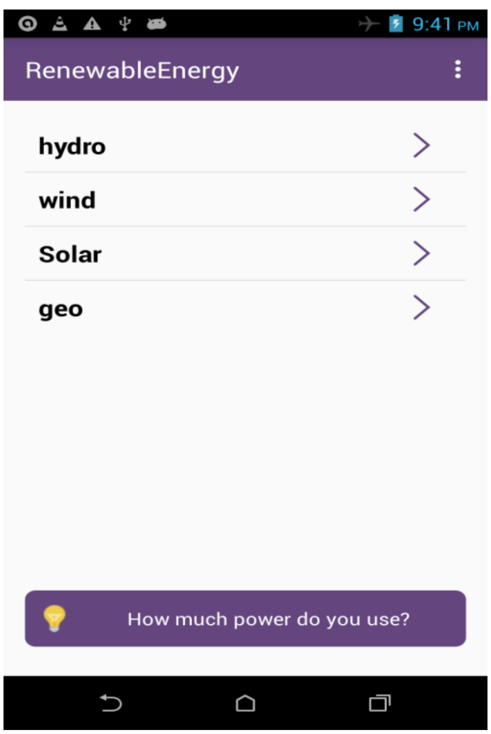

Figure 9: About Renewable energy

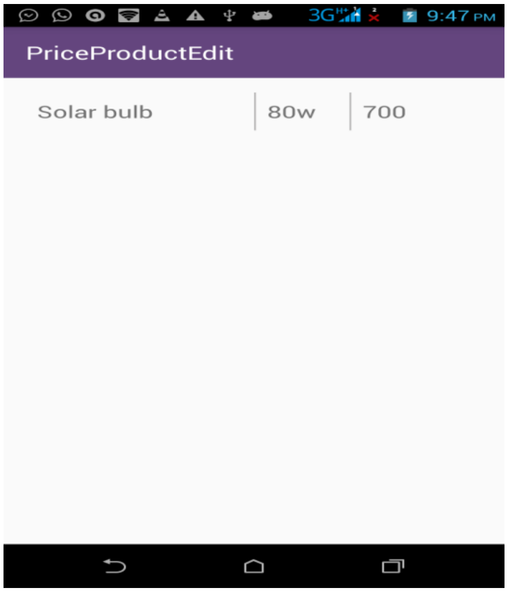

Figure 10: Checking for prices of RETs

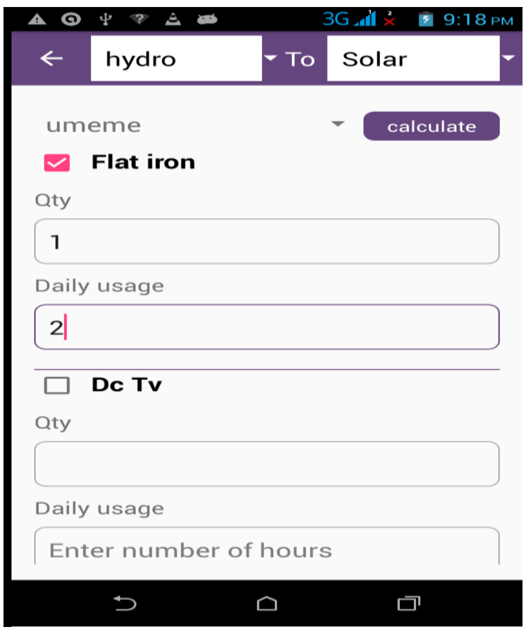

Figure 11: Screen showing comparison of Hydro vs. Solar Energy Source

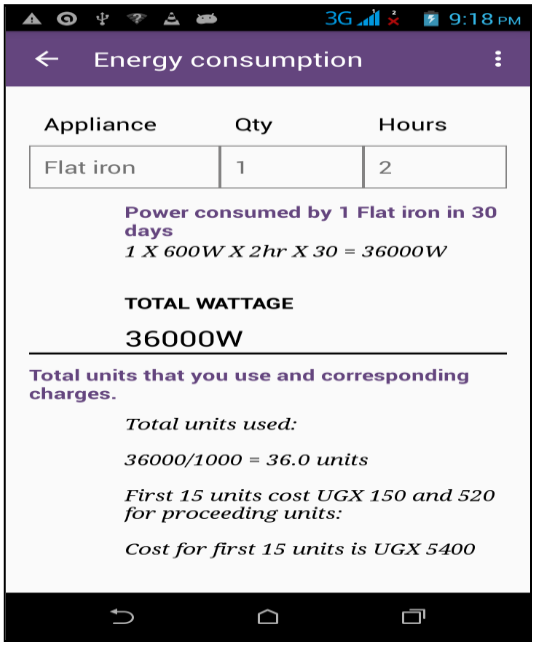

Figure 12: Screen showing total no. of units used when using Hydro

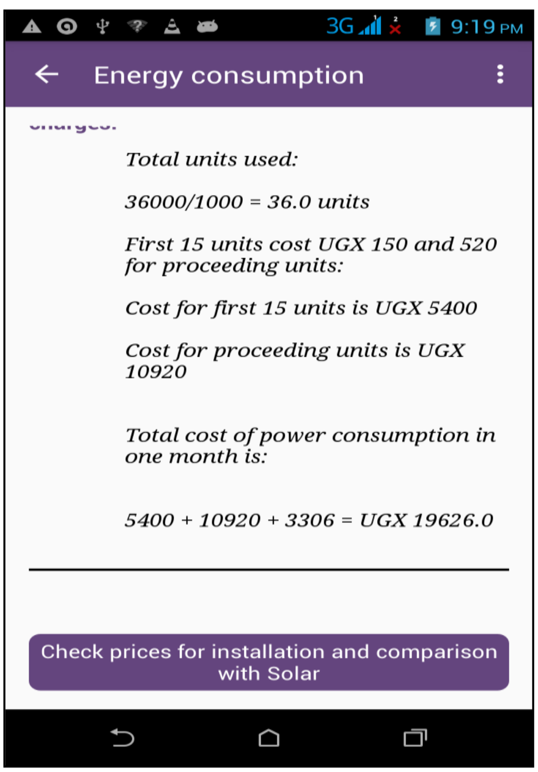

Figure 13: Screen showing amount spent in month when using Hydro

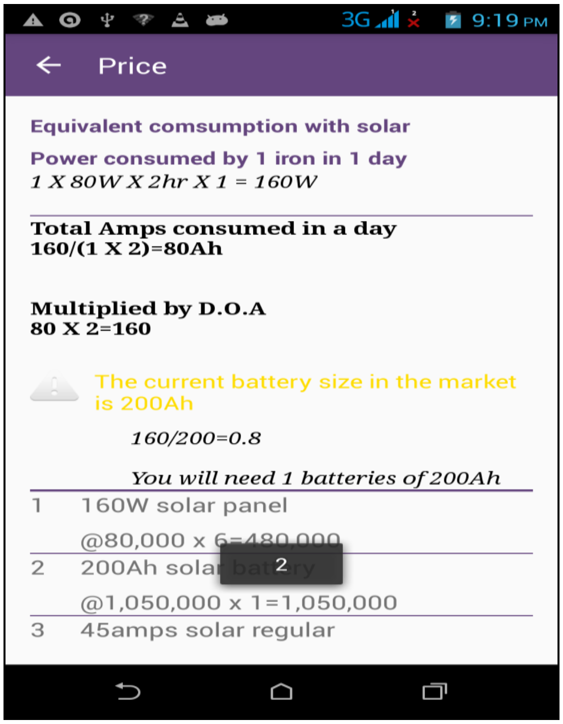

Figure 14: Screen showing equivalent consumption with Solar in terms of price

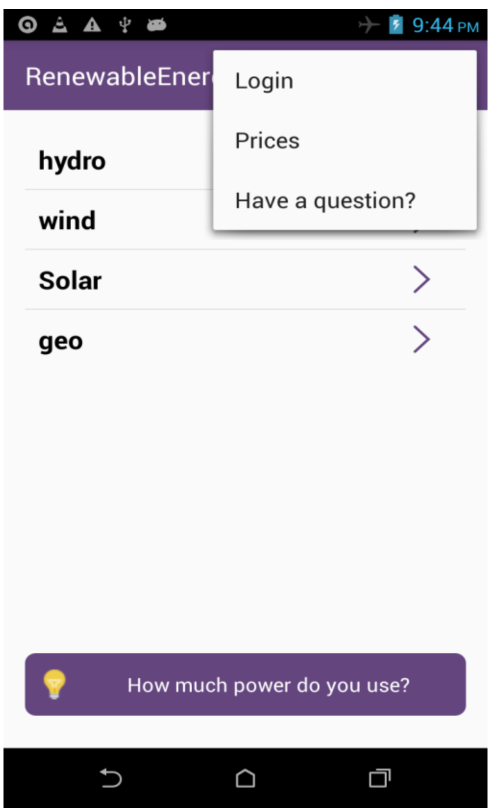

Figure 15: This interface enables user to make inquiries/ask questions

5.3 Testing

All tests were carried out were functionality tests for the Go Renewable mobile application. All the procedures that were followed were specified in the Test Specification. Each test procedure defined the steps to be followed and expected results from the tests.

5.4 Security Measures

Authentication of users with passwords was done for The Go Renewable app for so that sensitive information such as prices is not altered.

Authorizations was also done to ensure that the app keeps track of its users.

5.5 Documentation

This include documentation of work done during the entire development time. These documents follow a particular standard set by the IEEE Standard for Software User Documentation. The documentation was classified into three categories namely:

1. Technical Documentation: This includes system requirements specification, design and architectural specifications and code documentation.
2. User Documentation: This includes manuals for the end users, and system administrator
3. Test Documentation: This includes the test plan, test design specification, test log, test incident report and the test summary report.

5.6 System Evaluation

The application prototype was evaluated by 20 users on different platforms and a summary of the findings is as in the table below. The evaluation was to determine the user's satisfaction and willingness to use the designed application to acquire more information on RE technologies and make informed decisions.

The majority of the interviewees revealed positive results for the all the questions. The few that were negative mentioned that they don't have much interest in using mobile applications.

Table 5.2: User's satisfaction and willingness to use app

User satisfaction and willingness	**Yes**	**No**
Was the app easy to use?	18	2
Did the app provide you with the all necessary information you need to know on RE technologies?	18	2
Did the concept of the app convince you?	17	3

5.7 Conclusion

The actual implementation of the Go Renewable Energy application was documented in this. The user interfaces of the Go Renewable application and the database were constructed. Further, installation procedures for all the vital software and hardware are documented for further references whenever the need arises.

Tests were conducted to during system construction to verify that the system works according to the stated functional specifications.

CHAPTER SIX: DISCUSSION OF RESULTS, CONCLUSION, LIMITATIONS & RECOMMENDATIONS

6.0 Introduction

This chapter summarizes all the processes involved in the development and construction of the Go Renewable Mobile application, challenges encountered while carrying out the research project and recommendations for future research.

6.1 Discussion of Results

The major aim of the project was to improve the dissemination process of renewable energy information by designing a mobile application that can avail RE information to the public any time it's needed anywhere. These were achieved through the specific objectives as follows:

The first objective was to analyze and review literature of the current systems used in dissemination of renewable energy information. This was all discussed in chapter two by examining and critiquing the current information dissemination systems. It was discovered, as per the case study that dissemination is mainly through mass media i.e radios, television, newspapers and company newsletters.

More so, the researcher reviewed the different models used in information dissemination which guided on selecting the most suitable one for this project, i.e the Mobile Internet Based Service which is information dissemination through smart phone service.

System requirements were acquired by collecting data from intended users and the tool used here was the Interview guide.

Having gathered the system requirements, the researcher was able to come up with designs for the Go Renewable Energy application to guide in the system design as a way of achieving the second objective of the study. The research used the used a unified modeling language to come up with business processes for the system which served as input for the actual system implementation. These included the context diagram, Level one diagram and Entity Relationship Diagram. Finally, to meet objectives three and four, the application was tested on various platforms by different users with actual data to ensure that it meets the user requirements as stated in chapter 4 of this project.

6.2 Limitation of the Study

A couple of challenges were faced during the study which include; Time, which was not enough to learn the new technologies used in mobile application development since the researcher was new in this field. It was not easy to acquire the licensed version of the business process modeling software, so trail version was used, which does not bring out the work so well.

6.3 Conclusion

Compared to the current methods of creating awareness about the Renewable energy, which is mainly through mass media i.e. print, press, radio, and television and word of mouth, this application plays a bigger part to in creating awareness to all stake holders including Clients, and Suppliers of these energy sources. This is because people nowadays spend a lot of time on their phones and it’s easier to access this information because it can be available anywhere any time it’s needed.

6.4 Future Work

Future work should be on creating more user interfaces, like where a user can directly carry out a transaction directly with the supplier without involving third party. For example, a user being able to order for a RE technology with the application.

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APPENDIX

Appendix I Interview Questions

The objective of this interview is to examine interviewee's awareness of Renewable Energy and willingness to use the designed application to acquire more information on RE technologies and make informed decisions

1. How do you define renewable energy?

   ____

2. What kind of information do you know about Renewable Energy such as different types, costs, installation requirements?

   ____

3. From which sources did you get the information mentioned in (2) above?
   a) Word of mouth
   b) Internet
   c) Mass media (Radio, TV)
   d) Print material
4. What challenges did/do you face when trying to acquire knowledge about renewable energy?

   ____

5. Was/Is the information you acquire(d) helpful?

   ____

6. From 5 above;
   a) If yes, how has it been helpful?

      ____

   b) If no, why hasn't it been helpful?

      ____

7. Why do you think renewable energy is important for you?

   ____

8. What kind of renewable energy source/technology do you know?
   a) Biomass

b) Hydropower

c) Solar

d) Biogas

e) Wind

f) Geothermal

9. What do you suggest should be done to provide people with more information about renewable energy?

____

10. Do you think a mobile application would increase people's awareness of renewable energy?

____

11. What functionalities would you like to include on the mobile application?

Examples and suggestions of what to include

____

____

Appendix II: Interview Questions

The objective of this interview is to examine interviewee's willingness to use the designed application to acquire more information on RE technologies and make informed decisions

1. Is the app easy to use?
   a) Yes
   b) No

   If not easy, what improvements do you suggest?

   ____

   ____

2. Did the app provide you with the necessary information needed on RE technologies?

   Yes

   No

   If no, what kind of information should be added?

   ____

   ____

3. Did the concept of the app convince you?

   Yes

   No

   ____

   ____

Appendix III: System code

Sample code to compute energy usage for each appliance.

```
/**
 */
public class MathAdapter extends BaseAdapter
{
    private Context context;
    private List<ComputeEnergyModel> list;
    private LayoutInflater inflater;

    public MathAdapter(Context context, List<ComputeEnergyModel> list)
    {
        this.context = context;
        this.list = list;
        inflater = LayoutInflater.from(context);
    }

    @Override
    public int getCount() {
        return list.size();
    }

    @Override
    public Object getItem(int position) {
        return list.get(position);
    }

    @Override
```

```
    public long getItemId(int position) {
        return position;
    }

    @Override
    public View getView(int position, View convertView, ViewGroup parent) {
        ViewHolder viewHolder;
        if(convertView == null)
        {
            viewHolder = new ViewHolder();
            convertView = inflater.inflate(R.layout.compute_list_time, null);

            viewHolder.title = (TextView)convertView.findViewById(R.id.title);
            viewHolder.math = (TextView)convertView.findViewById(R.id.math);

            convertView.setTag(viewHolder);
        }
        else
        {
            viewHolder = (ViewHolder)convertView.getTag();
        }



        if(!TextUtils.isEmpty(list.get(position).hours)                    &&
!TextUtils.isEmpty(list.get(position).qty))
        {
            viewHolder.title.setText("Power      consumed      by      "+list.get(position).qty+"
"+list.get(position).appl + " in 30 days");
```

```
            int result = Integer.parseInt(list.get(position).wattage) * Integer.parseInt(list.get(position).hours) * Integer.parseInt(list.get(position).qty) * 30;

            viewHolder.math.setText(list.get(position).qty+"   X   "+list.get(position).wattage+"W   X   "+list.get(position).hours+ "hr X 30 = "+result+"W");
        }

        return convertView;
    }

    private class ViewHolder
    {
        TextView title;
        TextView math;
    }
}
```