KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

RENEWABLE ENERGY PROJECTS AS A TOOL FOR ALLEVIATING ENERGY POVERTY IN GHANA

Case Study: Bui Hydroelectric Project

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RENEWABLE ENERGY PROJECTS AS A TOOL FOR ALLEVIATING ENERGY POVERTY IN GHANA

Case Study: Bui Hydroelectric Project

By

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A thesis Submitted to the School of Graduate Studies, Kwame Nkrumah University of Science and Technology, in partial fulfilment of the requirement for the award of Master of Science Degree in Renewable Energy Technology

AUGUST, 2013

DECLARATION

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another award to the Kwame Nkrumah University of Science and Technology or elsewhere.

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CERTIFICATION

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ABSTRACT

This research work assesses the contrast in ‘energy resource wealth’ and its transformation into ‘energy poverty’ in developing societies. It appraises whether the implementation of a renewable energy project (REP) can act as a tool to alleviate energy poverty in Ghana. Developing nations are endowed with enormous energy resources yet are highly impoverished in energy delivery. These nations depend on unfriendly sources of lights and adopt inefficient wood fuels for cooking purposes.

In this research work, questionnaires were administered to a case study population (Bui Village, located in Brong Ahafo Region of Ghana) who have been affected by the implementation of REP, Bui Hydroelectric Project. The snowball approach was used to sample respondents who were affected by a REP. Questions on energy poverty indicators such as source of light, ownership of charging items, food preservation methods were enquired from the respondents before and after the implementation of the REP. Minitab 16 Statistical Software Package was used to analyse the results.

The null hypothesis that energy poverty leads to the use of unfriendly sources of light and that for the use of rural food preservation was confirmed by ‘W’ values of 53 and 43.5 respectively from a Mann-Whitney (MW) test. The W value in a MW test must be greater than 39 to accept the null hypothesis made. The null hypothesis that energy poverty leads to the use of less chargeable items yielded a ‘p’ value of 1.0 from a Paired t-test (PTT). The ‘p’ value in a PTT must be greater than 0.05 to accept the null hypothesis made. Majority of the respondents concluded that rural energy was more expensive than modern energy services. The social implication is that the implementation of a REP reduces energy unfriendly services (e.g. oil lamps and lantern for lighting) whilst increasing energy friendly services (e.g. use of rechargeable lamps, modern food storage devices). The associated negative health benefits in the use of such unfriendly energy services which causes the inflammation of the airwaves and lungs as well as the impairment of the immune system in affected populace are reduced.

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LIST OF ABBREVIATIONS

b – billion

bbl. /day – billion barrel litres per day

BHP – Bui Hydroelectric Project

CIA – Central Intelligence Agency

cum – Cubic meters

est. – estimate

GDP – Gross domestic product

GSS – Ghana Statistical Service

IEA – International Energy Agency

IPCC – Intergovernmental Panel on Climate Change

KPMG - Klynveld Peat Marwick Goerdeler

KVIP – Kumasi Ventilated Improved Pit Latrine

KWh – kilo watts hour

MWh/year – Megawatts hour per year

PAP – Project Affected Persons

Sq. km – square kilometres

UNEP – United Nations Environment Program

VRA – Volta River Authority

WHO – World Health Organisation

CHAPTER 1: INTRODUCTION

The International Energy Agency (IEA) states that, globally, 1.5 billion people lack access to electricity and about 3 billion lack access to modern cooking energy options (IEA, 2011). This is referred to as ‘energy poverty’ which is the lack of access to sustainable and clean energy (ibid). Energy is the basic demand for economic growth (Soytas and Sari, 2003). Other essential items necessary for development like food, clean water, education, health and hygiene will not be available without energy (Nussbaumer et al., 2012). Whiles productivity is high in developed economies, so cannot be said about undeveloped economies since the populace spend most of their time and resources searching for fuel to meet basic needs. Of the world’s ‘energy poor’, 95% are in Asia and Sub-Saharan Africa (IEA, 2011).

Klynveld Peat Marwick Goerdeler (KPMG (2012)) accounting firm identifies the quality of energy mix, electricity access, availability levels and the compatibility of energy policies with environmental challenges as the requisite tool for rating countries in the Global Energy Competitiveness Index. Graphical presentation of this index is presented in Figure 1.1.

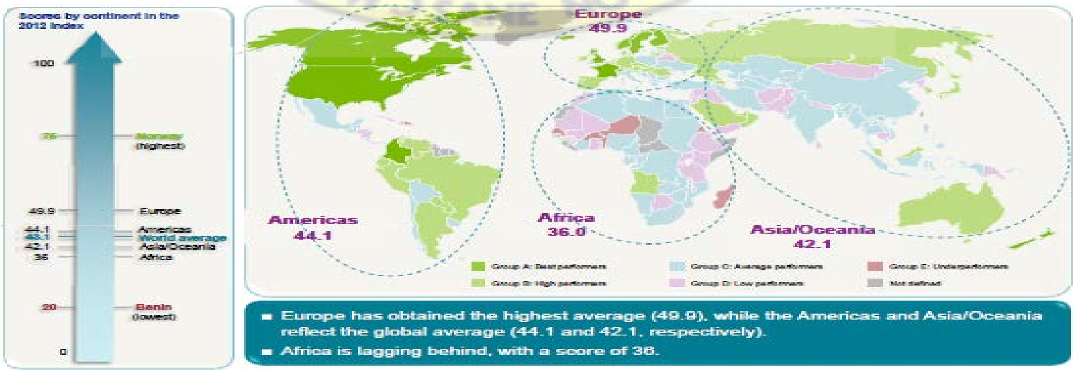

Figure 1.1: Overview of global disparities among continents in Global Energy Competiveness index: Source: (KPMG, 2012)

Renewable energy resources are mostly abundant in rural areas in Africa. People at these locations are on the contrary very impoverished in energy delivery (energy poverty). The recent demonstrations by the people of Ajena and Pese communities on March 11, 2009, two of the 52 project affected people (PAP) in the development of the Akosombo Dam after some forty years ago presents an opportunity to access renewable energy projects and its impact on the alleviation of energy poverty (Ghana Dams Dialogue, 2009). Granted the effect of these developments and the potential for the development of more renewable energy projects due to the existence of various rich sites across the length and breadth of the country, one can justifiably assume that renewable energy can act as a tool to alleviate energy poverty. This research therefore uses a case study to assess whether renewable energy can act as a tool to alleviate energy poverty.

The aim and objectives of this research are detailed hereafter:

1.1 AIM

The aim of the study is to ascertain if the implementation of renewable energy technology projects acts as a catalyst to alleviate energy poverty.

1.2 OBJECTIVES

i. To determine whether communities with energy resource abundance are energy impoverished.

ii. To determine whether the implementation of renewable energy projects in host communities can act as a tool to reduce energy poverty.

iii. To determine whether rural communities are aware of climate change and its effects

1.3 JUSTIFICATION

The development of the Bui Hydroelectric Project (BHP) in Ghana, located in the Tain and Bole districts provides the perfect opportunity to assess impacts on Project Affected Persons within the aforementioned context. Development of the 400 Megawatts BHP will involve the permanent inundation of about 400 km^2 of land, occupying about 21% of the Bui National Park, at its full supply level of 183 meters above sea level (Bui Power Authority, 2013a). Three groups of people were affected by the project:

- Group one included those affected by construction activities or those who lived within the immediate construction environs (ibid).
- The second group is made up of those living within the catchment of the reservoir where the lake was formed (ibid).
- The last group is the host community that houses the above groups in their community (ibid).

In total, two hundred and nineteen (219) households were affected by the development of the BHP (Bui Power Authority, 2013b). The Project Affected Persons (PAPs) were relocated to a new community known as the Bui Resettlement Township. Prior to their relocation, the PAPs had no access to modern energy. They relied on various traditional energy sources for their daily activities. The PAPs were fed onto the National Grid as part of the implementation of the BHP. The research therefore finds out whether the BHP has acted as a catalyst to alleviate energy poverty by using a case study population known as Bui Village.

1.4 OUTLINE OF THESIS

The report will be approached in five chapters. Chapter 1 introduces the research topic by providing a background to global energy poverty; states the research aim and objectives whiles justifying the research. At the end of the chapter, an outline of the content of the chapters of the thesis is given. Chapter 2 reviews the literature on the energy resource and its variations globally. Ghana's available energy resource will also be reviewed in this chapter. The historical background and the relevant terminology are discussed. Additionally, theories and concepts within previous research and its limitation on the research topic are also highlighted. Chapter 3 discusses the methodology adopted in the study. Chapter 4 provides an insight into the results obtained after studies conducted using the case study. Furthermore, the results obtained are analysed and discussed in this chapter. Chapter 5 states the conclusions and recommendations whilst outlining the study limitation. Proposal for future work is stated in this chapter.

CHAPTER 2: LITERATURE REVIEW

As stated in the introduction, the study is about renewable energy project as a tool for alleviating energy poverty in Ghana. The aim of this chapter is therefore to provide a historical background and the relevant terminology adopted in energy poverty. The framework for the literature review is presented in Figure 2.1.

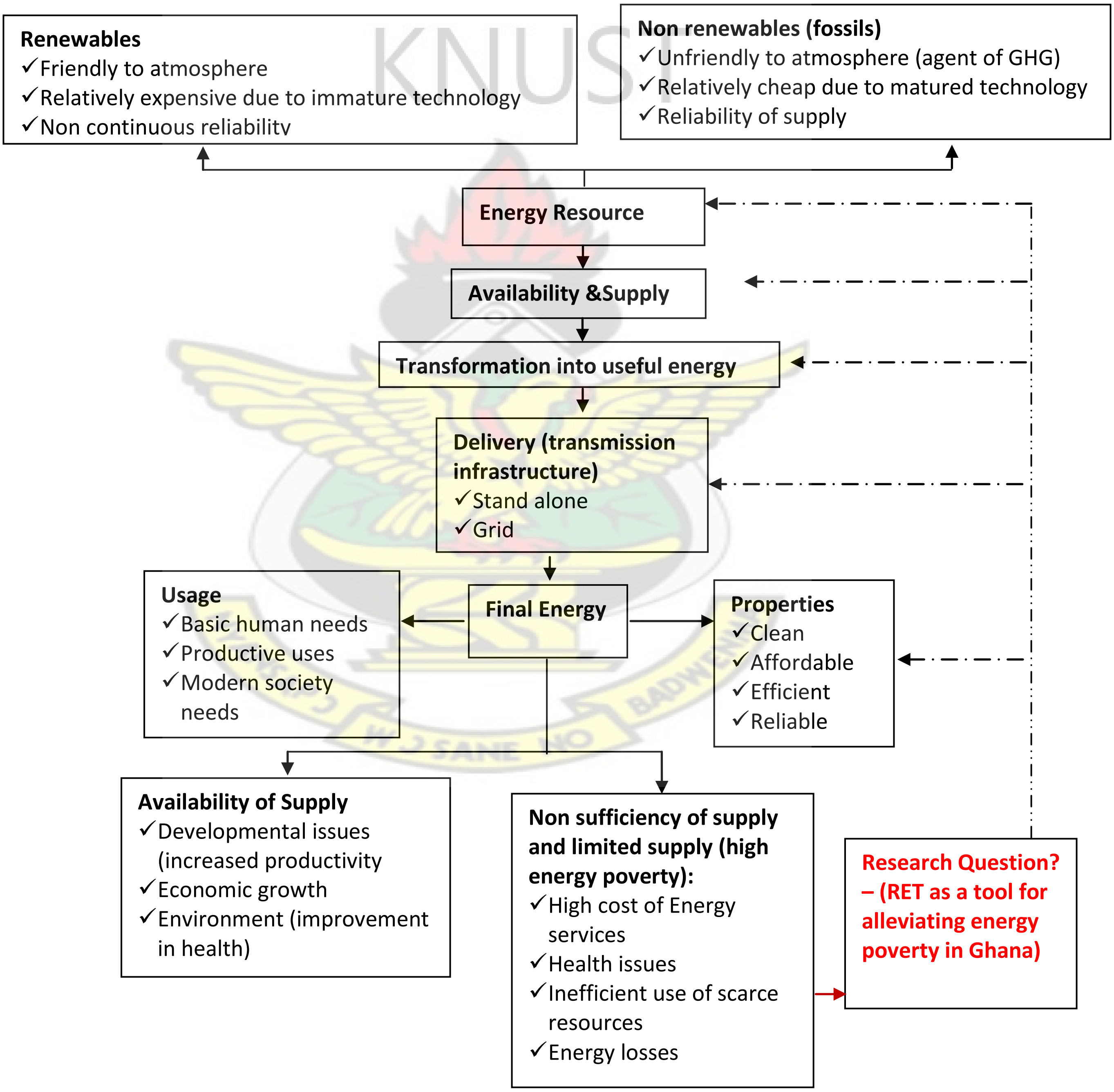

Figure 2. 1: Framework for literature review

2.1 GLOBAL ENERGY RESOURCE

The energy sources available are renewable and non-renewable energy (Open Energy Information, 2013). Each source is transformed as electricity, thermal or heat as the useful energy (see Figure 2.2). Naturally, the available energy resources in the world are renewable energy (hydro, solar, wind, biomass, geothermal), fossil energy (coal, petroleum, natural gas) and nuclear energy (Open Energy Information, 2013). Their extraction and processing are presented in Figure 2.2. Energy resource availability and transformation are unique to a particular geographic location. It requires technical skills in the extraction and processing of the resource to be delivered to the consumer based on their energy demand (Nuvan, 2011).

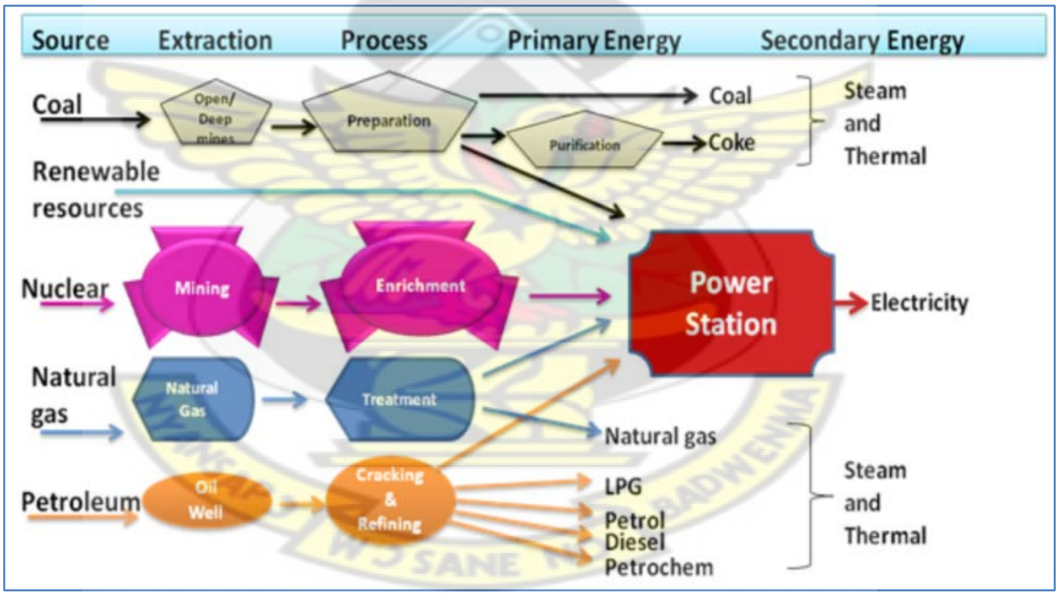

Figure 2. 2: Energy sources and end use

Source: (Nuvan, 2011)

The associated environmental impacts (carbon emissions) in the use of fossil and nuclear fuels has shifted attention to the investment in low carbon technologies (Sun et al., 2012). It is perhaps useful to recall that the consumption of non-renewable energy resources through anthropogenic activities releases greenhouse gases (GHGs). Carbon dioxide, methane, nitrous oxide, hydro fluorocarbons, per fluorocarbons and sulphur hexafluoride have been identified as GHGs released after consumption of fossil energy (IPCC, 2007b).These GHGs are standardized as carbon dioxide per their polluting potential which is different for each GHG (Urge-Vorsatz and Herrero, 2012). Continuous release of GHGs has been found to be increasing in global atmospheric concentrations. It is worth noting that the '*Keeling Curve*' which records the CO_2 emissions in Mauna Loa, Hawaii, establishes that CO_2 concentration in the atmosphere is increasing. CO_2 concentrations have risen from 315 parts per million by volume (ppmv) in 1950 to 392 ppmv in July 2011 (Grubb et al., 1999; Keeling et al., 2008; The World Bank, 2012)

Further to support the impacts of GHGs to the environment, the Intergovernmental Panel on Climate Change states that there will be a global rise in temperature by an average of 2^oC – 3^oC leading to changes in weather patterns (IPCC, 2007b). Temperature variations will lead to the melting of glaciers and snow pacts resulting in the flooding of coastal cities such as London, New York, Miami and Hong Kong (Stern, 2007). Excess CO_2 in the atmosphere will dissolve in the ocean leading to ocean acidification. This will lead to the extinction of 15-40% of fish stock which cannot live in acid oceans (IPCC, 2007b). Against this backdrop, differences in temperature will lead to vector borne diseases in the tropics and cold related deaths in higher altitudes (IPCC, 2007a).

It is surely significant that, the variation in weather patterns can also lead to a decline in crop yield resulting in famine and subsequently, malnutrition in the tropics (Stern, 2007). The thrust of IPCC (2007b) arguments in environmental changes will cause migration of populations leading to global hostilities. Stern (2007) has computed the resulting effect of global warming to be 20% of Gross National Product equivalent to 5,500 billion Euros.

As have been widely acknowledged by commentators (Kaygusuz, 2012; Thavasi and Ramakrishna, 2009a; Thiam, 2011; UNEP et al., 2013) low carbon technologies make use of renewable energy sources to produce energy. Renewable energy technologies (RET) produce electricity from renewable sources such as tides, wind, waves, rainfall, sunlight and geothermal heat. The United Nations Environment Program have indicated that energy resources are not free from monetary and environmental cost, as such should be selected based on community needs, affordability and end use technology (UNEP et al., 2013). Renewable energy resources comes from nature and are continuously replenished (UNEP, IUCN, & Pace University, 2013). They are known to be cleaner fuels because in their use to produce energy, they release no carbon emissions after construction (UNEP et al., 2013). Though the energy resource for renewable energy technology is free and peculiar to the resource location, the immature technology to transform the fuel resource to electricity makes it expensive to run (Chow et al., 2003).

In the transmission of electricity via the transmission line after production, losses are generated per the farther the distribution point is away from the production point. These losses are in the form of heat across the transmission cables. Ideally, the transmission network is expected to be in a loop to ensure that supply is maintained in the case one loop is accidentally damaged. This ensures continuity in supply (Bhattacharyya, 2013). RET provides an opportunity to use stand-alone transmission systems. Losses are considerably reduced because the energy source is closer to the communities.

Energy access has a strong correlation with gross domestic product (Chow, Kopp, & Portney, 2003). The improvement of these activities have a positive effect on GDP which measures the value of all final goods and services in a given time period of a country (Chow, Kopp, & Portney, 2003). The idea that governments places premium in the investment of energy projects to sustain economic development is also evident in energy consumption and development. Energy resource once found must be consumed to sustain economic activities (Lee, 2005).

Consumption of energy is affected by the socio-demography of a society (Figure 2.3). The older population consume energy mostly at the residential level. The younger population consume more energy than the older people. However, the younger population contribute to the industrial economy at subsistence level which compensates for GDP (Thavasi and Ramakrishna, 2009b). The question then is how do developing societies like Ghana develop their energy resources and use them to alleviate energy poverty? This is the object of the study and is further accessed hereafter.

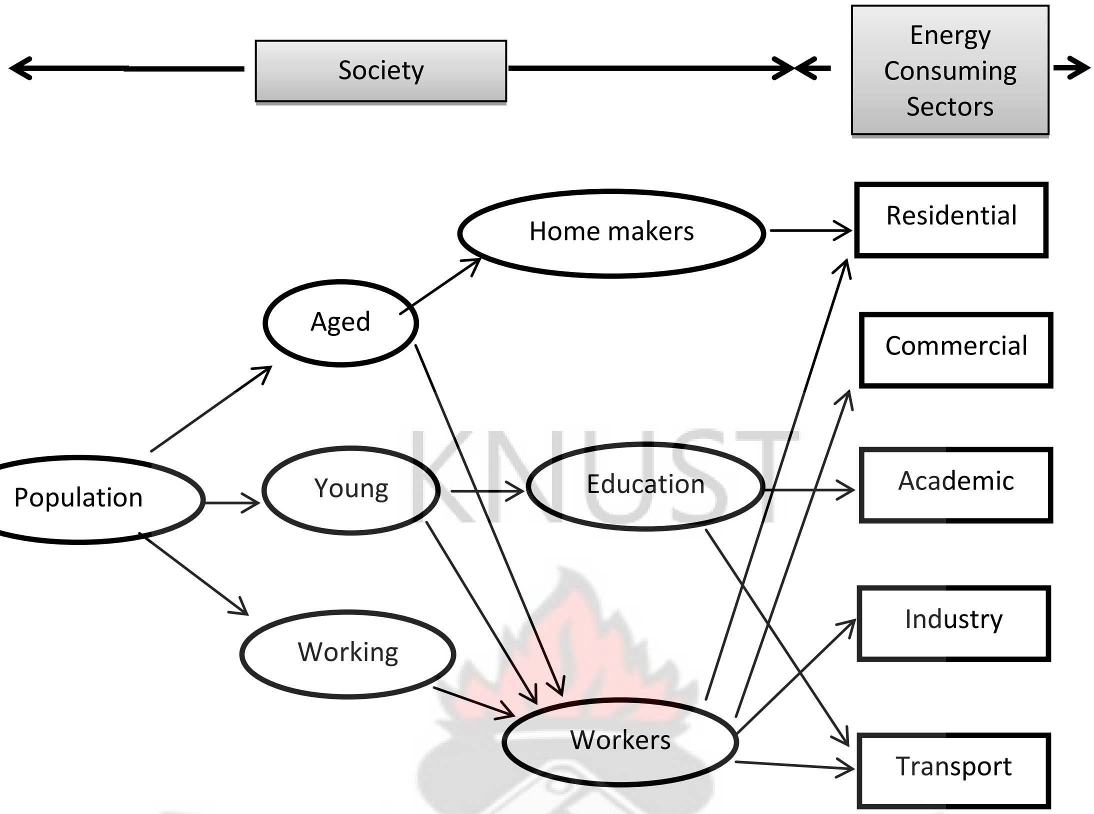

Figure 2. 3: Influence of socio-demography on energy use in various sectors

Source: (Thavasi & Ramakrishna, 2009b)

2.2 PARADOX OF ENERGY PRODUCTION IN DEVELOPING SOCIETIES

The developed country's objective is to attain increasing living standard whiles reducing energy use massively. Developing nations however strive for economic growth whiles increasing overall energy use moderately (Pachauri and Spreng, 2011). Challenges confronting energy access in developing societies manifests failure in policy intervention from Governments and Stakeholders (Bhattacharyya, 2013) and an attestation to the need for a radical shift in existing policies. These are evident in the losses and disparities in energy production, transmission and energy use.

2.2.1 Energy sources and production

Comparatively, some renewable sources like solar, wind etc. are more expensive to transform to electricity due to the immature technology required for the transformation (Chow, Kopp, & Portney, 2003). These renewable energy resources are in contrast most abundant in most of the developing societies (Kaygusuz, 2012). Sustainable measures are required since fossil fuels are expected to last for 100 years considering the current rate of consumption globally (Thavasi & Ramakrishna, 2009b).

Lack of access to sustainable electricity remains a huge challenge for developing societies. 58% of the entire African population have no access to electricity (IEA, 2011). In societies where they are available, the disparity between the rural and urban communities are very wide though most developing countries are very wealthy in this energy resource (Sovacool, 2013). Energy resources available to the rural citizenry in most developing countries are biomass driven. Within Asia, almost 80% of electricity-deprived and 86% of biomass-dependent populations are in the 'Big 5' countries (IEA, 2011). Demurger and Fournier (2011) have established that households switch from biomass to other modern energy forms as income increases. This explains that firewood is an inferior good that is used to meet energy needs. Scarcity of firewood increases collection time for wood fuels. Alternative use of substitutes like animal fodder, animal dung etc. which invariably hikes the price of firewood within these constraints leads to the detriment of the rural citizenry. The transformation of traditional fuels such as biomass into heat and thermal energy is accompanied by indoor air pollution. Improved cooking fuels and stove have a big impact on the health and environment yet energy poverty can act as a stumbling block in its acquisition. The World Health Organisation states that globally, 1.5 million people died from diseases caused by indoor air pollution in the year 2002 (WHO 2006). It has been established that particles from the burning of biomass, oil lamps and lanterns can cause inflammation of the airways (trachea) and lungs and impair the immune response of humans (ibid). This presupposes that the perceived cheap form of energy available to the rural dwellers can be expensive (Pachauri & Spreng, 2011).

2.2.2 Energy access

Rural urban disparity in developing countries is evidenced in the sharp contrast of energy infrastructure (Kaygusuz, 2012). Energy access is provided through grid extensions in the urban areas whiles the rural access is provided through an arbitrary chosen mix of grid extension, mini grids and off grid options. Subsistence farming has led to scattered settlements in most of the rural areas in developing countries. These settlements are farther away from urban centres. Development of transmission and distribution facilities has been skewed in favour of the urban centres because political power is detained by urban elites. The lack of representation of rural dwellers in this setting pushes on the poor to continuously feed on biomass (Bhattacharyya, 2013). In Africa alone, more than half of the population (see Table 2.1) have no access to modern energy (IEA, 2011).

Table 2.1 Number and share of people without access to modern energy in selected countries, 2009

	Without access to electricity		Relying on the traditional use of biomass for cooking	
	Population (million)	Share of population	Population (million)	Share of population
Africa	587	58%	657	65%
Nigeria	*76*	*49%*	*104*	*67%*
Ethiopia	*69*	*83%*	*77*	*93%*
DR of Congo	*59*	*89%*	*62*	*94%*
Tanzania	*38*	*86%*	*41*	*94%*
Kenya	*33*	*84%*	*33*	*83%*
Other sub-Saharan Africa	310	68%	335	74%
North Africa	2	1%	4	3%
Developing Asia	675	19%	1 921	54%
India	*289*	*25%*	*836*	*72%*
Bangladesh	*96*	*59%*	*143*	*88%*
Indonesia	*82*	*36%*	*124*	*54%*
Pakistan	*64*	*38%*	*122*	*72%*
Myanmar	*44*	*87%*	*48*	*95%*
Rest of developing Asia	*102*	*6%*	*648*	*36%*
Latin America	31	7%	85	19%
Middle East	21	11%	0	0%
Developing countries	1 314	25%	2 662	51%
World*	**1 317**	**19%**	**2 662**	**39%**

*World total includes OECD and Eastern Europe/Eurasia.

Source: (IEA, 2011 pp 11)

In the development of energy infrastructure, the state has played an important role in funding infrastructure investments such as energy transportation and distribution mechanisms. On the contrary, many developing countries have neglected the energy access issue for a long time (Bhattacharyya, 2013). International donor agencies have provided selective and limited support, whilst the innovative mechanisms are also unfriendly towards small-scale projects (Bhattacharyya, 2013).

Energy production and distribution have not been decentralised in most developing countries to ensure efficient production, transmission and distribution. Production points are far away from distribution points. Transmission infrastructures are obsolete and inefficient. The loop system of to create redundancy in order to ensure continuous power supply in most cases are not applicable due to high cost in its implementation (IEA, 2011).

2.3 INVESTIGATION INTO GHANA'S AVAILABLE ENERGY RESOURCES

2.3.1 Description of Ghana

Ghana is geographically located at 8 00N, 2 00W with a total population of 24,223,431 made up of 48.7% males and 51.3% females (Ghana Statistical Service, 2010). It recorded an annual intercensal growth rate and a population density of 2.4% and 102 in 2010 respectively (ibid). It has a total area of 238,533 square kilometres with a coastline length of 539km. Land and water occupies about 227,533sq km and 11,000 sq. km respectively (Central Intelligence Agency, 2013; Ghana Statistical Service, 2010; Open Energy Information, 2013).

2.3.2 Energy resources available in Ghana

Nkrumah (1965 pp1-14) opines that the energy resource potential of Ghana has not been extensively conducted, yet, even the present very inadequate surveys of Ghana's natural energy resources shows the country have immense, untapped wealth in this regard. The energy resources currently available to the country are wind, solar, natural gas, oil reserves and renewable energy. Geothermal, nuclear and fossil fuels have not been identified till date.

The readily available data (excluding biomass, hydro) (Table 2.2) obtained shows that wind potential of the country is class 3-7 estimated at 1,128 km^2 at a height of 50m above the ground, solar has a potential of 706,055,035MWh/year, Natural Gas Reserves of 22,650,000,000 cubic meters and 15,000,000 barrels of oil reserves (Central Intelligence Agency, 2013; Open Energy Information, 2013). Summary of the available energy resources (excluding biomass and hydro) is been presented in Table 2.2.

Table 2.2 - Energy resource potential of Ghana

Resource	**Value**	**Units**	**Period**
Wind Potential	1,128	Area(km^2) Class 3-7 Wind at 50m	1990
Solar Potential	706,055,035	MWh/year	2008
Coal Reserves	Unavailable	Million Short Tons	2008
Natural Gas Reserves	22,650,000,000	Cubic Meters (cu m)	2010
Oil Reserves	15,000,000	Barrels (bbl.)	2010

Source: (Central Intelligence Agency, 2013)

2.3.3 Energy consumption of the Ghanaian populace

In 2008, Ghana's biomass energy consumption was 11.7 million tonnes, whilst petroleum products and electricity consumption were 2.01 million tonnes and 9,152 GWh, respectively (Ministry of Energy, 2010b). In terms of total energy equivalents, biomass (fuel wood and charcoal) constituted 65.6%, with petroleum products and electricity accounting for 26.0% and 8.4% respectively (Ministry of Energy, 2010b). 120 million cubic meters of natural gas (Central Intelligence Agency, 2013) were consumed in 2010

In the Power sub-sector about 9,152 GWh of electricity was consumed in 2009. Out of the consumption, about 66.60% was produced from hydropower, 30.10% from thermal plants whiles 3.3% was imported from neighbouring countries (Volta River Authority, 2009)

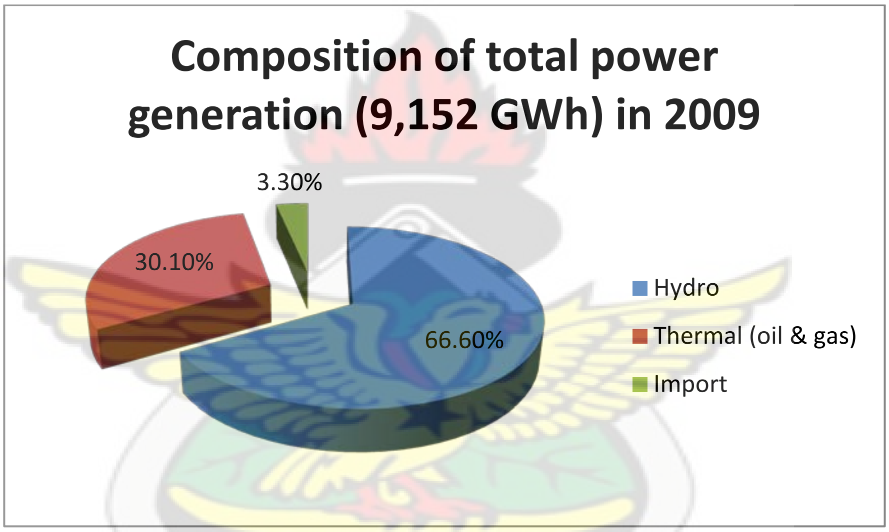

Figure 2. 4: Composition of Ghana's total power mix in 2009
Source: (Volta River Authority, 2009)

2.3.4 Synthesis of energy resource availability and consumption

UNEP et al., (2013 pp 1-5) advises that of the numerous energy resources should be carefully selected based on community needs, affordability and end use technology. In the Ghanaian energy dispensation, energy resources are used for thermal heating (mainly cooking), electricity and fuels for transport.

The availability of energy requires that its conservation may harm economic growth in developing countries regardless of it being transitory or permanent.

With a GDP per capital of 3,100USD (2011 est.) ranked 143 in the world (Wikipedia, 2013), it will be the priority of the government to explore the cheap forms of energy to aid in its development and alleviate energy poverty.

2.3.4.1 Energy resources usage

Per the available energy resource, biomass continue to dominate the rural population since access to power is not available to many of the rural population (Open Energy Information, 2013). The rural people have vast biomass coming from clearing land cover of trees and shrubs for agricultural purposes. These are collected and sometimes processed into charcoal for cooking. Because the burning of the biomass produces a lot of environmental waste in the form of noxious gases and ash, the Ministry of Energy in Ghana is promoting the utilization of more efficient charcoal production and end use technologies through training, fiscal incentives and regulation geared towards the improvement of its efficiency in the consumption of biomass (Ministry of Energy, 2010a).

Agyei (2009) states that the necessary legal basis for the rapid development of renewable energy in the national energy mix by establishing a Renewable Energy Law as part of meeting the objective of security of supply of energy. This law has been passed. It should be clear by now that the future for energy accessibility will be the implementation of renewable energy projects which can also be used as a policy mechanism to alleviate energy poverty.

2.4 ROLE OF ENERGY POLICY IN ALLEVIATING ENERGY POVERTY

WHO (2006) have set 2015 as a target year to reduce the number of people without effective access to modern cooking fuels by 50%, and make improved cooking stoves widely available. For this target to become a reality, 1.7 billion people will need to gain access to LPG, natural gas, biogas and other modern fuels (ibid). Knowledge of circumstances leading to energy poverty in developing societies (Figure 2.5) provides ammunition for designing effective policies to curtail the phenomenon. Measurable indicators to assess policy effectiveness to activate revision of policies when required are the best methods to address energy poverty (Thavasi & Ramakrishna, 2009b). These data are not available in most developing countries.

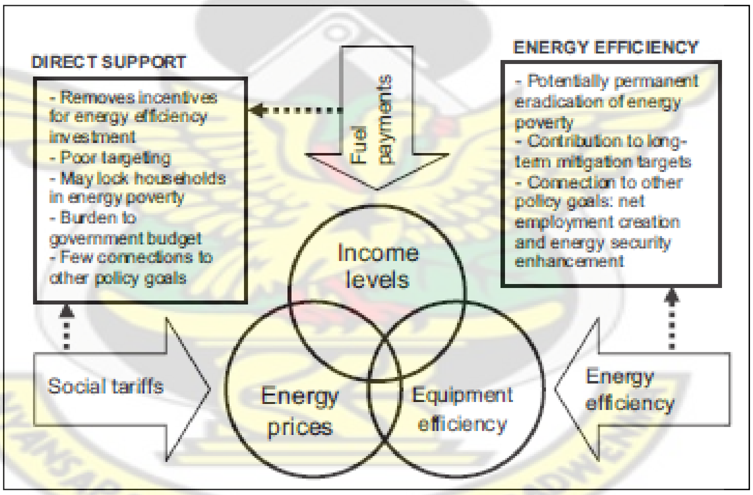

Figure 2. 5: Contributing factors and policy entry point to fuel poverty and their relation to climate change Source: (Urge-Vorsatz & Herrero, 2012)

Over reliance on biomass have been known to have detrimental effects on forest degradation, soil erosion, indoor air pollution whiles threatening sustainable development of forest reserves which acts as carbon sinks (IEA, 2011). Policies to curb these activities exclude the local people leading to weak enforcement resulting in difficulty to switch to alternative fuels. This explains the slow energy transition process during reform (Demurger and Fournier, 2011).

Corruption aided by interests in fossil fuels and grid electricity skews government incentives and subsidies to favour fossil energy (Sovacool et al., 2011). Currently due to the environment and climate change, intervention programs have evolved from a supply-driven financial approach to a demand-side. Micro-finance proceeds from 'carbon markets' which provides financing mechanism for electrification and clean cooking are channelled through Governments of various developing countries for implementation (Bhattacharyya, 2013). Weak government, weak institutions and poor policy environment of developing countries champion the misappropriation of funds earmarked to tackle energy poverty. There are no systematic review of financing issues and options for energy poverty reduction in developing countries (Bhattacharyya, 2013).

Understanding energy poverty in the context identified is central to any effort applied to alleviate it. The challenge is the modelling of appropriate energy-related sustainability indicators which will account for the impact of changes and policies will have on the future. An internationally consistent measurement framework and data collection system to effectively enable monitoring and reporting will be required (Thavasi & Ramakrishna, 2009b).

Decentralization of energy options (production, transmission, distribution etc.) and strengthening the power systems will be required for sustainable energy delivery. Implementation of policies in a transparent manner that identifies and proposes mitigation measures in the socio-demographical wastage of energy resources and mitigation measure should involve local stakeholder participation. Expansion of energy infrastructure and development of decentralised small scale energy options such as RET projects as well as improved modern cooking options is a condition precedent for upturn of ‘energy poverty’ into ‘energy wealth’ in developing societies. The transparency in the application of subsidies and the elimination of subsidies for fossil fuels, whiles incentivizing grid-connections on green energy will lead to sustainability of energy supply in developing countries.

CHAPTER 3: METHODOLOGY

As presented in the introduction and literature review, the study is about renewable energy project as a tool for alleviating energy poverty in Ghana; Case Study – Bui Resettlement Community. The aim of this chapter is to provide the framework for the methodology adopted for the research. This is presented in Figure 3.1.

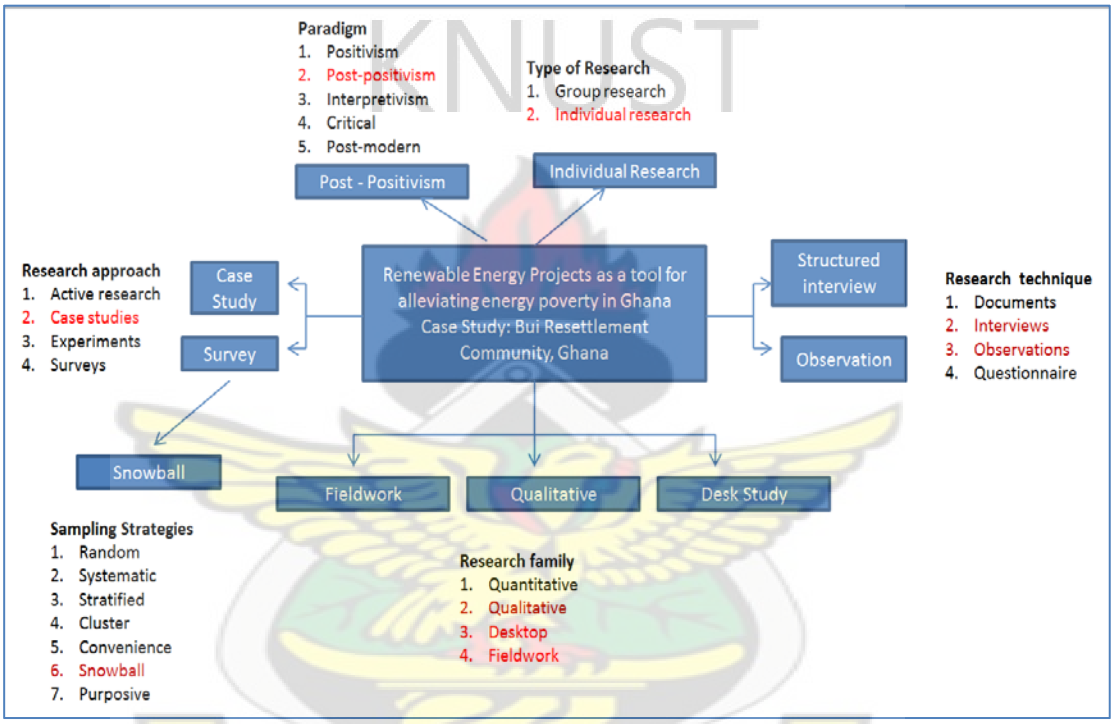

Figure 3 1 Framework for research methodology

3.1 METHODS

3.1.1 Type of research undertaken

The types of research available are the group research and an individual research (Blaxter et al., 2010). Correspondingly, the context of the task automatically presents the author to adopt an individual research. This is because; the research is a requirement by the Postgraduate programme in Renewable Energy Technology at the Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology as partial fulfilment for the award of an MSc Degree. It is aimed at developing and refining students' investigative skills, selecting appropriate method of information handling and presentation and equipping students to initiate and carry out a piece of independent academic research. It is expected to be placed in the context of the academic and professional published work and to reflect critically on findings in the content of the current practice in a chosen field.

3.1.2 Research paradigm

Five paradigms are available and presents a way of breaking down the complexity of the real world issues and offer the basic framework for dividing knowledge camps (Oakley, 1999). The paradigms are positivist, post-positivist, interpretive, critical and postmodern (Blaxter, Hughes, & Tight, 2010). Positivism adopts the use of experiments to offer an explanation leading to control and predictability (Bryman, 2012). The time period for the research topic makes this paradigm difficult to implement because the research has to be repetitive. Interpretivism indicates that research is approached in the context of understanding and explaining the research problem (Blaxter, Hughes, & Tight, 2010). The nature of the research topic which measures RET projects in energy poverty alleviation makes this choice unsuitable. Critical paradigm combines both the positivism and the interpretivism (Bryman, 2012). From the aforementioned explanations it becomes unsuitable to be adopted. Postmodern paradigm overcomes the boundaries of the research problem placed between the real issue and the theory (Blaxter, Hughes, & Tight, 2010). It is of similar nature to the critical paradigm which makes it unsuitable for this research. Post-positivism maintains the same set of basic beliefs as positivism. However, it presents that whereas objectivity remains ideal, there is an increased use of qualitative techniques in order to ascertain the validity of findings (Blaxter, Hughes, & Tight, 2010). Post-positivism is adopted in this research. From the research topic, knowledge of the social reality of energy poverty and the affected people can be known in social reality imperfectly and probabistically. While objectivity remains an ideal, the adoption of qualitative techniques will aim at checking the validity of findings against the knowledge in social reality.

3.1.3 Research technique

Consultation of documents, interviews, observations and questionnaires are available to be used as a research technique to find answers to the research question. The author is a staff of the Bui Power Authority which is the Authority responsible for the planning, execution and management of the Bui Hydroelectric Project considered as the Renewable Energy Project for the Case Study. Within this context, structured interview, consultation of documents and observations remains a good choice in the research technique. The limited number of people who could read and write created a huge challenge in the administration of questionnaires. The option available was to observe their activities during their daily lifestyles at the BPA Resettlement Camp in the Brong Ahafo Region where they were resettled after their relocation from their various villages in the Bui Dam construction environs.

Structured interview was also organised for people in the Bui Village at the

BPA Resettlement Camp. From the available data, the village consisted of 42 households with a population of 297. More than halve of the population were targeted. Due to the low literacy level of the respondents the questionnaire was filled by the interviewer. On the other hand, due to access and ethical issues, anonymous questionnaires were adopted. The research did not rely on audio video, photographic or any other recording medium. Participants were not identified from the responses they provided. Informed consent was sought from all participants before interview.

3.1.4 Sampling strategy

The sampling strategies available are the simple random, cluster, snowball, systematic, stratified, purposive and the convenience (Blaxter, Hughes, & Tight, 2010). The probability sample consists of the simple random, systematic sampling, cluster sampling and the stage sampling (ibid). Selection from these are at random or an n^{th} case (ibid). The non-probability sampling consists of the convenience sampling, voluntary sampling, purposive sampling, dimensional sampling and the snowball sampling. These sampling are undertaken in a convenient manner (ibid).

Due to the nature of the research community, the snowball approach was adopted for the research problem. The snowball sampling approach deals with the building up of a sample through informants (ibid). These informants started with people who were working with the Bui Power Authority where the author is a staff.

3.1.5 Research family

The two broad research families available are:

- Quantitative or Qualitative
- Deskwork or Fieldwork

Quantitative research is empirical research where the data are in the form of numbers. Qualitative research is however empirical research where the data are not in the form of numbers. On the other hand, fieldwork refers to the process of going out to collect research data. Observation, administration of questionnaires and interviews forms part of fieldwork. Desktop consists of those researches which are done whilst sitting behind a desk. They are inclusive of the analysis of data collected by others, literature search on the library and research using the library. From the choices made in the type of research, research paradigm and research technique, a combination of qualitative, deskwork and fieldwork was adopted for the research.

3.1.6 Research approach

The available research approaches are action research, case studies, experiments and surveys.

A conventional action research is envisage to

- Examine the nature of the problem situation;
- Devise an appropriate product based intervention;
- Trial this (and the supporting mechanisms);
- Evaluate the impact.

The cyclic process of the action research (examination, intervention, trial and evaluation) makes it suitable to be adopted since the time period available to conduct the research makes this choice non conducive (Blaxter, Hughes, & Tight, 2010). Case Study on the other hand is drawn from people's experiences and practices and so it is seen as strong in reality. It allows for the generalisations from a specific instance to a more general issue. The Bui Resettlement Community therefore presents a very good opportunity to undertake the research topic. Because the case study builds on actual practises and experiences, they can be linked with the paradox of energy use in developing societies and their insights contributing to global practice. Furthermore, confirmation that the data in case studies are close to people's experiences makes it more persuasive and more accessible. Notwithstanding the fact that the very complexity of a case study makes analysis difficult and challenging to know where the context begins and ends, the advantages outweighs the disadvantages within the research question.

3.2 CASE STUDY

3.2.1. The Renewable Energy Project

The Bui Hydroelectric Project (BHP) is the third dam in Ghana after Akosombo and Kpong dams. In 2007, the Government of Ghana signed an Engineering, Procurement and Construction (EPC)/Turnkey Project Contract with Sinohydro Corporation Limited of China to execute the 400MW Bui Hydroelectric Project located on the Black Volta in the Banda and Bole Districts (Bui Power Authority, 2012). The Bui Power Authority Act 2007 (Act 740) was enacted by the President and Parliament of Ghana in July 2007 to establish an authority known as Bui Power Authority (BPA) which was to plan, execute and manage the Bui Hydroelectric Project (BHP) (Bui Power Authority, 2013b). Development of the BHP will involve the permanent inundation of 444 km^2 of land, occupying about 21% of the Bui National Park, at its full supply level of 183 meters above sea level (Bui Power Authority, 2012). The creation of the reservoir and the inundated land will result in the total loss of livelihoods and immovable assets of three communities within the area of the reservoir, four communities living at the main dam area and resident officers of the Bui National Park.

3.2.2. Resettlement Package

The BPA implemented a Resettlement and Community Support Program to provide the platform to sustain the Project Affected Persons (PAPs) during the Resettlement Program (Bui Power Authority, 2013b). The main elements of the programme were made up of the following:

- New resettlement townships with the under listed communal facilities:
    - Community Centre, Nursery, Place of Worship, Boreholes, KVIPs
    - Houses: (Room for room plus kitchen, bath and living room)
- Compensation for loss of economic trees at Land Valuation Board of Ghana's rates
- Grants: GH¢ 100 as resettlement Grant and GH¢ 50 to till new farm land
- Income support: GH¢ 100/month/household for 1 year
- Livelihood Enhancement Program: To restore Lost Economic Activities and improve living Standards in Project Affected Areas

The project affected communities that require to be resettled were extensively consulted on their preferred resettlement site.

3.2.3. Research Concept

From the framework of the research methodology (Figure 3.1), structured interview with the snowball approach was adopted by employing the research concept in Figure 3.2. A sample of the questionnaire administered is provided in the appendix. The study was conducted for the Bui Village PAPs.

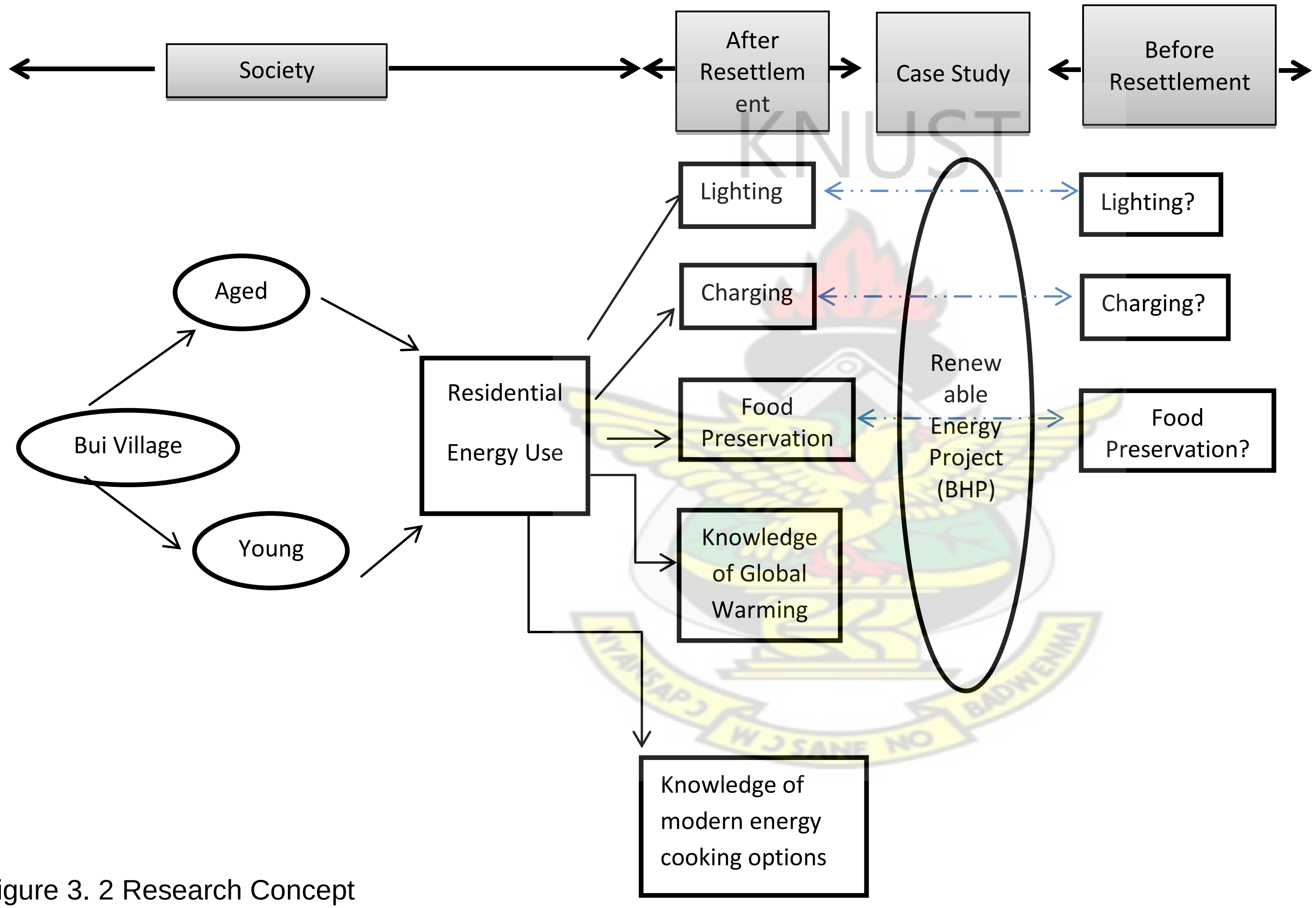

Figure 3. 2 Research Concept

3.2.4. Analysis of results

From the research concept, Minitab 16 will be used to perform the hypothesis test of the difference between two sample data before and after the implementation of REP (BHP). The test items as detailed in the research concept (Figure 3.2) will be in terms of lighting, ownership of charging items, food preservation, knowledge of modern energy cooking options, knowledge of global warming and cost of energy before and after the implementation of the REP in the alleviation of energy poverty.

The framework is detailed below:

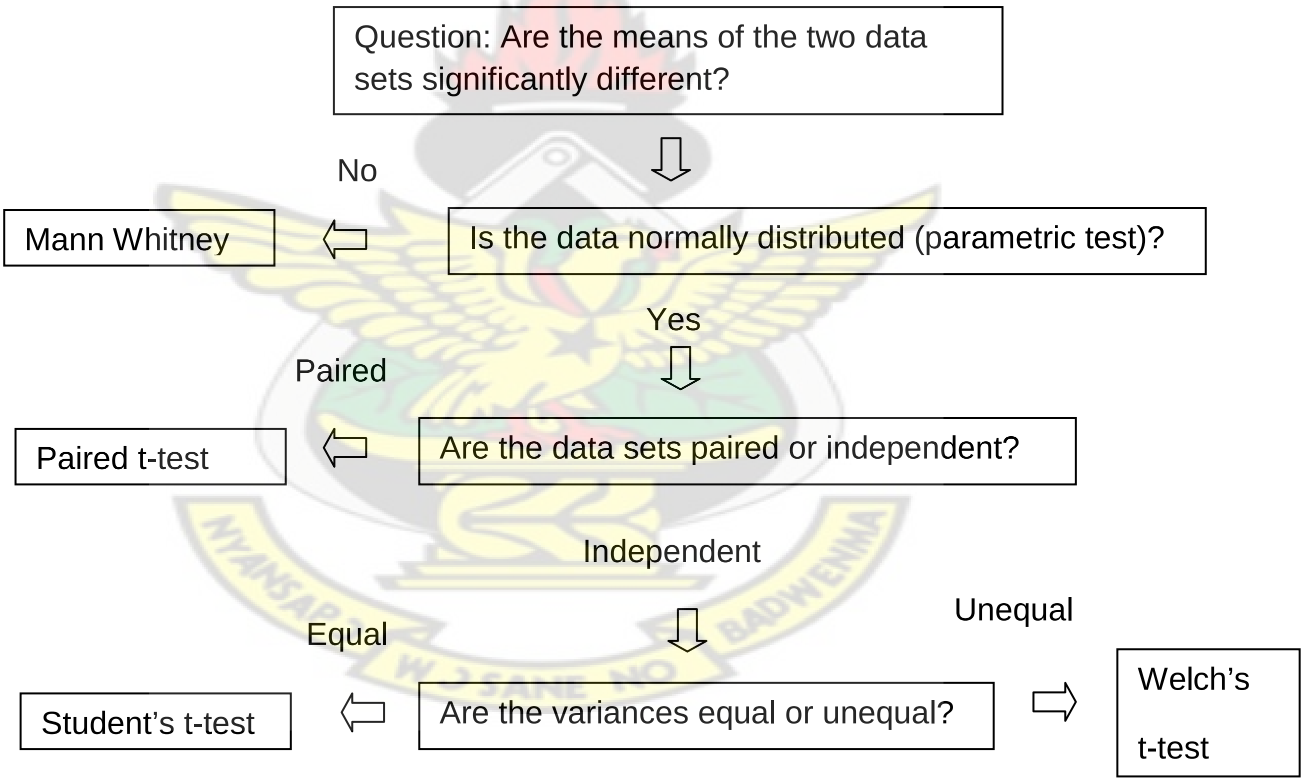

Figure 3. 3 Method to be employed in the analysis of data

When looking at the association between two data sets descriptive statistics is used to find out if there is a relationship between the data sets. Several identities such as the mean, mode, standard deviation, variance etc. can be used as a measure to check differences between data sets. This will be displayed in the 'descriptive statistics' of Minitab 16.

To identify the difference between the data set, a hypothesis test is adopted and used to compute a confidence interval in the means or medians of the data. The significance test will be used to validate the hypothesis for normal distribution of data set or otherwise (non-normal distribution). If the two data sets are normally distributed a paired t-test will be used to find out if the null hypothesis or the alternative should be accepted. If either of the data sets **is not** normally distributed, the Mann-Whitney Test will be used to find out if the null hypothesis or the alternative should be accepted. It is imperative to note that because the data sets are paired the framework in Figure 3.3 will not involve the Student's t-test and the Welch's t-test which relies on independent data sets.

Significance testing

It is equally worthy to note that in *significance testing*, the probability value (p-value) which identifies the confidence level in the data sample is used to validate the null hypothesis. In validating the data, a larger p-value will be accepted for the null hypothesis whilst the alternative is rejected. The implication of this is that if the p value is greater than 0.05 ($p>0.05$) then the null hypothesis is accepted. If the p value is less than 0.05 ($p<0.05$), the alternative of the null hypothesis will be accepted.

Paired t-test

The paired t-test performs a hypothesis test of the difference between 2 population means when observations are paired or matched. It tests the difference between two means when the data are paired and the paired difference follows a normal distribution. This will be adopted to ascertain if the data set after the implementation of the REP is different.

Mann-Whitney test

The test is a non-parametric (non-normal) procedure for comparing two populations (the equivalent of a parametric t-test). This test is conducted when one or both of the data sets are not normally distributed. The test assumes that the data are a random sample from each population and the samples are taken independently of each other. Rather than comparing the sample means, the Mann-Whitney test compares the sample medians. It further calculates the corresponding point estimate and the confidence interval with the assumption that the data sets are independent random sample i.e. same shape (variance) and a scale that is least ordinance.

Minitab determines the attained significance level of the test using a normal approximation with a continuity correction factor W. From this factor, if the value (W) is greater than 39 (W>39) it can be deduced from the hypothesis that the paired data set is statistically significant or not at the 0.05 confidence level.

CHAPTER 4: RESULTS, ANALYSIS AND DISCUSSIONS

4.1 RESULTS

The analysis of the results was based on the data drawn from the primary data in the form of the questionnaire (see appendix) served to the residents of the Bui Village in the BPA Resettlement (96 males and 64 females). Paragraph by paragraph was worked through whiles comparing the impact of the item being investigated before and after the implementation of the REP. For each relevant question, what was of interest were concerns raised in the literature review (households switch from biomass to other modern energy as income increases (Demurger and Fournier, 2011); energy poverty leads to the use of unfriendly lights and cooking options (WHO, 2006); modern form of energy is cheaper than rural form of energy (Pachauri and Spring, 2011); knowledge about global warming is limited in rural areas). The energy poverty phenomenon will be evident in the above criterion.

Results from the respondents are presented in Tables 4.1 – 4.5.

Table 4. 1 Source of light before and after implementation of renewable energy project

Gender	Age (years)	Source of light before resettlement				Light after resettlement					
		Lantern (A)	Oil lamps (B)	Other Environmentally unfriendly lights C	Total Environmentally Unfriendly lights (A+B+C)	Electricity (D)	Lantern F	Oil Lamps (H)	Rechargeable lamps (I)	Total Unfriendly (F+H)	Total Friendly (D+I)
Male	Up to 17	4	21	15	40	40	1	8	22	9	62
	18 - 40	9	15	2	26	26	9	2	13	11	39
	Above 40	5	25	0	30	30	2	25	3	27	33
Female	Up to 17	2	18	1	21	21	1	10	8	11	29
	18 - 40	1	21	0	22	22	1	13	10	14	32
	Above 40	1	20	0	21	21	1	10	7	11	28

Table 4. 2 Ownership of charging item before and after implementation of renewable energy project

Gender	Age (years)	Ownership of charging before		Ownership of charging after	
		Yes	No	YES	NO
Male	Up to 17	5	28	33	4
	18 - 40	1	25	18	8
	Above 40	0	13	9	4
Female	Up to 17	2	18	20	1
	18 - 40	3	15	22	0
	Above 40	1	9	18	3

Table 4. 3 Food preservation methods before and after implementation of renewable project

Gender	Age (years)	Food preservation before					Food preservation after					
		Salting (J)	Drying K	Smoking L	Other (M)	Total Rural method preservation J+K+L+M	Salting (N)	Drying O	Smoking P	Refrigerator Q	Other R	Total Rural method preservation N+O+P+Q+R
Male	Up to 17	2	2	3	0	7	2	2	4	2	0	8
	18 - 40	4	7	5	0	16	4	8	2	5	0	14
	Above 40	3	8	9	0	20	3	5	5	18	0	13
Female	Up to 17	21	18	20	0	59	21	18	20	2	0	59
	18 - 40	22	21	22	0	65	20	19	20	5	0	59
	Above 40	20	21	21	0	62	20	20	19	3	0	59

Table 4. 4 Knowledge of modern energy cooking options and causes of global warming

Gender	Age (years)	Knowledge of modern cooking options		Knowledge of Causes of Global warming	
		YES	NO	YES	NO
Male	Up to 17	8	32	2	38
	18 - 40	9	11	8	18
	Above 40	11	18	5	25
Female	Up to 17	2	19	2	19
	18 - 40	8	14	1	21
	Above 40	3	18	3	18

Table 4. 5 Comparison of rural and modern energy cost

Gender	Age (years)	Expensive energy	
		Rural	Modern
Male	Up to 17	32	8
	18 - 40	19	7
	Above 40	26	5
Female	Up to 17	15	6
	18 - 40	18	4
	Above 40	15	16

4.2 ANALYSIS OF RESULTS

From the framework detailed in Figure 3.3, the data is analysed by employing the use of the iterative tests detailed.

4.2.1 Lighting

First the data set is checked to see if the values recorded are normally distributed or not. The parametric test is first performed and significantly tested.

Parametric test (normality test)

Null hypothesis: Both set of data are normally distributed.

Alternative: Either of the data is not normally distributed.

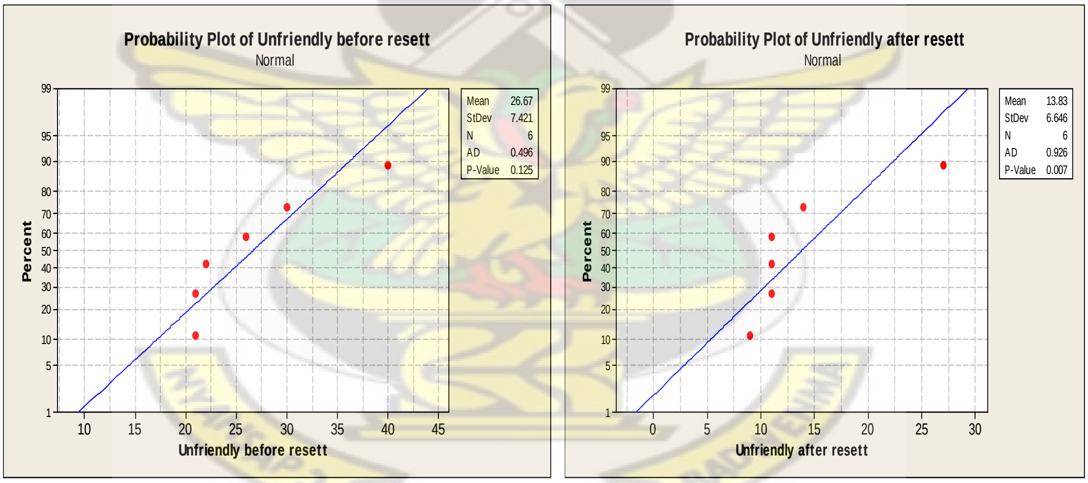

Figure 4. 1 Parametric test for type of light used before and after resettlement

From Figure 4.1, both data sets are not normally distributed since p > 0.05does not apply for each set of data (0.125 and 0.007), thus the alternative either of the data set is not normally distributed is accepted. This leads to the adoption of the Mann-Whitney test as detailed in Figure 3.3.

Mann-Whitney test

From Figure 3.3, the Mann-Whitney test is considered since both data sets are not normally distributed after using the significance test. Descriptive statistics for the data are presented in Figure 4.2:

Descriptive Statistics: Unfriendly before resett, Unfriendly after resett

```
Variable                   N  N*   Mean  SE Mean  StDev  Minimum     Q1  Median
Unfriendly before resett   6   0  26.67     3.03   7.42    21.00  21.00   24.00
Unfriendly after resett    6   0  13.83     2.71   6.65     9.00  10.50   11.00

Variable                      Q3  Maximum
Unfriendly before resett   32.50    40.00
Unfriendly after resett    17.25    27.00
```

Figure 4. 2 Descriptive statistics for type of light used before and after resettlement

Hypothesis testing for research question

The hypothesis question for the energy poverty and the use of unfriendly source of light is proposed and tested using Minitab 16.

Null hypothesis: Energy poverty leads to the use of unfriendly sources of lights.

Alternative: Energy poverty does not lead to the use of unfriendly source of light.

Mann-Whitney Test and CI: Unfriendly before resett, Unfriendly after resett

```
                          N  Median
Unfriendly before resett  6   24.00
Unfriendly after resett   6   11.00


Point estimate for ETA1-ETA2 is 12.00
95.5 Percent CI for ETA1-ETA2 is (7.00,21.00)
W = 53.0
Test of ETA1 = ETA2 vs ETA1 < ETA2


Cannot reject since W is > 39.0
```

Figure 4. 3 P value data for light use comparisons

From the Mann-Whitney test (Figure 4.3), the null hypothesis that ***Energy poverty leads to the use of unfriendly light source is accepted since W (53.0)>39.0***.

The test procedure adopted in section 4.2.1 within the framework of Figure 3.3 is adopted for sections 4.2.2 and 4.2.3.

4.2.2 Chargeable item (Electrical Storage devices)

Parametric test (normality test)

Null hypothesis: Both set of data are normally distributed.

Alternative: Either of the data is not normally distributed.

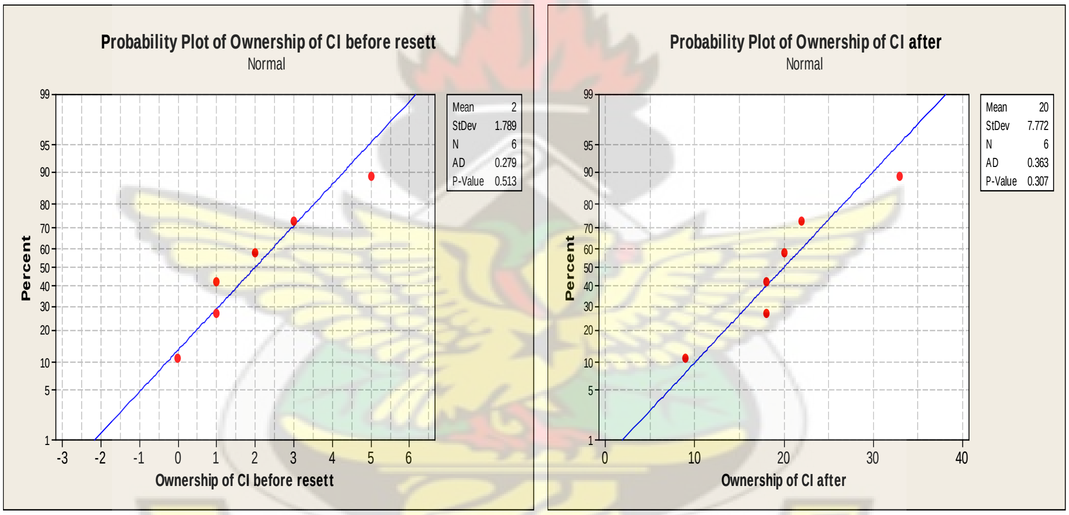

Figure 4. 4 Parametric test for ownership of chargeable items before and after resettlement

From Figure 4.4, both data sets are normally distributed since $p > 0.05$ for each set of data (0.513 and 0.307), as such; the null hypothesis that both data sets are distributed is accepted. A paired t-test is subsequently used to test the hypothesis of the research question.

Paired t-test

The descriptive statistics of the data sets is presented in Figure 4.5:

Descriptive Statistics: Ownership of CI before resett, Ownership of CI after

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
Ownership of CI before r	6	0	2.000	0.730	1.789	0.000	0.750	1.500
Ownership of CI after	6	0	20.00	3.17	7.77	9.00	15.75	19.00

Variable	Q3	Maximum
Ownership of CI before r	3.500	5.000
Ownership of CI after	24.75	33.00

Figure 4. 5 Descriptive statistics for ownership of chargeable items

Hypothesis testing

Null Hypothesis: Energy poverty leads to the use of less chargeable items

Alternative: Energy poverty does not lead to the use of less chargeable items

Paired T-Test and CI: Ownership of CI before resett, Ownership of CI after

Paired T for Ownership of CI before resett - Ownership of CI after

	N	Mean	StDev	SE Mean
Ownership of CI before r	6	2.00	1.79	0.73
Ownership of CI after	6	20.00	7.77	3.17
Difference	6	-18.00	6.07	2.48

95% lower bound for mean difference: -22.99
T-Test of mean difference = 0 (vs > 0): T-Value = -7.27 P-Value = 1.000

Figure 4. 6 P value data for ownership of chargeable item

From the paired t-test (Figure 4.6), the p value is 1.0 >0.05, thus, the null hypothesis that ***Energy poverty leads to the ownership of less chargeable items is accepted***.

4.2.3 Food preservation

Parametric test (normality test)

Null hypothesis: Both set of data are normally distributed.

Alternative: Either of the data is not normally distributed.

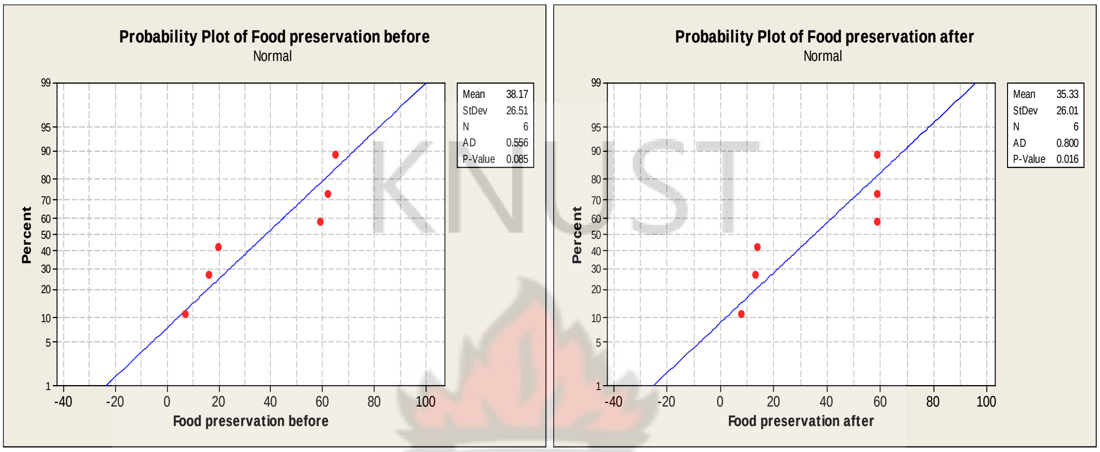

Figure 4.7 Parametric test for type of food preservation before and after resettlement

From Figure 4.7, both data sets are not normally distributed since $p > 0.05$ does not apply for both data sets (0.085 and 0.016), as such; the alternative, either of the data is not normally distributed is accepted. A Mann-Whitney test is used to validate the hypothesis.

Mann Whitney test

The descriptive statistics of the data sets is presented in Figure 4.8

Descriptive Statistics: Food preservation before, Food preservation after

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
Food preservation before	6	0	38.2	10.8	26.5	7.0	13.8	39.5
Food preservation after	6	0	35.3	10.6	26.0	8.0	11.8	36.5

Variable	Q3	Maximum
Food preservation before	62.8	65.0
Food preservation after	59.0	59.0

Figure 4. 8 Descriptive statistics for food preservation

Hypothesis testing of research question

Null Hypothesis: Energy poverty leads to the use of rural food preservation

Alternative: Energy poverty does not lead to the use of rural food preservation

Mann-Whitney Test and CI: Food preservation before, Food preservation after

```
                           N  Median
Food preservation before  6   39.50
Food preservation after   6   36.50


Point estimate for ETA1-ETA2 is 3.00
95.5 Percent CI for ETA1-ETA2 is (-42.99,48.98)
W = 43.5
Test of ETA1 = ETA2 vs ETA1 < ETA2


Cannot reject since W is > 39.0
```

Figure 4. 9 Mann Whitney test for food preservation before and after resettlement

From the Mann-Whitney test (Figure 4.9), the null hypothesis that the implementation of a renewable energy project has led to the use of modern food preservation cannot be discounted since W (43.5)>39.

4.2.4 Modern energy cooking options

A graph plotted to ascertain the respondent's knowledge in modern energy cooking options from Table 4.4 yielded the results in Figure 4.10.

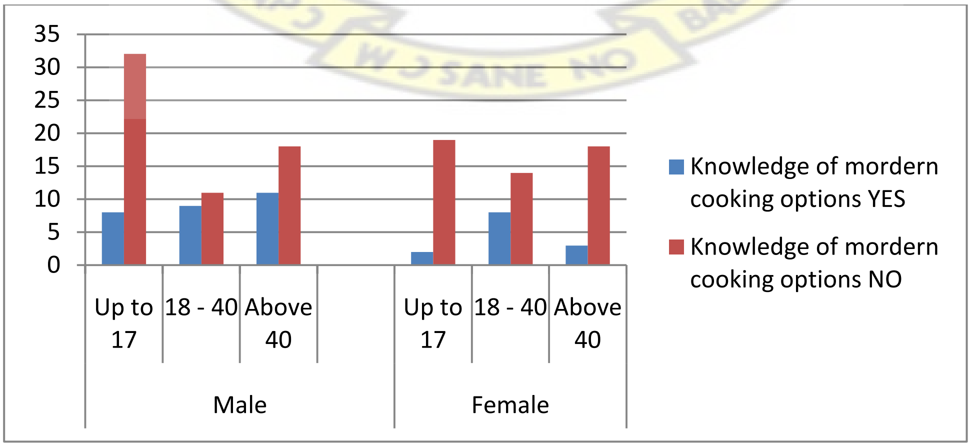

Figure 4.10 Knowledge of modern energy cooking options amongst age distribution

4.2.5 Global warming

A graph plotted to ascertain the respondent's knowledge in global warming in Table 4.4 yielded the results in Figure 4.11.

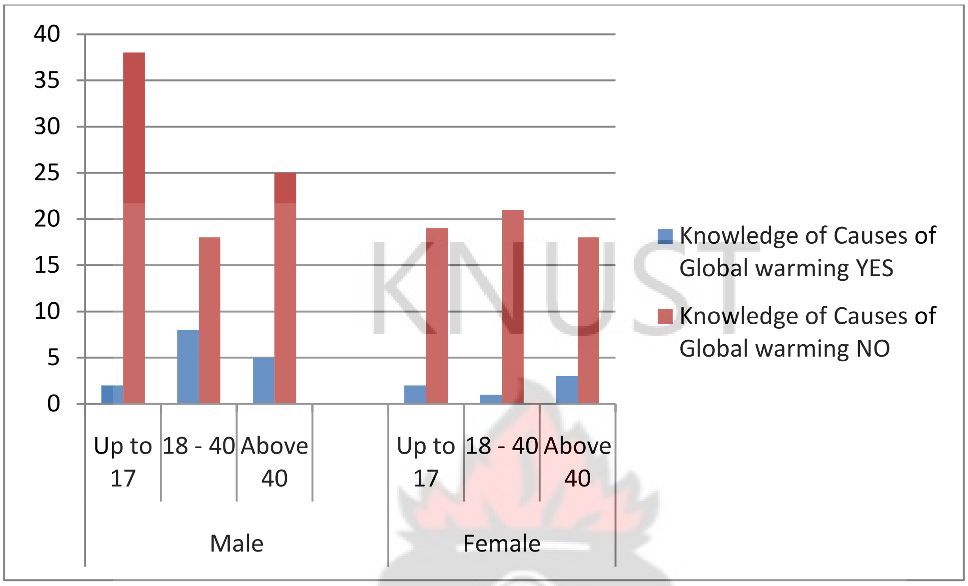

Figure 4.11 Number of respondents knowledgeable on the causes of global warming

4.2.6 Cost of energy

A plot of the respondent's perception of the type of energy which is expensive in Table 4.5 yielded the following results.

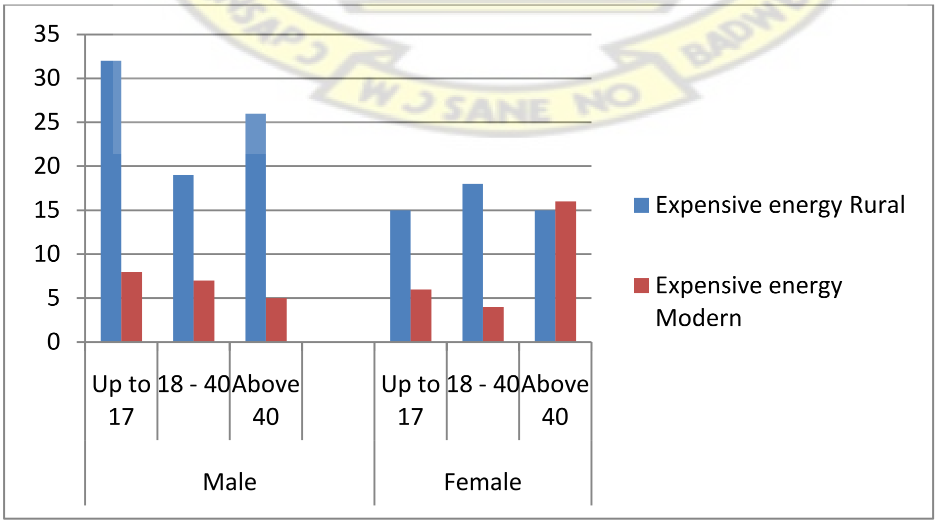

Figure 4.12 Cost of rural and modern energy as received from respondents

4.3 DISCUSSIONS

4.3.1 Lighting

From the data collected under lighting, answers recorded per the type of lighting employed before the implementation of the REP gave a mean of 26.67, a median of 24.00 and a standard deviation of 7.42. The minimum and maximum values recorded were 21 and 40 respectively. The data set was normally distributed. The p value recorded was 0.125 which is greater than the threshold of 0.05. The confidence level of the p value indicated that the unfriendly source of light (Figure 4.1) was uniformly adopted by the population.

Figure 4. 13 Unfriendly lighting systems such as oil lamps (left) and lanterns (right); Image source: http://www.insidehousing.co.uk/need-to-know/case-studies/shedding-some-light/6524417.article

The data recorded after the implementation of the renewable energy project was however not normally distributed. The p value recorded was 0.007 which shows that perhaps the unfriendly lights were being eliminated. The data set had a mean of 13.83, a median of 11.0 and a standard deviation of 6.65. The maximum and minimum value recorded was 27 and 9 respectively. The null hypothesis that energy poverty leads to the use of unfriendly sources of light gave a value of W=53 (greater than the threshold value of 39) confirmed that energy poverty leads to the use of unfriendly lights uniformly.

4.3.2 Chargeable items (Electrical Storage devices)

From the data collected under ownership of charging devices, the results show a mean of 2, a median of 1.5 and a standard deviation of 1.789. The minimum and maximum values recorded were 9 and 5 respectively. The data set was normally distributed. The p value recorded is 0.513 which is greater than the threshold of 0.05. The confidence level of the p value indicates that the population has no charging items due to the non-availability of services to re-charge them when their inbuilt battery loses its power.

The data recorded after the implementation of the renewable energy project was normally distributed. The p value recorded was 0.307 which explains why the implementation of renewable energy project has led to the acquisition of more charging devices. Perhaps, the facility to be used to re-charge them is now available. The data set had a mean of 20, a median of 19 and a standard deviation of 7.77. The maximum and minimum values recorded were 33 and 9 respectively. The null hypothesis that energy poverty leads to the non-acquisition of charging items gave a p value of 1.0 (greater than the threshold of 0.05) confirming that energy poverty does not lead to the acquisition of charging devices.

4.3.3 Food preservation

From the data collected, the results for the use of biomass and tripod food stove before the implementation of renewable energy project was normally distributed with a p value of 0.085. This implies that these methods were uniformly used across the population divide because the wood fuels (biomass) were readily available. A mean of 38.2, a median of 39.5 and a standard deviation of 26.5 were recorded as the descriptive statistics. The minimum and maximum values recorded were 7 and 65 respectively.

Figure 4.14 Biomass adopted in food preservation and cooking

The data recorded after the implementation of the renewable energy project was not normally distributed. The p value recorded is 0.016 which shows that the implementation of renewable energy project is phasing out the use of rural food preservation but not in a quick manner as evident in the descriptive statistics. The data set had a mean of 35.3, a median of 36.5 and a standard deviation of 26.0. The maximum and minimum values recorded were 59 and 8 respectively. The null hypothesis that energy poverty leads to the use of rural food preservation was confirmed with a W value of 43.5 greater than the threshold of 39.

4.3.4 Knowledge about modern energy cooking options, global warming and cost of energy

Majority of the age groups (up to 17 years; 18 years to 40 years and above 40 years) were not aware of modern energy cooking options. It was also evident from Figure 4.11 that more than 70% of each age category had no knowledge about the causes of global warming and its effects on the environment. It can be deduced that because the respondents had readily access to biomass or wood fuels, they see this energy source as cheaper than investing in energy efficient wood stoves and food preservation equipment.

On the other hand, all the age groups with the exception of the female age group above 40 years were of the opinion that rural energy was more expensive than modern energy. The marital status of these respondents was not ascertained by the research questionnaire. This would have been beneficial to identify whether the respondents in this category were single or married to draw a conclusion. It would have established whether the respondents in this category purchased the wood fuels themselves or were provided for by their dependants.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

In considering the problem of qualitative count as evidenced by the results and analysis of data the following matters arise:

First, the data obtained from lighting, ownership of charging items and food preservation methods indicate that the implementation of the renewable energy project has led to the reduction in energy poverty when considering their means which dropped from 26.67 to 13.83. Indeed, the postulation by Demurger and Fournier (2011) that households switch from biomass to other modern energy forms as income increases due to the implementation of a renewable energy project is confirmed by this study.

The benefits of these are numerous. The use of unfriendly lighting systems (Figure 4.13) are declining as evidenced by the increase of modern energy options such as the use of rechargeable lamps which can be easily recharged using readily available electricity. The associated impacts of the use of these lights which cause inflammation of the airways and lungs and impair the immune system (WHO, 2006) are being reduced as well due to the implementation of a Renewable Energy Project.

Secondly, though the acquisition of modern food preservation was evident, the data gathered showed little impact. The means recorded in this category reduced from 38.2 to 35.3. It was obvious from Figure 4.10 that the respondents were in the known of modern cooking options yet ownership was not highly evident in the data acquired. Biomass is still being adopted in cooking which adds up to the 2 million tonnes of biomass going up in smoke every day (IEA, 2011; WHO, 2006).

Interestingly, it was established that the respondents consider modern form of energy cheaper as compared to the rural energy (Figure 4.12). More than 70% responded in the affirmative. This reinforces the observation made by Pachauri and Spring (2011) that the rural energy is more expensive as compared to modern energy.

Finally, it was observed from the data that the respondents are less knowledgeable in matters relating to climate change (Figure 4.10) and its effects. Education on the causes and effects of climate change could lead to a paradigm shift in the use of modern energy methods in food preservation and cooking to save the forests which acts as carbon sinks for CO_2, the catalyst for climate change.

5.1 Study Limitations

The research was constrained by the limitations below:

- The lack of prior research on the research problem and the length of the study influenced access to many respondents even after the snowball approach was used for the sampling of respondents. The Renewable Energy Project which was recently implemented as well as the Case Study Community (Bui Village) also recently resettled played a big role in the lack of prior research.

- Due to the large number of potential participants in the study population, the respondents involved in the current study focussed only on members located within the Bui Village.
- To ensure manageability of collected data, survey used only multiple-choice items and did not include open-ended response items.
- Due to the low literacy level of the respondents, results might not accurately reflect the opinions of all members of the included population. This is because differences could be encountered between respondent's answers with respect to structured interview and self-completed questionnaires by literates.

5.2 Future Work

This research could serve as a pilot study to lay the groundwork for more complete research in the future. The future work should take note of the following:

- The structuring of the questionnaires based on the literacy level of the respondents.
- Sampling should encompass all the resettled community as well as cultural issues to allow for the generalization of the study. Structured methods of sampling such as the stratified approach can also be considered to allow for the division of the entire target population into subgroups of strata to highlight specific subgroups such as marital status, ethnicity and other demographic data.

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APPENDIX

QUESTIONNAIRE (Tick as many as appropriate)

BEFORE RESETTLEMENT

<u>Demographic data</u>

1. Gender Male/Female
2. Age……………………….
3. Education level

a. Not educated b. Middle School c. Tertiary

4. What was used to provide light
   a. Lantern b. Oil lamps c. Other …
5. Did you owe any chargeable item YES/NO
6. If yes which chargeable means was employed?

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7. What means was food was food preserved?

a. Salting b. Drying c. Smoking d. Other

8. What was used for cooking?
   a. Coal Pot b. Kerosene Stove
   b. c. Tripod wood stove
9. Did you owe any entertainment gadgets
   YES/NO
10. What was used to power the entertainment gadgets a. Dry Cell Batteries b. Solar panels c. Generators
11. Have you heard about global warming
    YES/NO
12. If YES where did you hear about it?

a. TV b. Radio c. Friend d. Other

13. If Q. 12 is YES, what do u know about global warming?

AFTER RESETTLEMENT

4*. What is used to provide light?
a. Electricity b. Lantern c. Oil lamps d. Other

5*. Do you owe any chargeable item?
YES/NO

6*. If yes which chargeable means is employed?

7*. What is the means for food preservation?
a. Salting b. Drying c. Refrigerator d. Smoking e. Other …………

8*. What is used for cooking?
a. Morden biomass stove b. Coal Pot c. Kerosene Stove d. Tripod wood stove d. Electric stove

9*. Do you owe any entertainment gadget?

YES/NO

10*. What is used to power the entertainment gadgets a. Dry Cell Batteries b. Solar panels c. Generators e. Electricity

11*. Which is expensive, Modern energy (electricity) or rural energy?

…………………………………………………………………