TOWARDS DEVELOPING A MANUAL POWER GENERATOR FOR CLIMATE CHANGE ADAPTATION AND SUPPLY FOR DOMESTIC ENERGY NEEDS

BARASA IGNATIUS MUKHWANA (B. Env. CD)

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DECLARATION

This Dissertation is my original work and has not been presented for award of degree or any other academic qualification in a learning institution.

Signature……………………………………Date:…………..…………………………………..

Ignatius M. Barasa (I54/76213/2012)

This research project has been submitted for examination with our approval as University supervisors.

Signature………………………………….….Date…………………………………………….

Prof. John Muthama Nzioka

Department of meteorology, University of Nairobi

Signature…………………………………………Date:…………………………………………..

Dr. Christopher Oludhe

Department of meteorology, University of Nairobi

DEDICATION

This work is dedicated to those who are vigilant to keep our land, air and waters free of real pollution, particulates and greenhouse gases.

ABSTRACT

This study was aimed at developing an alternative green energy technology amongst households in Bungoma South District, within Bungoma County. The households in the study area have traditionally relied on kerosene as a source of energy to meet most of the domestic energy needs.

The main objective of this study was to develop a manual power generator that will solve domestic energy and climate change challenges. Other specific objectives were to compare the suitability of kerosene energy and energy from the Manual generator, determine the applicability of green energy in the study area and establish if such a technology will meet the energy demands for rural households.

In this research project, I developed qualitative and quantitative distinctions between kerosene energy and green energy and showed that green energy is well placed to solve a myriad of health and socio economic problems while at the same time reducing Green House Gases (GHG) emissions. I also presented examples of green energy devices and compared them with kerosene energy. The results showed that kerosene use had socio economic and environmental consequences.

The study employed both primary and secondary data. The latter was collected from different sources such as books and journals, while the former was achieved through key informants' interviews and questionnaire surveys. These methods generated both qualitative and quantitative data that was analyzed using statistical packages.

Research findings indicated that the community under study was spending a lot of money on purchase of kerosene. Health consequences were also been felt in addition to social impacts such as loss of property due to accidental fire.

The study recommended the use of green energy as a substitute to the kerosene being used. In addition, it emphasized the need to identify and develop innovations geared towards solving environmental issues such as GHG emissions.

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LIST OF LIST OF TABLES AND THEIR HEADINGS

LIST OF ACRONYMS

AC	Alternating Current
BC	Black Carbon
CC	Climate Change
CDM	Clean Development Mechanism
CH_4	Methane
CFL	Compact Fluorescent lamps
CO	Carbon Monoxide
DC	Direct Current
EMCA	Environmental Management and Coordination Act
ERC	Energy Regulatory Commission
GDP	Gross Domestic Product
GHG	Green House Gas
IPCC	Inter Governmental Panel on Climate Change
MDG	Millennium Development Goals
MW	Mega Watt
NAMA	Nationally Appropriate Mitigation Action
NEMA	National Environment Management Authority
NOx	Nitrogen Compounds
PM	Particulate Matter

PV	Photo Voltaic
RE	Renewable Energy
SO_2	Sulfur Dioxide
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds
WHO	World Health Organization

CHAPTER ONE

1. INTRODUCTION

This chapter examines the background of the study, statement of the problem, objectives of the study, research questions, significant of the study, limitations of the study, research questions, in addition to basic information on the study area.

1.1 Background to the study

Rising fossil fuel burning and land use changes by human beings have emitted, and are continuing to release increasing quantities of greenhouse gases into the Earth's atmosphere. These greenhouse gases include Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). Admittedly, a rise in these gases has caused a rise in the amount of heat from the sun withheld in the Earth's atmosphere, heat that would normally be radiated back into space. This increase in heat has consequently led to greenhouse effect, resulting into climate change.

Climate change is one of the major challenges of our time and adds considerable stress to our societies, environment and the nation. From shifting weather patterns that threaten food production, to prolonged droughts that lead to Disasters, the impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly.

Climate change is a serious risk to poverty reduction and could undo decades of development efforts (Claire M., *et al*, 2002). While climate change is global, its negative impacts are more severely felt by poor people and developing countries like Kenya. They are more vulnerable because of their high dependence on natural resources and limited capacity to cope with climate variability induced events. Moving towards low-carbon societies can help reduce greenhouse gas emissions, improving human health and well-being and creating green jobs.

Climate change will have wide-ranging effects on the environment and on socio- economic sectors, including water resources, agriculture and food security and human health, among others. Changes in rainfall pattern have led to severe water shortages and/or flooding. Rising temperatures has caused shifts in crop growing seasons a adversely affecting food security and causing changes in the distribution of disease vectors putting more people at risk from diseases such as malaria and dengue fever. Temperature increases has the potential to severely increase rates of extinction for many habitats and species in the order of 30 per cent with a 2° C rise in temperature (UNFCCC, 2007).

Kerosene in Kenya is an important energy source for poor rural and urban populations. They use it for cooking and lighting. Since kerosene serves as a substitute for wood fuel, efforts to increase its consumption will relieve pressure on wood use. Use of kerosene as a lighting fuel either in wick lamps or brighter burning pressure lamps is common in some developing countries, particularly in regions where electricity supply is unaffordable, unreliable, or unavailable. An estimated one-fifth of the global population (approximately1.3 billion) in 2009 lacked access to electricity, while an even greater but unknown number had only intermittent access (IEA 2011).

1.2 Problem Statement

According to the 2009 Kenya Population and Housing Census, 12,712 rural households in Bungoma South District use lantern in addition to a further 45,994 tin lamp users. The urban households had 6,694 lantern users and 9,836 tin lamp users. With frequent increases in Kerosene prices, the product has become expensive for most households. Kerosene used as a home energy source, particularly in rural study area accounts for a significant percent of poisoning leads to serious health problems, complications and death. Smoke emitted by simple lamps Wick lamps is a source of black carbon that absorbs light, thereby heating the atmosphere.

Various efforts have been done to provide alternative sources of energy in the study area. Such efforts include Rural Electrification Programme. However, in a district where 56% of the population lives in absolute poverty (Bungoma South Development Plan 2008-2012), very few households are connected to the National Grid.

This study was aimed at providing a solution to contemporary problems brought about by kerosene use as a source of energy. A manual power generator was developed to charge various batteries to provide Direct Current power for domestic lighting. The generated power provide bright, reliable light for domestic use work without annoying smoke and dangerous chance of fire from kerosene lanterns, in addition to provision of electrical power for various electrical applications.

1.3 Justification for the Study

As Kenya aspires to be a middle income economy as envisaged in Vision 2030, it faces an enormous challenge of meeting its energy needs in order to transform into industrial economy. Therefore there is a need to come up with strategies and investment plans to secure sustainable supply of energy to meet the growing demand. Such small scale energy sources will lessen the demand placed on the Main National Grid.

Climate change is anticipated to have far reaching effects on the sustainable development of developing countries including their ability to attain the United Nations Millennium Development Goals by 2015 (United Nations Framework Convention on Climate Change, 2007) This therefore calls for measures to curb the release of Carbon Dioxide gas (CO_2) in the atmosphere through development and promotion of green energy technologies.

Global warming is likely to disrupt and even destroy some of the tourist sites such as the snow-caps of Mt. Kenya, the coastal rainforests, fragile marine ecosystems and the marine parks. For instance 'coral bleaching' of the Kenyan coral reef has been observed. Sea levels are rising with the implication that some of the popular beaches will eventually disappear. This therefore calls for the need to reduce further emissions of CO_2.

Mills (2012) asserts that beyond the well known benefits of reducing lighting energy use, costs, and pollution (which has its own health consequences), off grid electric light can yield substantial health and safety benefits and save lives. While knowledge of these benefits can enhance the business case for conversion to more efficient and less dangerous technologies such as green energy technologies, proponents often lack accurate information. Statements confusing lighting with the more widely known health impacts of cooking are a particularly common problem.

Fuel based is a significant cause of structural fires and severe burn injuries, with particularly high death rates (24% on average) in cases where kerosene is adulterated with other fuels, resulting in explosions. For context, more than 95% of deaths worldwide from fire and burns occur in the developing world, and the mortality rate is 5 times higher in low and middle income populations in Africa than in high income countries in Europe (Mills 2012). It is in view of such challenges that a cleaner, risk free energy source is proposed.

1.4 Research Questions

The research will be guided by the following questions:

1. Does the use of green energy contribute to a cleaner, healthy environment?
2. What are the social and health repercussions of kerosene and green energy sources?
3. What are the economic constraints for kerosene and green energy production?

1.5 Objectives of the Study

The project research will have the following main and specific objectives which will help in getting the information targeted, and these objectives are:

1.5.1 Main Objective

The main objective of this study was to develop a green technology that will solve domestic energy and climate change challenges.

1.5.2 Specific Objectives

The specific objectives were:

I. Develop a green energy generator for domestic energy needs
II. To establish if such a technology will meet the energy demands for rural households
III. Compare the suitability of kerosene energy and green energy produced by the generator.

1.6 Hypothesis

Use of green energy in place of kerosene provides a clean and healthy environment

1.7 Significance of the Study

Results from this study will help in a number of ways including helping people minimize the over reliance on kerosene as the major source of energy for domestic energy needs. In so doing, they will be able to save a considerable amount of money for other uses. This is because Kerosene lamps require refilling, unlike the manual power Generator that requires negligible money to maintain, once in place.

In addition, the study is aimed at developing power generators that will produce power for domestic purposes. Since there will be no emissions of gases such as Methane (CH_4) and Carbon Dioxide (major contributors to global warming) the environment will be clean and free from global warming.

1.8 Study Area

1.8.1 Position and size of the District

Bungoma South District lies between latitude 0 30' and 0 40' North and longitude 34^0 20' and $34^0$40' East. It covers an area of 663.3km^2, which is about 8 % of the total area of the province.

According to the Bungoma South District Development Plan (2009), it is one of the districts that form the Western province. It lies at the northern tip of Western province and borders Teso District to the northwest, Bungoma West district to the north, Bungoma North district to the northeast, Bungoma East district to the east, Mumias district to the south and Busia district to the west.

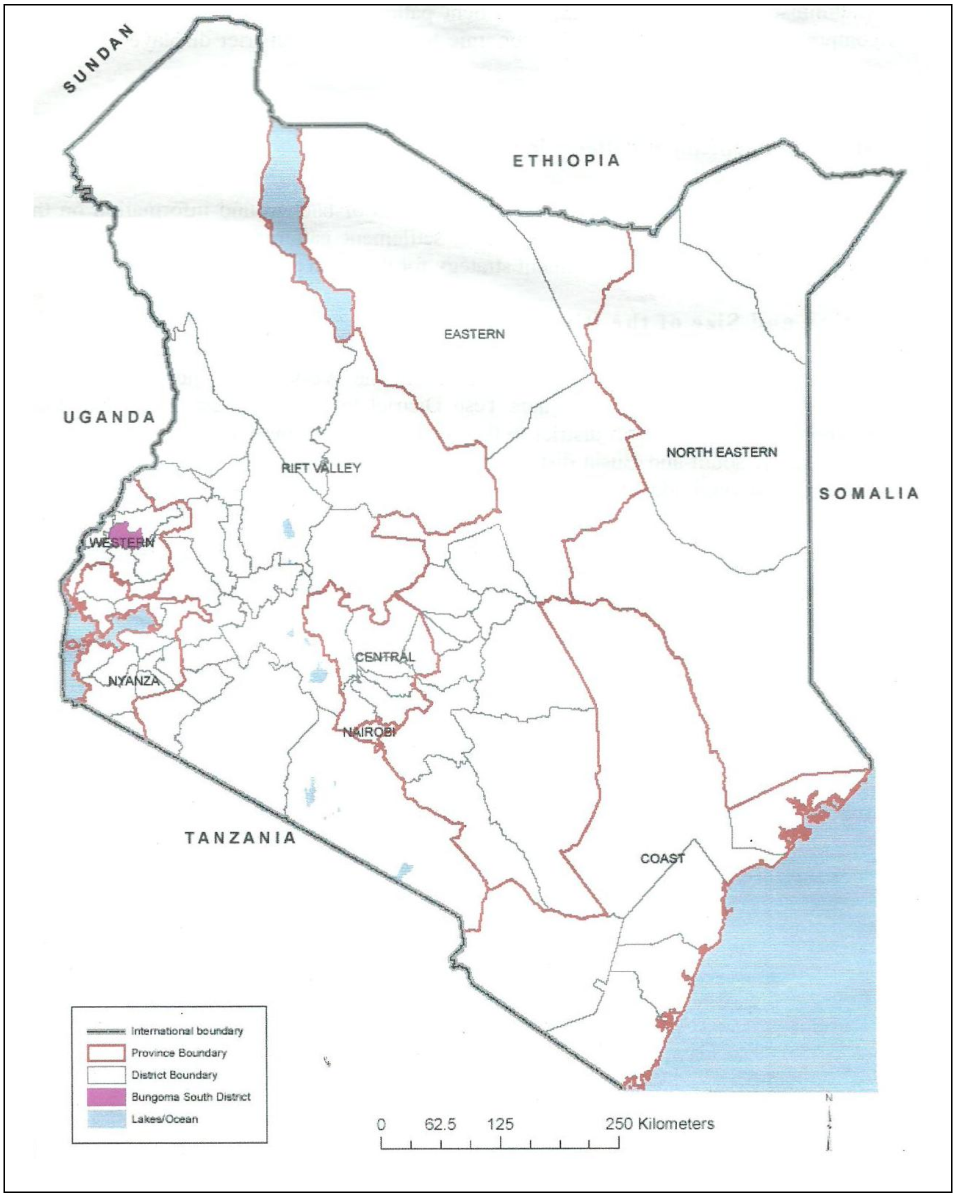


Figure 1: The Location of District on Kenyan Map. (Source: Bungoma South District Development Plan, 2009)

1.8.2 Administrative Units and Political Units

The District has two administrative divisions, namely; Kanduyi and Bumula. Bumula is the largest division with an area of 344.9 km^2 while Kanduyi is the smallest with an area of 319.4 km^2.

Table 1: Area of the District by Administrative Units (Bungoma South District Development Plan 2009)

Division	Area (km^2)	No. of locations	No. of Sub-Locations
Kanduyi	319.4	5	14
Bumula	344.9	10	24
Total	**663.3**	**15**	**38**

The district has two constituencies, Bumula and Kanduyi. There are also two local authorities with a total of twenty wards. The local authorities are Bungoma Municipal Council and Bungoma County Council. Bungoma County Council has the highest number of electoral wards.

1.8.3 Population profile

As per the 2009 census, the population of Bungoma South District stood at 408,598 (Bumula Constituency had 178,897 while Kanduyi Constituency had 229,701 people). The District has a population growth rate of 4.3% which is higher than the national population growth rate of 2.9%. The district is densely populated with average densities of 600 persons per km^2 in 2008. (Bungoma District Development Plan, 2009).

1.9 Energy

The major sources of energy in Bungoma South District are biomass energy sources (firewood, sugarcane and maize cobs), Hydro Electric power generated electricity, fossil fuels and renewable energy sources such as solar energy. The major challenges facing electrification are the prohibitive high cost of installation in addition to inadequate funding. The energy sector remains under developed as most of the rural population depends on firewood and fossil fuel thus necessitating the need to exploit other alternative sources of energy. Electricity coverage is very low.

1.10 Poverty

According to Bungoma District Development Plan (2009), approximately 56% (207,582) of the inhabitants of the district fall below the poverty line. Urban poverty level, taking Bungoma town in Kanduyi division as the urban centre, stands at 68% whereas rural poverty level averages 55%. Poverty levels are the highest among the male headed households as compared to the female headed households in the rural areas (58% and 56%) and vice versa for urban areas.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter explores the dominant themes of the research questions. It further explores the efforts done by researchers and other innovators, especially in line with green energy.

2.2 Climate change and human health

Kovats *et al* (2000a) argues that the emission of large amounts of greenhouse gases since the beginning of the industrial revolution has significantly altered the energy balance of the Earth. As a result, climate is changing on a global scale and will continue to do so for at least the next decades to come. Kovats proceeds to state "Human population health is affected by changes in climatic factors both directly (*e.g.,* by increased frequencies of heat waves) and indirectly *e.g.*, due to altered ranges of disease vectors". Health problems already prevalent today may become more (or less) urgent and new health risks may be introduced to currently unaffected regions (Kovats *et al*., 2000a, McMichael and Githeko 2001). Globally, massive development has taken place with consequent release of gases such as carbon dioxide and waste that end up generating methane gas, thus increasing the green house gases in the atmosphere.

Most human and natural systems are sensitive to climatic changes (Hans-Martin F., and Richard J.T, 2004). However, human health differs from other impact domains in various ways. The pathways along which climate change affects human health are often long and complex, and uncertainties accumulate along them. The majority of health impacts are strongly influenced by behavioural factors and by the socioeconomic characteristics of the community such as the overall level of economic development, the state of sanitation and public health systems, and building standards.

Kovats further claims "Since climate is, but one of many factors that determine the status of population health, assessing the role of climate in disease occurrence requires careful analysis." In addition, data acquisition is often more difficult in human health than in other impact domains because it usually depends on human co-operation and there is limited scope for controlled experiments (Kovats *et al*., 2000a).

About 1.3 billion people throughout the developing world (~20% of global population), lack access to electricity and therefore rely instead on fuel based lighting (International Energy Agency, 2011). Many businesses find themselves in the same situation, and additional users on the electric grid face routine outages or energy costs forcing reversion to fuel based light sources. Today, more people than the world's population at the time Edison introduced electricity spend on the order of $40 billion each year to operate highly inefficient and dangerous lamps, which, in the process, releases nearly 200 million tonnes of greenhouse - gas emissions (Mills, 2005).

Lighting is the dominant use of kerosene in rural areas and among the poorest populations (Rao, 2012), but kerosene plays a big role as fuel for cooking in urban areas or in areas without solid fuel supplies (e.g. Charcoal) or where it is promoted as a "cleaner" alternative to solid fuels (Dehran S. and Breden kamp, 2012).

More than 95% of deaths worldwide coming from fire and burns occur in developing Countries, and the mortality rate is 5 times higher in low and middle income populations in Africa than in high income countries in Europe (World Health Organization, 2002a). In South East Asia, the rate is 8.3 times greater than in Europe.
By one estimate, the global deaths from burns and smoke inhalation were on the order of 322,000 in the year 2002. However the value was estimated at 195,000 for the year 2008 (World Health Organization 2012b). Overall burn incidence rates are substantially higher for children and the elderly.

A random sample of homes in South Africa found that kerosene related fires (presumably for Cooking as well as lighting equipment) had occurred in 6.3% of all households (Matzopoulos *et al.,* 2006). One fire there, attributed to a single candle, killed two people, while destroying 500 homes and leaving 2,000 people homeless (Evan Mills, 2012).

Inhalation of particulates resulting from indoor combustion can cause a range of adverse health effects ranging from Tuberculosis to Cancer (Bai *et al.,* 2007 and Dominici *et al.,* 2003). Poor indoor air quality in developing countries creates a large societal burden, both economic and humanitarian (Zhang and Smith, 2007). As of 2004, an estimated 2 million deaths (World Health Organization, 2009) and 1.4 billion illnesses (Dasgupta *et al.*, 2004) occur each year from poor indoor air quality in developing Countries, the primary cause of which is cooking with solid fuels such as charcoal. The consequences of lighting---related pollutants are often conflated with those of cooking (which, ironically are generally stated to be improved when the user switches *to* kerosene fuel for cooking). Cooking related impacts are no doubt more severe than those of lighting, and equating the two does a disservice. However, lighting related risks merit concern. While human inhalation of particulate matter from simple wick lamps is about 5 times less than that of cook stoves, it is also about 5 times more than from ambient air. (World Health Organization, 2009)

Fuel based lanterns are often placed in close proximity to users, and emit indoor pollutants that can be inhaled deeply into the lungs. Emissions resulting from burning kerosene include carbon monoxide, carbon dioxide, sulfur dioxide, nitrogen dioxide, formaldehyde, and various VOCs (volatile organic carbons). Potentially harmful effects include impairment of ventilatory function, a rise in blood carboxyhemoglobin in people exposed to carbon monoxide in kerosene fuel combustion products (Behera *et al.*, 1991), and a higher incidence of acute lower respiratory infection among those using kerosene and bio fuels (Sharma *et al.*, 1998).

2.3 Energy sources in Kenya

According to the State of Environment Report of Kenya (2007) the principle energy supply sources have predominantly comprised of Biomass (68%), Petroleum (22%) and Electricity (9%). The energy sector still relies predominantly on the dwindling biomass energy resource especially to meet energy needs for rural households and heavy dependency on imported petroleum to meet the modern economic sector needs. In the electricity sub sector, hydro power accounted for 57%, whereas fossil based thermal generation energy contributed 10% of electricity generation. However other forms of renewable energy including Wind, Solar, Biogas and Micro Hydro power, to mention just a few accounted for less than 1%. This shows how the renewable energy sector has being under utilized in Kenya, in spite of the massive potential resources.

On the other hand, energy resources and availability have been adversely affected by climate change. The increasing frequency of extreme weather events such as floods and droughts requires continuous evolution of adaptation measures to safeguard future sustainability. As such, modern energy technology must be embraced to conserve the available resources while identifying other alternative renewable resources. This contrasts sharply with the status quo as the energy sector, in spite of the efforts being undertaken to promote renewable energy still relies on petroleum for thermal generation. There are several renewable energy sources in the country such as Hydro Power, Wind, Solar, Wind and Biogas. In addition, the renewable energy options often include the use of wastes to produce high valued and useful energy. For example, Mumias Sugar factory uses bagasse to generate electricity to meet its energy needs and supply the extra to the National Grid.

Petroleum Fuels are the most important source of commercial energy in Kenya, and are mainly used in transport, commercial and industrial sectors. Kenya relies entirely on imported petroleum products. Imports of petroleum accounted for16 per cent of the total import bill in 2002 and consumed 31 per cent of the country's foreign exchange earnings from merchandise exports. Consumption of petroleum products was 2.4 million metric tonnes, with per capita consumption at 76.2 kg. Projected growth in this demand, with Kenya's anticipated economic recovery was 2 per cent per annum (Ministry of Energy, 2004).

2.4 Research and Development in Kenya

Based on the evidence presented in the National Climate Change Response Strategy (2010), Research and development is important not only in understanding the causes, manifestations and impacts of climate change, but also in responding to it. The strategy further emphasizes that research activities are explicitly encouraged by numerous international Conventions and Agreements including the UNFCCC and the Kyoto Protocol, which call on Parties to promote, and to cooperate in scientific, technological, technical, socioeconomic and other research, systematic observation and development of data archives. The National Climate Change Response Strategy rightly concludes that research focusing on technological development plays an important role in preparing a low carbon society of the future by improving existing climate-friendly technologies and developing new ones.

Technology is an important factor that contributes to the adaptation to climate change efficiency. As pin pointed by the State of Environment Report of Kenya (2007) Cooling systems, desalination technologies and other engineering solutions represent some of the available options to improved outcomes and increased coping mechanism to climate change. Therefore, use of appropriate technology and its transfer can help communities, nations and continents to adapt to climate change. Adaptation may include first growing nitrogen fixing fuel wood species, renewable energy technology, energy production, conversion, transformation, transmission and distribution technologies and soft technologies (insurance schemes, agro forestry management systems as well as information and knowledge.) As such, a successful adaptation strategy combines both hard as soft technologies. Likewise, technology facilitates the reduction of vulnerability to the impacts of climate change by improving the prevailing social, economic and environmental conditions and management practices in a system. (State of Environment Report of Kenya (2007).

The fourth report of the IPCC documented evidence that global warming observed over the past 50 years is attributable to human activities. It further predicted that human activities will influence change of atmospheric composition throughout 21C since some energy production transformation and consumption processes continue to emit greenhouse into the atmosphere especially carbon dioxide. It is released by burning fossil and biomass fuels. It is projected that CO_2 accumulation in the atmosphere will continue an upward trend into the future due to the increasing industrialization. Fossil fuels accounts for 86% (dominant form of energy) while current anthropogenic CO_2 emissions accounts for about 75% (IPCC, 2007)

2.5 Pollution from household energy consumption

According to Kituyi (2000) production and consumption of solid fuels (firewood and charcoal), and liquid fuels (kerosene and Liquefied Petroleum Gas), are key source of a range of gaseous and particulate pollutants that include CO_2, CO, N_2O, NOx, CH_4, NMHCs and PMs. These gases and aerosols have a range of impacts on human health and the environment. CO_2, CH_4 and N_2O are greenhouse gases (GHGs) with potential effect on global warming, while others such as NOx, CH_4 and CO are precursors to important secondary products such as tropospheric ozone, which has serious impact on vegetation and human health particularly in high altitude regions.

PMs and CO are also well known respiratory health hazards. Unsustainable charcoal and fuel wood production can also contribute to deforestation and desertification. (Kituyi, 2000).

Although quality of data is still low, there is indication of rapidly changing demand for these fuels in rural and urban areas. Demand for charcoal has dropped from 2.91 million tonnes in 1997 to 2.48 million tonnes in 2000 and to 1.6 million tonnes in 2004 (Government of Kenya, 2004). The use of forestry and agricultural residues shows an increase from 1.37 million tonnes in 1997 to 2.9 million tonnes in 2000. Demand for firewood decreased slightly from 15.42 million tonnes in 1997 to 15.1 million tonnes in 2000. (ESDA, 2005). The use of kerosene and Liquefied Petroleum Gas for cooking continues to grow steadily in both rural and urban areas. For instance, Kenya had less than 50,000 household LPG cylinders in use in 1995, confined to only a few key urban areas. However, by 2002, over 700,000 cylinders were in use throughout the country. The growing use of kerosene was in part attributable to convenience and competitive pricing especially as charcoal price was rising (Kituyi, 2000).

2.6 Urban and rural household energy choices

Studies have shown that there was a shift from biomass fuel to kerosene and liquid petroleum gas (LPG) by mid income urban households, and to LPG and electricity by higher income urban households (TERI, 1992; Reddy and Reddy, 1994). In rural areas, the pattern was different. Studies in western and central Kenya (Mugo, 1997 and Mugo, 1999) found that all households regardless of socio-economic status used woody or high quality crop residues (like maize cobs) before changing to other forms of biomass energy for cooking. In western Kenya, all the maize cobs were used before the population turned to wood or maize stalks, and in central Kenya, all the coffee and tea pruning and maize cobs were used before the population turned to wood or other lower forms of residues. Therefore, in rural households of a given area, the types of fuels used for cooking were nearly uniform among all income groups. However, as scarcity increased, the better-off population switched to using wood while the poorer groups of society turned to lower forms of crop residues. In Bungoma district, it was found that all households preferred wood fuel for cooking (Mugo, 1997). Maize cobs were the next favourite energy source followed by kerosene, gas, electricity and charcoal. In urban areas, the choice of cooking fuel depends on income while those in the rural areas make decisions based on available alternatives, which can change from region to region as well as time to time. Policy interventions and plans for sustainable energy supply have thus to be customized to regional needs.

2.7 Household kerosene uses and fuel characteristics

Cooking, lighting, and heating are the main household services provided by kerosene, although there are kerosene refrigerators and other appliances in some areas. Kerosene heating is not widespread in temperate or highland areas of developing countries, mainly because of cost. Where heating fuel is needed, biomass or coal is usually used because it is cheaper and readily more available (Long, 1997)

Kerosene cooking is widespread in many developing countries, especially in urban populations, where biomass needs to be purchased, and electricity and LPG are expensive or unavailable. There are many kerosene stove designs, but they can be broadly categorized into two broad types depending on how the fuel is burned—wick stoves, which rely on capillary transfer of fuel, and the more efficient and hotter burning pressure stoves with vapor-jet nozzles that aerosolize the fuel using manual pumping or heat. In low-income households, wick stoves are more commonly used, because they are cheaper, they easily provide simmer heat for some staple foods, and they have no nozzles that can get clogged by soot (Budya *et al*, 2011).

2.8 Pollutants Emitted From Kerosene Appliances

Kerosene, when burned in appliances, emits many potentially health-damaging pollutants. An exhaustive list would include hundreds of compounds. As a frame of reference for interpretation of concentrations reported in the following sections, short summaries of the best-established adverse health effects associated with some of these pollutants are presented. As applicable, guideline levels established by the World Health Organization (WHO) (2006; 2010) are included. WHO also provides interim target levels for some pollutants, which are higher than guideline levels and intended to provide incremental transition steps for situations with high baseline conditions, from which it is difficult to rapidly achieve guideline levels.

There is a strong and consistent body of evidence indicating that exposure to fine particulate matter (PM) increases the risk of respiratory and cardiovascular disease, cancer, and mortality

(Krewski *et al*. 2005; Samet and Krewski 2007; Tsai et al. 2012; Yang 2008). Fine PM originates from both natural and anthropogenic sources and is emitted as a product of incomplete combustion.

Formaldehyde (HCHO) is produced by combustion sources as both a gas and adsorbed to particles. Being water soluble, over 90% of gas-phase formaldehyde is absorbed in the upper respiratory tract, unless it is bound to fine particles, which allow for deeper penetration into the lungs. Formaldehyde is classified as a Class 1 carcinogen (IARC 2006), because of sufficient epidemiologic evidence that it increases the risk of nasopharyngeal cancers and myeloid leukemia. Short-term effects include sensory irritation such as eye itching and frequent blinking at levels >0.38 mg/m3.

Carbon monoxide (CO) is a colourless and odourless gas generated by the incomplete combustion of hydrocarbon fuels. When inhaled, CO binds to hemoglobin in red blood cells to form carboxyhemoglobin, reducing oxygen-carrying capacity of the blood and increasing the risk of chronic and acute adverse health effects in adults, children, and fetuses. The effects of acute exposures include dizziness, muscle cramping, loss of consciousness, and, in extreme cases, death. Low-level chronic exposures have been associated with neuro developmental effects (Dix-Cooper *et al*. 2012; Garland and Pearce 1967; Hiramatsu *et al*. 1996; Long 1997) and cardiovascular diseases (Yang *et al*., 1998).

Sulfur dioxide (SO_2) is generated from the sulfur content of fuels during combustion. The majority of sulfur emitted indoors exists as SO_2, but is later converted to secondary sulfur containing compounds in the atmosphere (e.g. sulfate). Acute effects attributed to SO_2 exposure Include changes in pulmonary function and respiratory symptoms, while chronic exposures at levels<20 μg/m3 have been associated with increases in all-age mortality and childhood respiratory disease. WHO established a precautionary 24-h indoor guideline level of 20 μg/m3, with interim target levels at 50 and 125 μg/m3 (WHO 2010). To protect against acute adverse effects, a 10-min guideline level was set at 500 μg/m3.

Nitrogen oxide (NO) and nitrogen dioxide (NO_2) are formed in reactions between atmospheric nitrogen and oxygen during the combustion process, particularly at higher combustion temperatures. There is strong evidence linking NO_2 with adverse respiratory health effects in adults and children. These effects include inflammation, asthma, and reduced immune defenses that lead to exacerbation of, or susceptibility to, existing or new respiratory infections (World Health Organization 2006).

2.9 Kerosene use and related hazards

Both kerosene stoves and lamps can emit substantial quantities of fine PM even during normal operation. Both size and composition play a role in determining the toxicological risk of inhaled particles. In general, the median diameter of particles emitted from combustion is well below 2.5 µm, ensuring the majority will deposit in the deep lung (Apple *et al*. 2010 and Sahu *et al.* 2011). The influence of combustion source, which may alter the extent to which chemicals are adsorbed to the surface of particles, and hence their toxicity, has been less studied.

In animal studies, co exposure to kerosene soot or fuel and asbestos resulted in apparently synergistic alterations of the normal metabolic processes of the lung. Arif *et al*. (1994) reported that rats given a single intra tracheal dose of kerosene soot (5 mg) and chrysotile asbestos (5 mg) showed inhibition of drug-metabolizing enzymes critical in the clearance mechanism of the lung. The joint effect was greater than that measured for exposures to soot or asbestos alone. A follow-up study found that rats given intra tracheal doses of either kerosene fuel (5 ml) or soot (5 mg) with asbestos exhibited alterations to biochemical parameters indicative of tissue inflammation and injury to alveolar macrophages (Arif *et al*. 1997). Both kerosene soot and chrysotile asbestos were found to be genotoxic on an approximately additive scale when hamster embryo fibroblasts were exposed (Lohani *et al*. 2000). Co exposure effects were also demonstrated with dermal exposures. La Dow *et al*. (2011) recently found that co exposure to kerosene and BaP for mouse skin increased the uptake of BaP by skin and internal organs. These findings suggest that kerosene aerosol/vapor, and perhaps soot, may modify the risk of other health-damaging pollutants that are co emitted or present from other sources.

2.10 Local innovations in Solar Energy

Evans wadongo designed a solar lamp which he calls 'MwangaBora (Swahili for "Good Light") in 2004 as a way to address poor education, climate change, health and poverty in rural areas in Kenya. Evans named the entire project 'Use Solar, Save Lives' as he aimed to use solar technology as a way to save lives in the poor communities he grew up in (http://en.wikipedia.org/wiki/Evans_Wadongo).

He joined Sustainable Development For All-Kenya (SDFA-Kenya), a non-profit in 2006. SDFA-Kenya was officially registered by the NGO Coordination Board in June 2007 and its primary focus is environment, education and economic empowerment. Evans was the founding chairman. SDFA-Kenya adopted the 'Use Solar, Save Lives' programme as its main focus program as it combines the three aspects of education, environment, and economic empowerment. SDFA-Kenya is now working in all regions in Kenya. In addition, it is now working in Malawi in partnership with Jacaranda Foundation. To date, SDFA-Kenya under the leadership of Mr. Wadongo has influenced directly over 100,000 people and, indirectly, millions of others. (http://en.wikipedia.org/wiki/Evans_Wadongo).

CHAPTER THREE

3.0 MATERIALS AND METHODOLOGY

3.1 Introduction

This chapter presents the systematic and theoretical analysis of rate and the methods applied in this study in order to achieve the specific objectives of the study and overall goal of this study.

This project utilized both quantitative and qualitative data collection tools, but was rooted in a qualitative epistemological position that recognizes the importance of locating the research within a particular social, cultural, and historical context. A qualitative evaluation was used in the analysis of this research project leveraging subjective methods such as interviews and observations to collect substantive and relevant data. These interviews were conducted by research assistants. Upon collecting the qualitative data derived from the said interviews, careful analysis, both manual and use of the SPSS software was done. On the other hand, other techniques including questionnaires were used to analyze quantitative data.

The chapter also details the methods that were used to develop the Manual Power Generator and the generator can be used to achieve the goals of the study.

3.2 Types and sources of Data

The study employed two categories of data types; the primary data and secondary data, collected from primary and secondary sources.

3.2.1 Primary Data

This information was obtained from observations and photographs collected in the field. This "primary information" formed the basis of each investigation. Fieldwork provided sufficient information to enable adequate interpretation and analysis. It further involved the collection of both qualitative and quantitative primary information. Quantitative information was collected through questionnaires, which entailed identification of respondent's location, household general information, energy sources and needs within the district, energy source and education input amongst households, health issues related to Kerosene use, comparison of kerosene with other energy sources, economic dimensions that pertains to fossil fuel use and lastly, social dimensions of fossil fuel. On the other hand, Qualitative information was collected though observation and subjective judgment.

3.2.2 Secondary data

This research involved gathering information from sources that have already been compiled in written, statistical or mapped forms. The information collected included human health and climate change, sources of energy in Kenya, hazards related to kerosene use, pollution from Kerosene appliances, household kerosene uses and its characteristics, .urban and rural household energy choices, in addition to research and development in Kenya.

3.2.3 Key Informants Interviews

Face to face interviewing and telephone interviewing were used. This process involved solicitation of information by research assistants via verbal evidence and data from knowledgeable informants. The recorded information was then written in a transcript before analysis being performed.

3.2.4 Questionnaire Surveys

A series of questions and other prompts for the purpose of gathering information from respondents was prepared.

3.3 Manual Lead Acid Accumulator Charger

3.3.1 Description

Using locally available resources such as metals, rubber belts and motor vehicle Alternator, a manual battery charger for charging Lead Acid Accumulators was developed. Bicycle parts were modified and arranged into a structure capable of charging a number of lead acid accumulators (12 Volts batteries). This charger is capable of charging a number of batteries for domestic energy needs. It comes in handy to replace the smoky kerosene lamps and Tin lamps that were witnessed in almost all homesteads visited during field work.

With a rotation/charging of 20 minutes, the battery is fully charged. Once charged, the user, with the aid of a technician can do some minor connections. The energy from the battery can be used in Direct Current form (DC) or Alternating Current (AC).

The DC power requires less labour and can comfortably be used to meet domestic energy needs such as lighting. With additional devices such as efficient power inverter and cable extension, the power can meet various electric needs such as mobile phone charging, playing radio, and e.t.c

3.3.2 Materials required for the Generator

Table 2: Materials for the Manual Power Generator and their corresponding functions

PART	FUNCTION
Pedal	The pedals are rotated with the help of human legs or hands. Once rotated, the Crank set gains kinetic energy and rotates clockwise. This rotation is transmitted via a chain to the rim.
Chain	The chain links the hub to the Crank set.
Rim	The Rim aids the Alternator to rotate at a faster rate since it has a larger radius than the pulley on the alternator
Belt	The belt connects the Rim with the alternator
Alternator	The alternator converts mechanical energy to electrical energy in the form of alternating current. This energy is then stored in a Battery, once the alternator rotates. The alternator is connected to the batteries with the aid of strong copper wires.
Battery	The Battery stores electrical energy in Direct Current form. It can be used in DC form or alternatively connected to a power inverter to be converted in Alternating Current.

Adaptor	The Adaptor aids in selecting the preferred Direct Current within a 1-12 Volts limit, depending on the Electrical device being used.
Voltmeter	The Voltmeter gives the Battery reading. If the voltage is below 8 Volts, the Battery has to be recharged again
Wires	Wires of different sizes connect various devices to the other. The following connections are required; Alternator - Battery Battery - Adaptor Battery - Voltmeter Battery- to Electrical appliances such as DC Bulbs, radio, Television e.t.c Red wires are connected to positive terminal of the battery whereas the black wires are connected to the negative terminal
Power Extension	The power extension emanates from a power inverter. It is useful when AC is required
Support Frame	
Paint	
Tools such as the Pliers, Screw drivers,	

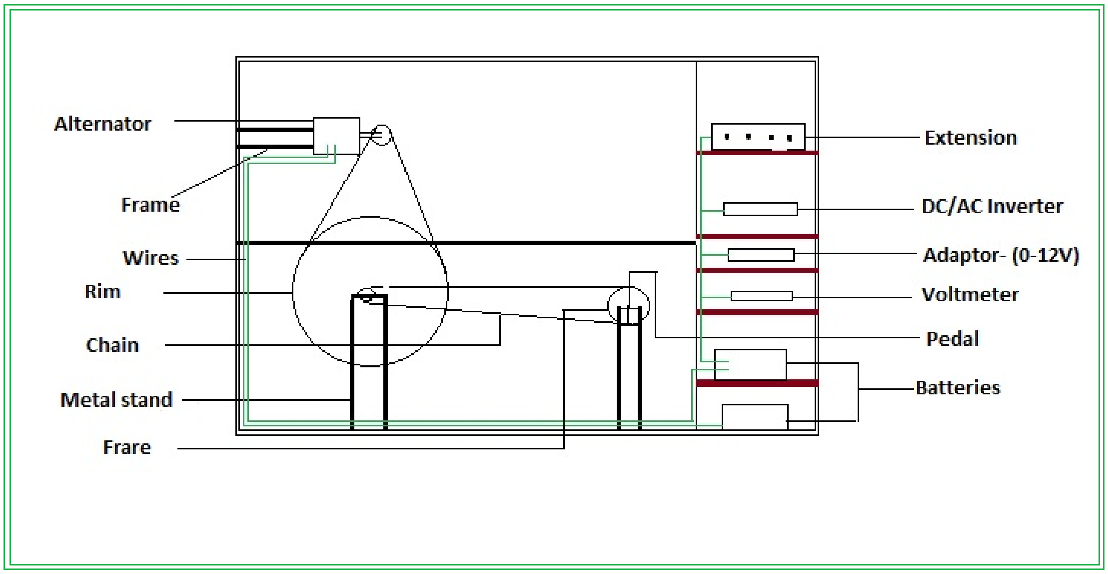
3.3.3 Assembly of the power generator

Procedure

- Assemble all the materials required
- With the help of a technician, cut the square tube into required sizes
- Support metals are welded on the frame to give the structure the required support
- The rim is fixed on the bicycle frame at the rear end
- The seat, nuts, support structure for the alternator and a shelve to accommodate the Battery, Adaptor, Voltmeter and the Inverter are fixed
- The Belt connecting the Rim to the Alternator is fixed

- The chain linking the Crank set to the hub is fixed

Diagram 1: Parts of the Manual Power Generator



3.3.4 How it works

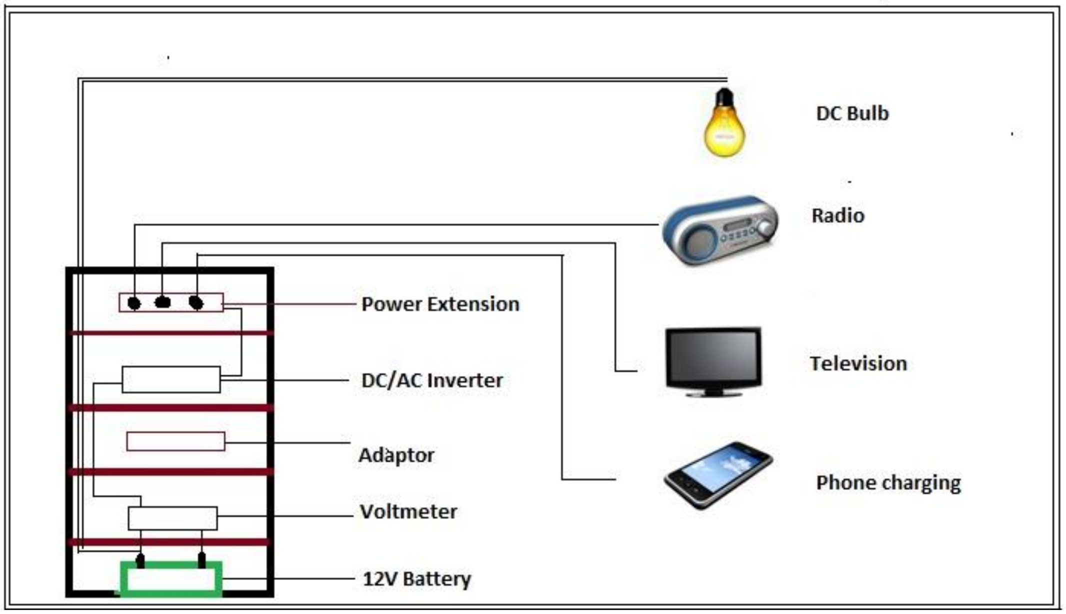
- The device has a chair and pedals. A person comfortably seats and pedals at a comfortable speed
- The pedal is connected to a rim via a chain. Once cycled, the rim rotates at a higher speed.
- The rotating rim further rotates the alternator via a belt that links the Alternator with the rim at a higher speed.
- The alternator has a series of wires that have positive and negative terminals, and it can charge at least two batteries.

3.3.5 Connections and Wiring

- The Battery has two terminals (positive terminal and negative terminal)
- The red wire is connected to the positive terminal whereas the black wire to the negative terminal
- For DC connections, the two wires are connected to the electrical devices to their respective terminals (red wire to the positive and black wire to the negative)

- For AC connections, the two wires are connected to the Inverter. A power extension is then fixed on the Inverter to meet various electrical needs

Diagram 2: Schematic diagram showing various uses of power from the generator



3.3.6 Application

1. It can be used to charge at least two lead acid generators at once.
2. The fully charged battery (12 volts) can be used to meet domestic lighting needs (with a combination of energy saver bulbs or it can also be connected to a power regulator (with a range of 1-12 volts). The suitable volts required can be acquired by simply marching the switch with the volts on the scale)
3. Similarly, the charged battery can be connected to a power invertors, hence meeting the energy needs for most AC electrical apparatus such as mobile phones, radio, television, etc
4. The device can also be used as an exercising tool.

3.3.7 Advantages

a) Compared to the temporary energy sources that the community relies on to charge the battery, the charger offers cheap, sustainable battery charging solutions. Currently the study area heavily relies on battery chargers powered by KPLC. However, with the aid of these new charger, all that one needs is to pedal for some minutes, using physical energy.

b) The device can also help to save on time. Normally, battery charging (with KPLC power) takes approximately 48 hours. Taking into account the time constraints, the new battery charger aims to alleviate this mess. The time wasted can be used for to do other productive work.

c) The battery charger can charge several batteries simultaneously. More so

d) The device can also be modified to act as a physical exercise tool. The principle of energy production requires pedaling with legs. With proper physical training instructions, the device can be incorporated to meet such needs too. The battery will require daily charging, just as physical exercise.

e) Since the assembled device is efficient in operation, it can be used to generate power to meet other energy needs that have not been utilized/ captured, hence adapting to climate change. For instance, disasters can be alleviated in homes via setting alarm systems that can tap power from the charger.

f) In areas not connected to the National grid, the device can be used to produce power that can be in turn be used for income generation. Services such as hair shaving, mobile phone charging, charging torch among others.

g) Unlike the naked tin lamps and kerosene lamps, the device is not susceptible to disasters. Tin lamps have been known to cause major fire out breaks, with severe consequences.

h) The power generated can be used to produce power for longer periods of time, unlike the expensive, smoky kerosene lamps. Kerosene oil can be depleted and will require rationing, given that most people in the study area are poor. (Absolute poverty level of the District is 52%)

3.5 Data Analysis

Questionnaire surveys was entered and analyzed using statistical software, notably Statistical package Social Sciences (SPSS) after being transposed to synthesize and compare categories of data, and show relationships through tabular or graphical presentation. The information entered into the SPSS included Energy sources, energy use among school attending students, gender, health issues related to kerosene use, comparison of kerosene with other energy sources, economic dimensions pertaining the use of kerosene and social dimensions of fossil fuel use.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results obtained as per the objectives of the study based on the methods outlined in chapter three. The quality of data used was however examined first before proceeding to carry out the analyses. Results from qualitative and quantitative data that were collected in the field were analyzed using the SPSS software. For credibility and flow, results from the questionnaires and focused group discussions have been integrated into discussions as a way of correlating with existing literature.

4.2 Socio spatial characteristics of the population

This sub section discussion provides an outline of the social structure of the study population as a basis for understanding the extent to which social relations shaped the communities reliance on kerosene as a source of energy.

The population of the district is more or less evenly distributed and does not seem to follow a particular pattern. However, there is tendency for most of the people to be concentrated in the major urban centers which provide various types of infrastructure hence attracting a number of people. People have also tended to concentrate around the major factories in the district in search of employment opportunities. There exist some pockets of poor in the district especially where sugarcane is grown and which are affected by non-payment of the farmers by local sugar companies. (Bungoma South District Development Plan, 2009).

During research work, it was revealed that the society is organized in family structure consisting of an extended family. The head of the homestead was the Man, with one or two wives. In homesteads where the man had two wives, each wife had `1her own main house with another house serving as a kitchen. The youths, particularly boys had their separate house known as "Esimba". Girls had separate rooms within the main house. Each house had its own source of light (mainly kerosene lamps and tin lamps). Almost all households had a separate kitchen.

4.2.1 Community Livelihoods

Most respondents listed crop farming and livestock farming as their main livelihood source with crop farming comprising 46.7% and livestock farming 16.6 %. A few people were in public service sector, as illustrated in the table below. Table 3 below presents the livelihood system by proportion.

Table 3: Livelihood sources

Livelihood System	Percent (%)
Crop farmer	46.7
Livestock farmer	16.7
Trader	16.6
Teacher	15.0
Wage labourer	5.0

According to the Bungoma South District Development Plan 2009, the percentage of households using kerosene was 40%. This percentage is in agreement with the data gathered.

4.3 Kerosene Consumption

All households surveyed stated that they used kerosene in one way or another. Of those respondents who used kerosene, the vast majority (95%) used it primarily as a lighting fuel (out of 95%, 73.3% used Kerosene lamps for lighting while 21.7% depended on Tin Lamps). Electricity supply is not well connected in the area, hence most people had no access to electricity. Table 4 below shows the proper turn of lighting sources by energy source.

Table 4: Kerosene Consumption

Energy source	Percent (%)
Kerosene Lamp	46.7
Tin Lamp	16.7
Electricity	16.6
Any other	15.0

4.4 Energy source for cooking

Table 5 below shows the various sources of energy for cooking within Bungoma South District.

Table 5: Energy source for cooking

Energy source	Percent (%)
Stove	8.3
Firewood	73.3
Gas cooker	1.7
Charcoal	13.3

Most of the respondents indicated that firewood was the most commonly used energy for cooking especially in rural areas of the District. Charcoal was also a major source of energy for cooking. All respondents who used stoves were mainly in urban centres/ trading centres. Electric power was rarely used for cooking, just as was LPG gas. Majority of the population sampled relied on firewood as a source of energy for cooking (73.3%). Firewood is readily available in the area studied. Charcoal was also commonly used especially in urban centers within the district (13.6%). LPG gas and electricity were rarely used as shown in the table below.

Table 6: Livelihood System within the study area

Livelihood System	Percent (%)
Crop farmer	46.7
Livestock farmer	16.7
Trader	16.6
Teacher	15.0
Wage labourer	5.0

4.5 Electric Power Energy Distribution and utilization

To meet a number of varied electric energy needs, the society had a number of energy sources to choose from. KPLC was the least energy source used. KPLC power distribution in the area is below average, since it was at 6.7% by correspondents. Lead Acid Batteries distribution was rated at 83.1% while Solar energy was rated at 10.2%.

Table 7: Electric Power Distribution

Electric energy source	Percent (%)
KPLC power	6.7
Electric Solar Energy	10.2
Lead Acid Accumulators	83.1

This was attributed to high poverty level, lack of awareness/ knowledge and low political will. However electricity submission was peaking up in some regions. Solar energy, which is a renewable energy source, had not picked up well despite the available radiation from the sun. 13.6 % of the respondents . Energy from Battery acids (recharged at local markets) seemed to be the most relied on source of domestic electric energy.

4.6 Energy use among School going students

Of the total respondents, 91.4 % had school going siblings and children. About 39.6% of the students were attending primary schools, whereas 56.6% were attending Secondary schools. The remainder attended tertiary institutions. The majority of the students attended evening preps (86.8%). However, only a third of category attended preps regularly on a weekly basis (26.9%). Majority of the students who didn't attend preps attributed their failure to lack of lighting facilities such as kerosene and electric power. This could probably be indication of high levels of poverty within the area studied.

4.7 Health impacts of kerosene

Table 8: Symptoms of Kerosene Consumption

Symptoms of Kerosene consumption	Percent (%)
Headache	26.4
Dizziness	11.2
Restlessness	13.1
Shortness of breath	9.0
Coughing	40.3

Regarding inhaling/swallowing kerosene, whether willingly or otherwise, 67.8% admitted to have done so. The table above shows the effects of kerosene consumption in percentage

4.8 Kerosene as a source of income

All respondents admitted to have seen traders selling kerosene mainly in trading centers. This therefore was a positive indication that people were earning a living from the sale of kerosene. Table 7 shows the distribution of quantities of kerosene sold. Most of the traders were selling on retail basis either in 500ml or 300ml bottles (70%) and 30% on wholesale. Besides just seeing kerosene traders, 96.3%

Most traders were selling on retail, either in 500ml or 300ml bottles. (70% retail and 30% wholesale). Besides just seen kerosene traders, 96.3% of the respondents admitted that kerosene was a profitable business.

Kerosene is widely used in both urban and rural areas of the District. It is marketed by multinational oil companies and small private companies. There are numerous retailers who buy kerosene for resale, making the commodity easily accessible in both urban and rural areas.

4.9 Impacts of Price fluctuations

Kerosene price fluctuations have been common in the recent past, as postulated by the respondents. 98.3% of the respondents admitted to have heard via print and electronic media (Television, Radio, newspaper and internet) about kerosene price fluctuations. As a result, most people opted to switch to other sources of energy (25.0%). Others were forced to buy kerosene in small quantities (15%) whereas some a whopping 60% opted to sleep earlier. 43.1% of the respondents bought kerosene in one litre bottle, 12.1% in 500ml bottle whereas 44.8 % bought in 300ml bottle.

4.10 Kerosene Costs

All correspondents interviewed admitted that prices in kerosene have being increasing of late. Table 8 below shows the average kerosene prices by quantities sold over the period 2010-2013.

Table 9: Kerosene Price

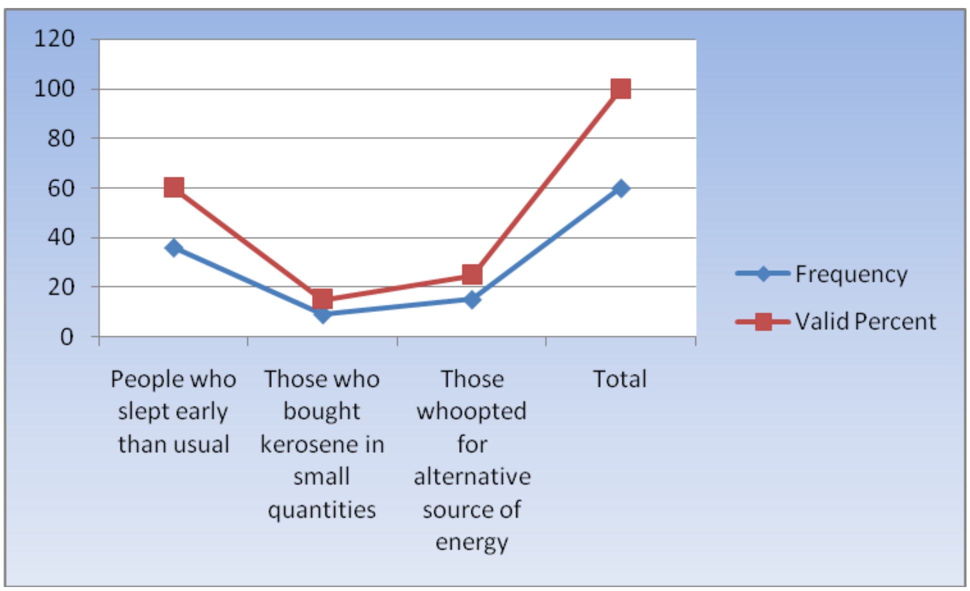
MEASUREMENT IN ML	**YEAR**			
	2010	2011	2012	2013
1000Ml	76	80	86	90
500 Ml	38	40	43	45
300 Ml	20	25	28	30

Most of the respondents indicated that they purchased Kerosene in 300Ml bottles due to their inability to buy in large measures due to poverty, among other factors. Asked about the reasons for this, poverty was rated highest. Purchase of Kerosene in small measures enable respondents to purchase other basic such as foodstuff, clothing and invest in farming.

From the table 8 above, it is quite evident that kerosene prices have been shifting at an alarming rate. For instance, a 300ml bottle of kerosene cost Kshs 20 in the year 2010 but went up by 2013 to cost Kshs 30 for the same measure. Given that majority of respondents spent two 500ml bottles of kerosene per week, it translates to Kshs (2 x45 x 1 x 4 = 360) per month on average for lighting alone. This amount is too high given that majority of the households are poor. The district absolute poverty rate stands at 52%, according to the Bungoma South District Development Plan 2008-2012.

4.11 Consequences of increase in Kerosene prices

Figure 1: Consequences of Increase in Kerosene Prices



4.12 Disasters caused by Kerosene

Research evidence revealed that 60 per cent of the fire was caused by flame burns due to explosions that occurred during the use of kerosene appliances for cooking and lighting. In each of the families, two or more people were affected. The overall mortality was 20 per cent, of which the larger contribution of 10 per cent was in children. Other consequences included loss of property (houses, sugarcane plantations, food crops, among others).

Table 10: Energy source for lighting

Energy Source	Percent
Kerosene Lamp	73.3
Tin Lamp	21.7
Electricity	3.3
Any other	1.7

CHAPTER FIVE

5.0 SUMMARY AND CONCLUSIONS

5.1 Introduction

This chapter summarizes intentions of the research and concludes discussions arising from the results of the research. It further recommends appropriate actions to be taken in the light of the conclusions.

5.2 Summary

This study has looked at the possibilities of developing green energy for domestic use with the aim of replacing kerosene in Bungoma south District. The main objective of this study was to evolve a green technology that will solve domestic energy and climate change challenges. The specific objectives of the study were to compare the suitability of kerosene energy and green energy, determine the applicability of green energy in the study area and establish if such a technology will meet the energy demands for rural households.

Those interviewed admitted having school going siblings and children (91.4 %) who relied on kerosene for light provision. However, only a third of this category did attend preps regularly on a weekly basis (26.9%). Majority of the students who didn't attend preps attributed to lack of lighting facilities such as kerosene. This was an indication of high levels of poverty.

Regarding health repercussions, most people admitted to have suffered from health complications brought about as a result of kerosene use. Most people complained of headache, irritation to the eyes, dizziness, and restlessness among others. Half of those interviewed said that the light produced by kerosene was dim. 13.8% said the light kept on fluctuating, hence affecting visual impairment.

It was unanimously agreed that there has been an increase in kerosene prices of late. As a result, most people opted to switch to other sources of energy (25.0%). Others were forced to buy kerosene in small quantities (15%) whereas a whopping 60% opted to sleep earlier. 43.1% of the respondents bought kerosene in one litre bottle, 12.1% in 500ml bottle whereas 44.8 % bought in 300ml bottle.

Research evidence revealed that 60 per cent of the fire was caused by flame burns due to explosions that occurred during the use of kerosene appliances for cooking and lighting. In each of the families, two or more people were affected. The overall mortality was 20 per cent, of which the larger contribution of 10 per cent was in children. Other consequences included loss of property (houses, sugarcane plantations, food crops, among others). Burning of property and cash crops such as sugarcane led to further emission of Carbon dioxide gas.

In general it can be concluded that kerosene was widely used in the study area for provision of light and other needs such as cooking. Since kerosene contains carbon it releases carbon dioxide and other products like water and oxygen once burned. Carbon dioxide is a major greenhouse gas that contributes to global warming, hence leading to Climate Change.

5.3 Recommendations

The results of the study lead to the following recommendations:

1. Substitution of the intrinsically dangerous fuel based technologies that have severe, irreversible consequences has to be done
2. There is a need to do public awareness to change the mentality of people towards kerosene use in the study area
3. Since in the long run kerosene use is expensive, people ought to embrace the use of green energy such as the one discussed in this research project
4. There is a need for cooperation amongst the households to put their resources together and develop some of these devices collectively, since most households are poor
5. Governments, Nongovernmental organizations and other key stakeholders need to identify and facilitate individuals talented with ideas/ innovations that might lead to identification of more ways of generating green energy
6. There is a need to involve local communities in renewable energy technology projects such as solar, wind and improved stoves to increase energy security and mitigate against climate change.

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APPENDIX 1

Questionnaire

Dear Respondent,

This questionnaire is intended to collect your views concerning the use of fossil fuels (kerosene, diesel, e.t.c). The information gathered shall be handled with utmost care and shall be used purely for academic purposes. Kindly cooperate.

MODULE 1: IDENTIFICATION OF RESPONDENT'S LOCATION /QUALITY CONTROL

COUNTY		INTERVIEWER	
DISTRICT		INTERVIEW DATE	
DIVISION		TIME STARTED	
LOCATION		TIME ENDED	
SUB LOCATION			
VILLAGE			
TOWN/TOWNSHIP			
PLACE OF INTERVIEW			

MODULE 2: GENERAL INFORMATION ABOUT THE HOUSEHOLD

No.	Question	Code/Answers
A1	Gender of respondent	Male { } Female { }
A2	Age of respondent	1. Child (15 -18) { } 2. Young adult (18 -30) { } 3. Medium age (30 -55) { } 4. Elderly (55) { }
A3	Marital status of the household	1. Married { } 2. Single { } 3. Widowed { } 4. Divorced { }
A4	Education of respondent	**1.** None { } **2.** Primary { } 3. Secondary { } 4. Tertiary { }
A5	No. of houses within the compound	Kitchen { } Main House { } Cottage(Simba) { }
A6	No. of Tin lamps (Tobe) per house	Kitchen { } Main house { } Cottage { }
A7	No. of kerosene lamps per house	Kitchen { } Main house { } Cottage { }
A8	Major household livelihood classification	Codes 1=Crop farmer 4= Teacher 2=Livestock farmer 5=Wage labourer 3= Trader 6= Others *(Kindly indicate as either 1,2,4 e.t.c as appropriate)*

MODULE 3: ENERGY SOURCES AND NEEDS WITHIN THE DISTRICT

No.	Question	Codes/ Answers
A1	Name energy sources commonly used for cooking in your area	1. 2. 3. 4.
A2	Tick the energy sources that you use for lighting the house at night in your homestead/ compound	1. Kerosene lamp { } 2.Tin lamp { } 3.Electricity { } 4.Pressure lamp { } 5.Any other
A3	What are the reasons for using the energy Sources mentioned in A2 above?	1. 2. 3. 4. 5.
A4	Among these energy sources, which one do you commonly use for your radio/ television?	1. Battery acid { } 2. KPLC power { } 3. Generator { } 4. Solar Energy { }
A5	Give reasons for the choice indicated in **A4** above	

A5	On a scale of ten (10) rate the distribution of electricity transmission In the District	8 out of 10 { } 6 out of 10 { } 4 out of 10 { }
A6	What do you think are the reasons for the distribution rate indicated in **A5** above?	

MODULE 4: ENERGY SOURCE AND EDUCATION INPUT AMONGST HOUSEHOLDS

No.	Question	Codes/ Answers
	Do your children/siblings go to school/ Attended School?	**Yes { } No { }**
	If yes, which level?	**Primary { } Secondary { }** **Tertiary { }**
	Do the children/siblings study evening preps/ did they study evening preps?	**Yes { } No { }**
	If yes, from what time do they start evening preps/did they start evening preps?	7:00 Pm – 8:00 Pm { } 7:00 Pm – 9:00 Pm { } 8:00 Pm- 9:00 Pm { }
	Do they study daily/ did they study daily?	Yes { } No { }

	(Monday to Sunday)	
	If No, what are some of the reasons/ What were the reasons?	1. Lack of lighting { } 2. Tiredness { }

MODULE 5: HEALTH ISSUES RELATED TO KEROSENE AND DIESEL USE

No.	Question	Codes/ Answers
A1	Have you ever inhaled or swallowed kerosene accidentally?	**Yes { } No { }**
A2	If the answer to question A1 is yes, how did you feel upon inhaling?	a. Headache { } b. Dizziness { } c. Restlessness { } d. Coughing { } e. Shortness of breath { } Any other
A3	How did you respond to the above effects?	

A4	Have you ever used a Tin Lamp? (Tobe)	Yes { } No { }
A5	If yes, when was that?	I still use it { } Last year { } Two years ago { } Five years and beyond { } Any other
A6	What were you using it for?	a. Reading { } b. Cooking { }
A7	How was the quality of light?	a. Bright light { } b. Dim light { } c. Average { } d. Kept on fluctuating { }
A8	Were you comfortable while using the Tin lamp?	Yes { } No { }
A9	If the answer to above is No, what made you uncomfortable?	a. b. c. d.
A10	Did you witness irritation to your eyes?	Yes { } No { }
A11	If yes, how did you respond to the irritation?	
A12	Will you advise someone to use kerosene	

	in tin lamps?	

MODULE 6: KEROSENE VIS A VIS OTHER SOURCES OF ENERGY

No.	Question	Codes/ Answers
A1	What is the common source of energy used by the community in your area at night for lighting?	Tin lamp { } Kerosene lamp { } Electricity { } Solar energy { }
A2	Do you enjoy using Tin lamps and Kerosene lamps?	
A3	Given the opportunity, which source of energy will you prefer to use as a source of energy for Lighting?	
A4	Why do you think people use Kerosene to light their houses?	a) It is cheap { } b) Locally available { } c) It is packaged in small quantities that can be easily be purchased { } d) Other alternative sources of energy are Expensive { } e) Others are using it { }

A5	For how long have you witnessed the use of kerosene in your area?	Past 10 years { } Past 20 years { } Past 30 years { } 30 years and beyond { }
A6	Supposing if there was no oil (kerosene) in Kenya for a long period of time;	
	i) Which consequences do you expect to occur?	
	ii) What will people use instead of kerosene as a source of light?	
	iii) What will be the reasons for switching to the source of energy mentioned in ii) above?	
A7	Rate the efficiency of stoves in terms of heat production	Excellent { } Good { } Poor { }
A8	How do you rate the quality of light produced by the kerosene lamps?	Very bright { } Convenient { } Poor Quality { } Satisfactory { }

A9	How often do you use kerosene at night?	Full week { } Three days per week { } Once per week { } Any other viable period………
A10	What do you use as a substitute during the days when you don't use kerosene?	
A11	Why do you use the substitute energy source in A10 above?	

MODULE 7: ECONOMIC DIMENSIONS PERTAINING TO FOSSIL FUEL USE

No.	Question	Codes/Answers
A1	Have you ever seen businessmen/ ladies selling kerosene?	Yes { } No { }
A2	Where were they selling the kerosene?	a. On the market { } b. At home { } c. Moving from house to house { }
A3	Were they selling on retail or wholesale?	Retail { } Wholesale { } Both retail and wholesale { }
A4	Did the Businessmen/ women have other items to sell apart	Yes { } No { }

	from Kerosene/ petrol?	
A5	If yes, what were the other items they were selling?	a. b. c.
A6	At what time were they opening their business?	Morning { } Evening { }
A7	Do you think selling kerosene/ petrol is a profitable business?	Yes { } No { }
A8	Have you ever heard on the media radio/Television/Newspaper about the increase in oil prices?	Yes { } No { }
A9	When did you hear last time about the increase in oil prices?	This year { } Last year { } Two years ago { }
A10	How did the kerosene/petrol users adjust to new prices?	a. b. c. d.
A11	Did you think of changing the use of kerosene lamps/ stoves to other alternative energy sources due to the change in prices?	Yes { } No { }
A12	If yes, what were the energy sources you thought of switching to?	

A13	What were the consequences after the increase in oil prices?	
A14	What is the current cost of kerosene?	1 litre …………………………………… 500 ml………………………… 300 ml…………………………
A15	What is the current cost of petrol?	1 litre………………………… 500 ml……………………….. 300 ml………………………..
A16	What was the price of kerosene in the years indicated?	2010 2011 2012
A17	Do you use kerosene/ have you ever used kerosene?	Yes { } No { }
A18	In which quantities do you/did you buy kerosene?	1 Litre { } 500 ml { } 300 ml { }
A19	How long does the quantity indicated in A18 last?	Two days { } One week { } Two weeks { } Others (specify) { }
A20	Do you have records for the previous purchase of	

	kerosene?	

MODULE 8: SOCIAL DIMENSIONS OF FOSSIL FUEL USE

No.	Question	Codes/ Answers
A1	Have you ever heard of a disaster (fire) caused by tin lamp, kerosene lamp or stove?	Yes { } No { }
A2	If yes, what were some of the damages?	
A3	Who was responsible for the cause of fire?	a. Child { } b. Mature person { }
A4	Did the fire affect neighbouring households?	Yes { } No { }
A5	If yes, how were they affected?	

A6	At what time do you go to sleep? (at night)	
A7	What are the reasons for sleeping early?	a. I usually get tired at the end of the day { } b. I don't have enough kerosene { } c. Insecurity reasons { }

AOB

Any other comments the respondent may have regarding the use of fossil fuels

APPENDIX II

District Fact Sheet

Information Category	**Statistics**
Area in Km^2	**663.3**
Arable Land (89%)	**591.2**
Non arable land (11%)	**73.1**
Topography and Climate	
Altitude (m)	
Highest	
Lowest	
Rainfall seasons:	
Long rains (mm) March to july **Short rains** August to October	**500-1000** **430-800**
Temperature range:	
Highest	**25**
Lowest	**21**
Temperature range	**23**
Demographic and Population profiles	
Population size 2008 **2012**	**399,192** **460,335**
Population Structure	
Total number males 2008	**190,914**
Total number of females 2008	**208,278**

Female/male sex ratio	
Total population 0-5 years Male Female Total	 **43,816** **44,865** **88,681**
Total no. of primary school going age (6-13) Male Female Total	 **47,545** **49,704** **97,249**
Total no. of Sec School going age (14-17) Male Female Total	 **24,539** **25,850** **50,389**
Youthful age (18-35) Male Female Total	 **47,779** **56,804** **104,583**
Total population above 35 years Male Female Total	 **33,661** **38,950** **72,611**
Reproductive female population (15-49)	**92,366**
Total labour force (15-64) Male Female	 **88,882**

Total	**102,576** **191,448**
Rural Population Male Female Total	**142,592** **157,502** **191,448**
Urban population (Towns with over 2000 people) Male Female Total	**48,876** **50,743** **99,619**
Total no. of working children 5-17 years	**59,231**
Dependency ratio	
Population density 2008 2012	**601** **693**
Crude birth rate per 1000 live births	**46.6**
Crude death rate per 1000 live births	**12.3**
Life Expectancy (years) Male Female	**54.3** **61.5**
Child mortality rate (CMR) Male Female	**42** **39** **81**
Under five mortality (U5MR) Male Female	**122**

	103 **225**
Total fertility/growth rate (%)	**4.3**
Socio-Economic Indicators	
Total no. of households	**83.166**
Average household size	**4.8**
No. of female headed households (30.2%)	**29.166**
Absolute poverty (%)	**52**
Contribution to national poverty %	**1.8**
Average household incomes: Sector contribution %	
Agriculture	
Average farm size Small scale Large scale	**2 ha** **7 ha**
Main food crops produced (bags) Maize Beans Sweet potatoes Cassava	**137860** **39000** **4675** **384**
Main food crops produced (tons) Sugarcane Passion Sunflower Oil palm	**2500** **52** **210** **125**

Total acreage under food crops (ha)	**14149**
Total acreage under cash crops (ha)	**6880**
Main storage facilities (on and off farm) Granary Silos	 **28,000** **1**
Main Livestock production	
Grade cattle	**16,200**
Indigenous cattle	**62,200**
Grade goats	**40**
Indigenous goats	**23,000**
Grade sheep	**11,000**
Indigenous sheep	**30000**
Donkeys	**70**
Pigs	**15,000**
Commercial layers Commercial broilers	**10,000** **400**
Indigenous chicken	**286,000**
Land carrying capacity	
Main species of fish (quantity in metric tons) **Tilapia** **African catfish**	 **9.936** **0.204**
Population fish farmers	**165**
No. of fish ponds	**340**

% of people engaged in forest related activities	**58**
Cooperatives	
No. of registered cooperatives	
Coffee processing	**2**
Urban Sacco	**15**
Rural Sacco	**2**
Investments	**1**
Unions	**1**
Water and sanitation	
No. of households with access to piped water	**20,120**
No. of households with access to portable water	**40,826**
No. of permanent rivers	**4**
No. of shallow wells Kanduyi Bumula Total	 **45** **120** **165**
No. of protected springs Kanduyi Bumula Total	 **11** **75** **86**
No. of boreholes Kanduyi Bumula Total	 **30** **70** **100**

No. of dams/pans Kanduyi Bumula Total	**3** **9** **12**
Households with roof catchments (%)	**48**
Average distance to nearest portable water points (km)	**1**
Latrines coverage (%)	**75**
Pre primary	
No. of pre primary schools Public Private Religious Local authority Total	**178** **128** **53** **2** **361**
Total enrolment Boys Girls Total	**8,237** **8,249** **16,486**
Primary	
No. of primary schools Kanduyi – Municipality zone Sang'alo zone Mwibale zone Total Bumula – Kabula zone Bumula zone	**47** **30** **3815** **25**

Kimaeti zone Siboti zone Total	**27** **22** **24** **213**
Health	
Three most prevalent diseases and their prevalence rate Malaria Respiratory tract infection/pneumonia Diarrhoea	**15** **14** **10**
HIV/AIDS prevalence %	**5.1**
Doctor/population ratio	**1:26613**
No. of dispensaries	**10**
No. of health centres	**1**
No. of hospitals	**1**
Average distance to health centres (km)	**10**
% of households with access to health centres (km)	**10**
% of household with access to health facility	**60**
Energy	
% of households with electricity	**52**
% of trading centres with electricity	**40**
% of households using firewood/charcoal	**60**

% of households using kerosene, gas, biogas	**40**
Transport facilities	
Road Bitumen length (km) Gravel length (km) Earth length (km)	 **28** **85** **152**
Total length of railway line and no. of stations Length (km) Stations	 **25** **3**
Communication	
% of households with telephones	**20**
No. of public and private org. with telephone connection	**680**
Mobile service coverage %	**80**
No. of post/ sub post offices	**6**
% of households with radios	**85**
No. of cyber cafes	**50**
Banks and financial institutions	
No. of banks	**8**
No. of other financial institutions	**8**

APPENDIX III

Interview Questions

No.	Question
1.	Is Kerosene used in your area for provision of light and cooking?
2.	Have you ever witnessed an increase in Kerosene price?
3.	Do you use Kerosene, and for what purpose?
4.	Most houses get burnt especially at night. Do you think kerosene is responsible for some incidences?
5.	Do we have renewable energy technologies like solar and wind energy in the area?
6.	How do you meet energy needs for your Television, Radio and Mobile phone incase you have one?
7.	What are the reasons for people not having renewable energy sources such as solar panels
8.	Have you heard of climate change/ Climate change?
9.	What do you think are the consequences of Climate Change in your Village?
10.	Rate the distribution of KPLC power connection in your village and explain why its the way it is.