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A study on how Ghana can develop and implement a strategy for renewable energy in the perspective of the United Nations' Sustainable Development Goals and the Paris Climate Agreement.

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Globalization
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PROJECT DESCRIPTION

The purpose of the study is to do a combined study of Ghana regarding renewable energy resources and capacity in order to develop a strategy for energy production (and consumption).

RESEARCH OBJECTIVES:

•To explore renewable energy sources in Ghana.

•To find out the capacity of Ghana in the production and consumption of renewable energy.

•To explore strategies for the implementation of renewable energy in Ghana.

•To know how these strategies are implemented in the perspective of the United Nation's Sustainable Development Goals and the Paris Climate Agreement.

•To assess the constraints to investments in renewable energy generation.

RESEARCH QUESTIONS:

•What are the sources of renewable energy in Ghana?

•What capacity does Ghana have in the production and consumption of renewable energy?

•What are the strategies for the implementation of renewable energy in Ghana?

•How are these strategies implemented in the perspective of the United Nation's Sustainable Development Goals and the Paris Climate Agreement?

•What are the constraints to investment in renewable energy generation?

PREFACE

This thesis is the final result of the MSc in Globalisation, Politics and Culture program at the Norwegian University of Science and Technology, and is supervised by and produced for the Department of Industrial Economics and Technology Management during the spring 2016.

The journey that led to this moment began in August 2015 when I started my academic internship (as part of my program) with SINTEF Teknologi og Samfunn in Trondheim, Norway. The internship offered me a great opportunity to develop my professional skills. During the internship period, I also had the privilege to participate in the 5^{th} EnergyTech 2015 Conference under the theme "Sustaining Our Energy Future" at the Wolstein Center Cleveland State University in the United States of America. All these useful experiences propelled me to write my internship report in collaboration with Marcela Reggiani (fellow intern at SINTEF) on "Hydropower Development in the Global South" under the supervision of Gunnar Lamvik and Markus Steen. It alsoinformed the choice of my master thesis topic.

I would like to express my profound gratitude to John Eilif Hermansen, Associate Professor at IØT, NTNU, for his supervision and unflinching support. Special thanks also go to Michael Agyekum, Kwabena Otu-Danquah, Dorothy A.Y Adjei, Kennedy Amankwa, Richard Arthur, David Ato Quansah, Albert Boateng, and Johnny Andoh-Arthur for their valuable contributions to the study. To the wonderful people at Betel International Church (Trondheim), I say thank you.

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ABSTRACT

Ghana is far from having a sustainable and independent energy system. The current energy mix in the country is: traditional biomass (66.7%); crude oil/petroleum products (26.2%); and electricity (7.1%) is mainly from high hydro plants. The present energy insecurity dilemma where demand for energy is sufficiently needed for sustainable development leaves Ghana with no option than to exploit her renewable energy resources and increase electricity supply. The study seeks to address five main research questions: (a) What are the sources of renewable energy in Ghana? (b) What capacity does Ghana have in the production and consumption of renewable energy? (c) What are the strategies for the implementation of renewable energy in Ghana? (d) How are these strategies implemented in the perspective of the United Nation's Sustainable Development Goals and the Paris Climate Agreement? (e) What are the constraints to investment in renewable energy generation?

The four main Renewable Energy resources identified in Ghana are solar, biomass, hydro energy and wind energy. Detailed analysis for each resource was done. The study concludes with a plan on where, why, and how to implement renewable energy strategies in the perspective of the UN SDGs and the Paris Climate Agreement. The study therefore recommends that there should be a creation of regulatory framework that is RE friendly and promoting awareness of the benefits of RETs.

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LIST OF ABBREVIATIONS

ACGF	Africa Catalytic Growth Fund
AfDB	African Development Bank
BHP	Bui Hydroelectric Project
BST	Bulk Supply Tariff
CAP	Country Action Plan
CBOs	Community-based Organizations
CEPA	Centre for Economic Policy Analysis
CIA	Central Intelligence Agency
Das	District Assemblies
DPs	Development Partners
DSC	Distribution Service Charge
EC	Energy Commission
ECG	Electricity Company of Ghana
EPA	Environmental Protection Agency
EUT	End User Tariff
FiT	Feed-in-tariff
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GEDAP	Ghana Energy Development and Access Project
GEF	Global Environment Facility
GGC	Ghana Gas Company
GHG	Green House Gases
GIDA	Ghana Irrigation Development Authority
GPRS	Ghana Poverty Reduction Strategy
GRIDCO	Grid Development Company
GSA	Ghana Standards Authority
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
HDI	Human Development Index
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
KITE	Kumasi Institute of Technology and Environment
KPMG	Klynveld Peat Marwick Goerdeler
KVIP	Kumasi Ventilated Improved Pit Latrine
LPG	Liquefied Petroleum Gas
MAAF	MDG Acceleration Framework
MDGs	Millennium Development Goals
MEST	Ministry of Environment, Science and Technology
MMDAs	Metropolitan, Municipal and District Assemblies

MOEn	Ministry of Energy
MRP	Mineral Reserve Plant
MWh/year	Megawatts hour per year
NAMAs	Nationally Appropriate Mitigation Actions
NBSSI	National Board for Small Scale Industries
NCCAS	National Climate Change Adaptation Strategy
NCCP	National Climate Change Policy
NEDCO	Northern Electricity Company
NES	National Electrification Scheme
NFAG	National Fishermen Association of Ghana
NPA	National Petroleum Authority
PAP	Project Affected Persons
PUE	Productive Uses of Energy
PURC	Public Utility Regulation Commission
PV	Photovoltaic
RE	Renewable Energy
REA	Rural Electrification Agency
REF	Rural Electrification Fund
RETs	Renewable Energy Technologies
SDGs	Sustainable Development Goals
SE4ALL	Sustainable Energy For All
SEAAF	Sustainable Energy for All Acceleration Frameworks
SECO	Swiss Agency for Economic Affairs
SHEP	Self-Help Electrification Project
SMEs	Small and Medium Enterprises
SWHs	Solar Water Heaters
SWPs	Solar Water Pumps
TAPCO	Takoradi Power Company
TICO	Takoradi International Company
TTPP	Tema Thermal Power Plant
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
VALCO	Volta Aluminium Company
VRA	Volta River Authority

1. INTRODUCTION

Predominant environmental issues linked to the use of energy resources in Ghana are; deforestation which is occurring at the rate of 22,000 hectares or 2.1% per annum (Hagan, 1994); desertification and land degradation (soil erosion). These coupled with existing energy insecurity dilemma, where demand for energy services are desperately needed for survival and sustainable development, leaves Ghana with no other option than to exploit utilization of its renewable energy resources. However, most of the modern renewable energy (RE) projects established over the years in Ghana are not viable and many have already collapsed. Certain RE projects are in existence only because of continual donor and external support, which in itself is not sustainable and these projects will collapse as soon as external funding ceases. This study seeks to find answers to the following questions: what are the sources of Renewable Energy; where, why, what and how to implement RE technologies/projects in Ghana, and also what are the challenges to the development of RE in Ghana. The study is to bridge up the knowledge gap and to develop trends for potential renewable energy projects, as well as on how Ghana can develop and implement a strategy for renewable energy in the perspective of the United Nation's Sustainable Development Goals and the Paris Climate Agreement.

1.1 BACKGROUND TO THE STUDY

Over the years there have been countless discussions on the issue of energy. Effective and sustained access to energy plays a significant role in improving people's living conditions, and contributes to economic and human development. Energy provides services to meet many basic human needs, particularly heat, mechanical power (e.g. water pumps and transport) and light. Business, industry, commerce and public services such as modern healthcare, education and communication are also highly dependent on access to energy services (Apergis et al., 2010).

Indeed, there is a direct relationship between the absence of adequate energy services and many poverty indicators such as infant mortality, illiteracy, life expectancy and total fertility rate. Inadequate access to energy also exacerbates rapid urbanization in developing countries, by driving people to seek better living conditions (Schipper and Meyer, 1992).

Despite this, 1.3 billion people lack access to electricity and 2.7 billion people rely on traditional biomass for cooking and heating (IEA, 2011). With more than one-third of a household's budget being set aside for fuel costs in many countries in Sub-Saharan Africa, the region's population pays an onerous price for fuel (mainly biomass) that is of poor quality and not very effective.

The International Energy Agency has forecast that use of traditional biomass will decrease in many countries, but it is likely to increase in South Asia and sub-Saharan Africa alongside population growth. Overall, the IEA forecasts that by 2030, the total number of people reliant on biomass will not have changed significantly. While the use of traditional energy sources is not necessarily undesirable in itself, concerns have been raised over how they are currently being used.

Modern energy sources, such as electricity and petroleum-based fuels, generally provide only a small part of the energy use of poor rural people. This is mainly because they are too expensive and because it is difficult to achieve regular supplies to isolated rural communities. The predominance of traditional fuels for cooking however takes a heavy toll on the environment through desertification and soil erosion, and the absence of modern fuels propels the poverty spiral further downward(Energy Commission, 2012).

In recognition of the critical need to improve global access to sustainable, affordable and environmentally sound energy services and resources, the United Nations General Assembly declared 2012 the International Year of Sustainable Energy for All (SE4ALL) and urged member states and the UN system to increase the awareness of the importance of addressing energy issues and to promote action at the local, national, regional and international levels. In response, the UN Secretary General launched a global Initiative to achieve "Sustainable Energy for All by the year 2030". The key objectives of this initiative are: (1) ensuring universal access to modern energy services; (2) doubling the rate of improvements in energy efficiency; and (3) doubling the share of renewable energy in the global energy mix (Energy Commission, 2012).

Ghana has mainstreamed the MDGs into the country's successive medium-term national development policy framework, Ghana Vision 2020: The First Step (1996-2000); the First Medium-Term Plan (1997- 2000), the Ghana Poverty Reduction Strategy (GPRS I), 2003 – 2005, the Growth and Poverty Reduction Strategy (GPRS II), 2006–2009, and currently the Ghana Shared Growth and Development Agenda (GSGDA), 2010-2013. In addition to direct poverty reduction expenditures, government expenditure outlays have also been directed at policies and program to stimulate growth, which have high potential to support wealth creation and sustainable poverty reduction (Energy Commission, 2012).

The First Medium-Term Development Plan (1997-2000) based on Vision 2020 focused on the following priority areas: Human Development, Economic Growth, Rural Development, Urban Development, Infrastructure Development, and an Enabling Environment. GPRS I sought to restore macroeconomic stability and reduce the incidence of poverty by focusing on the following themes: Production and Gainful Employment, Human Resource Development and Basic Services, Special Programs for the Poor and Vulnerable, and Governance. Across these themes, five areas were selected for priority action: Infrastructure, Rural Development based on Modernized Agriculture, Enhanced Social Services, Good Governance, and Private Sector Development (Energy Commission, 2012).

The GPRS II placed emphasis on growth as the basis for sustained poverty reduction "so that Ghana can achieve middle-income status within a measurable planning period". Its thematic areas were: Continued Macroeconomic Stability, Private Sector Competitiveness, Human Resource Development, and Good Governance and Civic Responsibility (National Development Planning Commission, 2010).

The Government of Ghana through its current medium-term national development policy framework, the Ghana Shared Growth and Development Agenda (GSGDA), 2010-2013, sought to maintain macro-economic stability and generate higher levels of shared growth in order or to reduce socio-economic inequalities, ensure rapid reduction in poverty and accelerate the achievement of the Millennium Development Goals.

Employment and improved standards of living, especially for the marginalized are therefore a major priority outcome expected from the implementation of national and sector development policies, including energy policy (National Development Planning Commission, 2010).

The GSGDA is anchored on the following themes:

1. Ensuring and sustaining macroeconomic stability;
2. Enhanced competitiveness of Ghana's private sector;
3. Accelerated agricultural modernization and natural resource management;
4. Oil and gas development;
5. Infrastructure, energy and human settlements development;
6. Human development, employment and productivity; and
7. Transparent and Accountable Governance.

The major thematic areas that relate most directly to energy access are: i) accelerated agricultural modernization and natural resource management; ii) oil and gas development; and infrastructure, energy and human settlements development. The key areas of policy focus in the medium to long-term for the oil and gas sub-sector are: employment creation; protecting the environment; revenue management and transparency; diversification of the economy; capacity development; and increasing access to petroleum products. Under infrastructure, energy and human settlements development, the key areas of policy focus for the medium-term are: transport infrastructure; energy and energy supply to support industries and households; science, technology and innovation; information and communication technology development; human settlements development; recreational infrastructure; and water, environmental sanitation and hygiene (National Development Planning Commission, 2010).

There have also been concerns raised on the use of energy from traditional sources as these release greenhouse gases such as carbon that contributes to global warming. Aside the environmental harm caused by the use of traditional sources of energy, they are also limited in supply because we use them much more rapidly than they are being created. Due to these limitations of traditional sources of energy, renewable energy has become suitable, efficient and much safer for use. Renewable energy uses energy sources that are constantly replaced by nature. These sources include plants, the wind, the earth's heat and water. The use of renewable energy has also become convenient due to concerns about sustainability. Renewable energy has been considered to a large extent as the driver of sustainable development (Apergis et al., 2010a).

Renewable energies will inevitably dominate the world's energy supply system in the long run. The reason is both very simple and imperative: there is no alternative. Mankind cannot base its life on the consumption of finite energy resources indefinitely. Today, the world's energy supply is largely based on fossil fuels. These sources of energy will not last forever and have proven to be one of the main causes of our environmental problems. Environmental impacts of energy use are not new but they are increasingly well known. As links between energy use and global environmental problems such as climate change are widely acknowledged, reliance on renewable energy is not only possible, desirable and necessary, it is an imperative. The earth receives solar energy as radiation from the sun, in a quantity far exceeding mankind's use. By heating the planet, the sun generates wind. Wind creates waves as observed by (United States Environmental Protection Agency, 2014).

The sun also powers the evapo-transpiration cycle, which allows generation of power by water in hydro schemes – currently the largest source of renewable electricity in use today. Plants photosynthesize, which is essentially a chemical storage of solar energy, creating a wide range of so-called biomass products ranging from wood fuel to rapeseed, which can be used for the production of heat, electricity and liquid fuels (United States Environmental Protection Agency, 2014). Interactions between the sun and the moon produce tidal flows that can be intercepted and used to produce electricity. Renewable energy sources are based on the natural and interconnected flows of energy of our planet earth.

Though humans have been tapping into most renewable energy sources (wood, solar, wind, geothermal and water) for thousands of years for their needs, so far only a tiny fraction of the technical and economic potential of renewable energy has been captured and exploited. Yet, with existing and proven technologies, renewable energies offer safe, reliable, clean, local and increasingly cost-effective alternatives for all our energy needs (Hamm, 2014).

The Renewable Energy Sector has become a driving force for a sustainable economy in the 21st century. Investments in renewable energy and energy efficiency will lead the way out of the economic crisis that Europe and the world at large are facing today (Hamm, 2014).

Confronted not only with an economic crisis but also with the challenge posed by climate change, as well as increasing import dependency and rising fossil fuel prices, it is a matter of urgency that we come up with a solution now and for future generations on how to conserve economic and social livelihoods and maintain a balanced ecological system. By promoting renewable energy technologies, we are able to tackle both the security of energy supply and climate change, while at the same time creating a future-oriented sustainable economy (FriederikeAdra, 2014).

1.2.1 Research Issue

The talk on renewable energy and sustainable development has in mind the production of energy which will not compromise the safety of the environment and also energy future generation can fall on. The urgency to ensure a sustained safe environment has led to several conferences that have led to agreements between countries to have obligations to protect the environment. One of such agreements of focus to this study is the Paris Climate Agreement, dubbed Paris COP21. This was birthed out of a conference held in Paris where 190 countries adopted the first legally binding global climate deal to limit global warming (AMPCAPITAL, 2016).

At the moment, both governments and private organizations are taking steps to combat the challenges that come along with using non-renewable which pose threat to the environment. Research has gone into ways energy can be generated through renewable sources. It is in this regard that Ghana’s Energy Commission has been given the mandate, to ensure effective development and efficient use of local energy sources in the country. Ghana is blessed with inexhaustible energy sources that range from the wind, biomass to hydro. It is for this reason that this thesis seeks to study how Ghana can develop and implement a strategy for renewable energy in the perspective of the United Nation’s Sustainable Goals and the Paris Climate Agreement.

1.2.2 Purpose of the Study

The study intends to achieve the over-arching aim of the study by examining the following specific objectives:

1. To explore renewable energy sources in Ghana.
2. To find out the capacity of Ghana in the production and consumption of renewable energy.
3. To explore strategies for the implementation of renewable energy in Ghana.
4. To know how these strategies are implemented in the perspective of the UN SDGs and the Paris Climate Agreement.
5. To assess the constraints to investments in renewable energy generation.

1.2.3 Research Questions

The research questions this study seeks to answer are:

1. What are the sources of renewable energy in Ghana?
2. What capacity does Ghana have in the production and consumption of renewable energy?
3. What are the strategies for the implementation of renewable energy in Ghana?
4. How are these strategies implemented in the perspective of the UN SDGs and the Paris Climate Agreement?
5. What are the constraints to investment in renewable energy generation?

1.2.4 Contributions of the study

The study will seek to contribute to the;

- Development of an energy policy that directly links decentralized RE projects to already existing economic activity at the grassroots level. In the short term, this helps in improving economic status of the community which subsequently results in ability to pay back for the renewable energy project investment and running cost in the longer term.
- Development of knowledge on RETs research and development in Ghana.

- Assisting stakeholders such as rural communities, NGOs, investors, Government, Local RET vendors etc. by boosting investor confidence in RETs.

1.2.5 Structure of the Study

Chapter 1 lays out the introduction and background to the study as well as the research objectives. Chapter 2 provides an overview of the research methodological approaches utilized in the study. Chapter 3 focuses on the theoretical framework exploring essential concepts and theoretical resources related to the research questions such as Sustainable Development, Sustainable Energy access, Green Economy and Strategy. Chapter 4 does a literature review examining available well known renewable energy policies and instruments utilized in other parts of the world. It also analyses RE measures employed in Ghana for identification of gaps. An outline of the energy situation in Ghana is captured in Chapter 5. Analysis of interviews and documents is laid out in Chapter 6. The results of the analysis regarding the research questions are discussed and recommendations are offered in Chapter 7. Finally, a short conclusion, presentation of the findings and suggestions for further research are given in Chapter 8.

2. METHODOLOGY

As presented in the introduction, the study is about how Ghana can develop and implement a strategy for renewable energy in the perspective of the UN Sustainable Development Goals and the Paris Climate Agreement. The aim of this chapter is to provide the framework for the methodology adopted for the research.

2.1 METHODS

Methods are the collection of research strategies and techniques to form a particular approach to data and mode of analysis.

2.1.1 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.

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.

2.1.2 Research paradigm

Five paradigms are available and present 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 23 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 study. 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.

2.1.3 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. Within this context, both structured and unstructured interviews, as well as consultation of documents remain a good choice in the research technique.

2.1.4 Sampling strategy

The sampling strategies available are the simple random, cluster, snowball, systematic, stratified, and 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 nth 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).

2.1.5 Research family

The two broad research families available are:

1. Quantitative or Qualitative
2. 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, qualitative analysis was adopted for the research.

2.1.6 Research approach

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

2.1.7 Research Concept

From the framework of the research methodology, structured interview with the snowball approach was adopted by employing the research concept.

2.2 LITERATURE COLLECTION

To develop a strong theoretical background, several of these materials were utilized, which enabled the researcher to select those that I considered most suitable for this thesis. The books and articles were found using the search engines on the internet.

2.2.1 Sources of Information

Review of national studies and reports related to renewable energy projects, their evaluation, reasons for success and failures and lessons learnt.

2.3 COLLECTION OF DATA

The qualitative approach is used for this study and it involves the assessment of existing RE policies and resources, evaluation of projects and barrier analysis on each of the identified RET.

The study started with significant amounts of desk study to compile a full inventory of all types of renewable energy interventions in Ghana. Those interventions that target the poor or rural dwellers were particularly of interest. Field surveys and site visits were undertaken for data collection on the projects, to interview beneficiaries and more importantly, to verify at first hand, the authenticity in the reports that were utilized.

Almost every research work inevitably faces some basic limitations and this study is no exception. Time frame for the completion of this research was a major limiting factor which affected the conduct of a comprehensive research. Lack of readily organized data was a limiting factor, however, within the constraints; all attempts were made to undertake a valid comprehensive study.

Additionally, since I had to collect some of the relevant data and information in Ghana from here via various social media such as Skype, emails, and yahoo messenger, among others, it was quite challenging arranging for meetings due to unfavorable or poor access to internet.

2.3.1 Documents and Sampling

Based on the review of the national analysis and experiences, I selected a number of relevant RETs in the country for consideration and detailed analysis. Selection criteria include:

- Adequate resource base for the RET (hydro, solar, biomass, etc);
- Environmental impacts and job creation;
- Available technologies and their costs;

- Socio-economic impacts , including job creation;

2.3.2 Interviews

I conducted interviews with relevant stakeholders to obtain specific information on current status of RETs (technical and commercial issues), adequacies of policies and plans, financial, legal mechanisms and other barriers. Experts, practitioners, relevant governmental institutions/ ministries including rural agencies were consulted. Some of these interviews were carried out via electronic mails, telephone conversations and Skype.

2.4 DATA ANALYSIS

Analysis of interviews and documents serve as a useful source of information on the research issue. The responses received from the interviews and documents were analyzed.

2.5 ETHICAL ISSUES

Ethics include the concern, dilemmas and conflicts that arise over the proper way to conduct research. Ethic help to define what is or is not legitimate to do, or what 'moral' research procedure involves (Newman, 2007).

Participants' consent were sought before they were interviewed and this was after explanations on the nature and purpose of the study have been given. Confidentiality and anonymity were maintained during the research.

2.6 RELIABILITY AND VALIDITY

Validity: Research design is often divided into three broad categories, according to "the amount of control the research maintains over the conduct of the research study". These three broad categories namely: "Experimental, field and observational research. They vary on two important characteristics: Internal and External validity. The External research concerns the overall validity of the research study (Watt & Van Den Berg, 1995, p.186-194). In an Experimental research, the researcher controls the setting in which the research is been conducted and may influence the variable(s), while observing the changes or no change in the variables. Thus, due to the ability to control and eliminate certain variables and conditions that may have a profound effect on the outcomes of the research, would likely improve the validity of the research.

In a field research, the researcher retains control over the independent variable(s), but conducts the research in a natural setting without any control over environmental influences. On the other hand, in an observational research, the researcher can neither control the variable(s), or the research setting. This kind of research usually takes place sometime after the actual process being researched (Watt & Van Den Berg, 2002).

Internal Validity describes or accounts for all factors, including those, which are not directly specified in the theory being tested, but might affect the outcome of the study. In other words, it usually concerns the soundness of the research being carried out. External validity conclusions cover the specific environment in which the research study is conducted to similar real world situations (Watt & Den Berg, 2002). In this case, a study which has a generalized conclusion could be more valuable than one whose conclusions cannot be applied outside the research environment.

The research for this thesis could be considered as a field research as it is carried out among people who happen to constitute the future work force and whose responses I cannot influence in any significant manner. Furthermore, to ensure both internal and external validity believes to have used the most accurate and up-to-date literature. The right and relevant questions asked in the survey, the most feasible data collection method used, and the tools used to analyze the data are also considered to be accurate and produce valid results; the overall validity of this thesis is considered to be high. However I would argue that the internal validity of this thesis is relatively high, but the same cannot be said for its external validity.

Reliability: The aim of any study I believe is to use a given procedure and reach a conclusion that will be applicable in any given environment. The primary objective should be that if a later investigation followed exactly the same procedures as described by an earlier investigator and conducted the same study all over again; this later investigator should be able to arrive at the same results and conclusions. Thus, the study is considered to be highly reliable. However, due to the very nature of human beings 100% reliability cannot be considered for this study, as individual perceptions are central in this study. In other words, because we are different as individuals and that our individual wants and preferences are different, future investigations may not produce exactly the same results as reported in this thesis. Nonetheless, I believe that the results of this study could be regarded as highly reliable.

3. THEORETICAL FRAMEWORK

The most relevant theoretical resources and the theoretical framework for the analysis of the research issue are presented in this chapter. The theoretical concepts discussed include sustainable development, sustainable energy access, green economy, strategy as well as definition of terms.

3.1 SUSTAINABLE DEVELOPMENT

Sustainable development can be broadly defined as living, producing and consuming in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs. It has become a key guiding principle for policy in the 21st century. Worldwide, politicians, industrialists, environmentalists, economists and theologians affirm that the principle must be applied at international, national and local level. Actually applying it in practice and in detail is of course much harder! In the international context, the word ‘development’ refers to improvement in quality of life, and, especially, standard of living in the less developed countries of the world. The aim of sustainable development is for the improvement to be achieved whilst maintaining the ecological processes on which life depends. At a local level, progressive businesses aim to report a positive *triple bottom line*, i.e. a positive contribution to the *economic, social and environmental* well-being of the community in which they operate (UN, 2015).

The concept of sustainable development became widely accepted following the seminal report of the World Commission on Environment and Development (1987). The commission was set up by the United Nations because the scale and unevenness of economic development and population growth were, and still are, placing unprecedented pressures on our planet’s lands, waters and other natural resources. Some of these pressures are severe enough to threaten the very survival of some regional populations and, in the longer term, to lead to global catastrophes. Changes in lifestyle, especially regarding production and consumption, will eventually be forced on populations by ecological and economic pressures. Nevertheless, the economic and social pain of such changes can be eased by foresight, planning and political (i.e. community) will (IRENA 2012).

Energy resources exemplify these issues. Reliable energy supply is essential in all economies for lighting, heating, communications, computers, industrial equipment, transport, etc. Purchases of energy account for 5-10% of Gross National Product in developed economies. However, in some developing countries, energy imports may have cost over half the value of total sustainable development. World energy use increased more than tenfold over the 20th century, predominantly from fossil fuels (i.e. coal, oil and gas) and with the addition of electricity from nuclear power. In the 21stcentury, further increases in world energy consumption can be expected, much for rising industrialization and demand in previously less developed countries, aggravated by gross inefficiencies in all countries. Whatever the energy source, there is an overriding need for efficient generation and use of energy (UNCSD, 2012).

Fossil fuels are not being newly formed at any significant rate, and thus present stocks are ultimately finite. The location and the amount of such stocks depend on the latest surveys. Clearly the dominant fossil fuel type by mass is coal, with oil and gas much less. The reserve lifetime of a resource may be defined as the known accessible amount divided by the rate of present use. By this definition, the lifetime of oil and gas resources is usually only a few decades; whereas lifetime for coal is a few centuries. Economics predicts that as the lifetime of a fuel reserve shortens, so the fuel price increases; consequently demand for that fuel reduces and previously more expensive sources and alternatives enter the market. This process tends to make the original source last longer than an immediate calculation indicates.

In practice, many other factors are involved, especially governmental policy and international relations. Nevertheless, the basic geological fact remains: fossil fuel reserves are limited and so the present patterns of energy consumption and growth are not sustainable in the longer term.

Moreover, it is the emissions from fossil fuel use (and indeed nuclear power) that increasingly determine the fundamental limitations. Increasing concentration of CO_2 in the atmosphere is such an example. Indeed, from an ecological understanding of our Earth's long-term history over billions of years, carbon was in excess in the Atmosphere originally and needed to be sequestered below ground to provide our present oxygen-rich atmosphere.

Therefore from the arguments of: (i) the finite nature of fossil and nuclear fuel materials, (ii) the harm of emissions and (iii) ecological sustainability, it is essential to expand renewable energy supplies and to use energy more efficiently. Such conclusions are supported in economics if the full external costs of both obtaining the fuels and paying for the damage from emissions are internalized in the price. Such fundamental analyses may conclude that renewable energy and the efficient use of energy are cheaper for society than the traditional use of fossil and nuclear fuels (IPCC, 2012).

The detrimental environmental effects of burning the fossil fuels likewise imply that current patterns of use are unsustainable in the longer term. In particular, CO_2 emissions from the combustion of fossil fuels have significantly raised the concentration of CO_2 in the Atmosphere. The balance of scientific opinion is that if this continues, it will enhance the greenhouse effect and lead to significant climate change within a century or less, which could have major adverse impact on food production, water supply and human, e.g. through floods and cyclones. Recognizing that this is a global problem, which no single country can avert on its own, over 150 national governments signed the UN Framework Convention on Climate Change, which set up a framework for concerted action on the issue. Sadly, concrete action is slow, not least because of the reluctance of governments in industrialized countries to disturb the lifestyle of their voters. However, potential climate change, and related sustainability issues, is now established as one of the major drivers of energy policy (IPCC, 2012).

In short, renewable energy supplies are much more compatible with sustainable development than are fossil and nuclear fuels, in regard to both resource limitations and environmental impacts.

Consequently almost all national energy plans include four vital factors for improving or maintaining social benefit from energy:

1. increased harnessing of renewable supplies
2. increased efficiency of supply and end-use

3. reduction in pollution
4. Consideration of lifestyle.

3.2 SUSTAINABLE ENERGY ACCESS

Over the next ten years, countries in sub-Saharan Africa are expected to increase their share of energy generation and utilization to meet economic growth. Despite the existence of enormous energy sources in this region, electrification rates remain low. Rural electrification rates of around 15% and national rates in the 30–40% range have become one of the most restrictive bottlenecks to development. In addition, population growth is exceeding connection rates in most countries, which does not augur well for raising electrification rates (Haanyika, 2006).

Given current conditions and financial constraints, energy planning in Sub-Saharan Africa should center on self-sufficient and environmentally sound energy policies that take full advantage of the impact of investment and support economic growth (Weisser, 2004). Strategies that lower electrification costs, particularly household connection costs, are crucial to the economic future of the region.

In spite of the widespread unanimity that, the provision of affordable, reliable, and socially conventional energy services are prerequisites for achieving the Millennium Development Goals and inadequate access to energy services continues to be a major challenge to sustainable development (Brew Hammond et al, 2009).

The global energy sector faces a number of challenges including lack of access to the electric grid at reasonable prices, volatile oil price markets, high initial cost of renewable energy technologies, a general lack of cognizance of the scale of renewable energy resources, increased greenhouse gas emissions, etc. (IEA, 2002; Sawin; UNDP,2004). Although most of the challenges facing developing countries are comparable to those in the industrialized countries (Sawin, 2004), delicate economies, growing population, low investments and poor energy infrastructure, among others, compounds the challenges of developing countries.

Ghana‘s energy sector policy objectives of ensuring reliable, adequate and cost-effective supply of high quality energy services for households, industries, agriculture and transport are consistent with the outlined prerequisites for achieving the MDGs (EC, 2004). Ghana has also subscribed to the energy access targets of the Economic Community of West African States (ECOWAS) White Paper for a regional policy geared towards increasing access to energy services.

3.3 GREEN ECONOMY

The concept of green economy has many definitions and is used differently in a range of contexts. Green economy works as a tool enabling us to achieve sustainable development and economic growth (UNCSD, 2012; World Bank, 2012).
The concept was one of the main themes of the Rio+20 conference in 2012, leading to an increased global interest and surge of research and articles aiming at defining and explaining green economy (UN Sustainable Development Knowledge Platform, 2015a).

3.3.1 Renewable Energy Sources and Sustainability

Renewable energy sources replenish themselves naturally without being depleted in the earth; they include bioenergy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy.

Tester (2005) defines sustainable energy as, “a dynamic harmony between the equitable availability of energy-intensive goods and services to all people and preservation of the earth for future generations”.

The world’s growing energy need, alongside increasing population led to the continual use of fossil fuel-based energy sources (coal, oil and gas) which became problematic by creating several challenges such as: depletion of fossil fuel reserves, greenhouse gas emissions and other environmental concerns, geopolitical and military conflicts, and the continual fuel price fluctuations. These problems will create unsustainable situations which will eventually result in potentially irreversible threat to human societies (UNFCCC, 2015). Notwithstanding, renewable energy sources are the most outstanding alternative and the only solution to the growing challenges (Tiwari & Mishra, 2011). In

2012, renewable energy sources supplied 22% of the total world energy generation (U.S. Energy Information Administration, 2012) which was not possible a decade ago.

Reliable energy supply is essential in all economies for heating, lighting, industrial equipment, transport, etc. (International Energy Agency, 2014). Renewable energy supplies reduce the emission of greenhouse gases significantly if replaced with fossil fuels. Since renewable energy supplies are obtained naturally from ongoing flows of energy in our surroundings, it should be sustainable. For renewable energy to be sustainable, it must be limitless and provide non-harmful delivery of environmental goods and services. For instance, a sustainable biofuel should not increase the net CO_2emissions, should not unfavorably affect food security, nor threaten biodiversity (Twidell & Weir, 2015). Is that really what is happening today? I guess not.

In spite of the outstanding advantages of renewable energy sources, certain shortcoming exists such as: the discontinuity of generation due to seasonal variations as most renewable energy resources is climate-dependent, that is why its exploitation requires complex design, planning and control optimization methods. Fortunately, the continuous technological advances in computer hardware and software are permitting scientific researchers to handle these optimization difficulties using computational resources applicable to the renewable and sustainable energy field (Baños et al., 2011).

3.3.2 What climate change is Ghana experiencing?

Ghana is already experiencing an increase in extreme weather conditions, with higher incidences and longer periods of flooding and drought. Temperatures have warmed by 1°C over the past 30 years. Ghana has a warm and comparatively dry south east coast, is hot and humid to the south west and hot and dry in the north. From a 20 year observed data, temperatures in all zones are rising, whereas rainfall has been reducing and becoming increasingly erratic. The seasonal distribution of rainfall is particularly important for the maintenance of the ecology and current agricultural production (UNDP, 2011).

3.3.3What will be the expected future change?

The Government notes that Ghana‘s climate is already unpredictable and the country can expect more intense weather events, such as torrential rains, excessive heat and severe dry winds as a result of climate change. Temperatures in Ghana are already high with a mean annual temperature above 24°C. Average figures range between 24°C and 30°C although temperatures ranging from 18 – 40°C are more common. There will be warming for all regions, particularly the three Northern regions with increases of between 2.1-2.4°C by 2050. This falls to 1.7-2°C for the Central regions and to 1.3 to 1.6°C for the southern regions (UNDP, 2011). The forecast for precipitation gives a cyclical pattern over 2010-2050 for all regions, with high rainfall levels followed by drought every decade or so. Changes in runoff and stream flows will increase the risk of floods and/or droughts in both rural and urban areas. Since most of the changes in river levels will result from climate change in upstream areas outside the territory of Ghana, the government has identified the need for increased regional dialogue in the management of shared water resources (ibid).

3.3.4 Paris Climate Change Agreement

Presently, the term "climate change" is of great interest to the world at large, scientific as well as political discussions. Climate has been changing since the beginning of creation, but what is alarming is the speed of change in recent years and it may be one of the threats facing the earth. The growth rate of carbon dioxide has increased over the past 36 years (1979–2014) (Asumadu-Sarkodie&Owusu, 2016c, 2016f), "averaging about 1.4 pm per year before 1995 and 2.0 pm per year thereafter" (Earth System Research Laboratory, 2015). The United Nations Framework Convention on Climate Change defines climate change as being attributed directly or indirectly to human activities that alters the composition of the global atmosphere and which in turn exhibits variability in natural climate observed over comparable time periods (Fräss-Ehrfeld, 2009).

For more than a decade, the objective of keeping global warming below 2°C has been a key focus of international climate debate (Asumadu-Sarkodie, Rufangura, Jayaweera, &Owusu, 2015; Rogelj, McCollum, Reisinger, Meinshausen, &Riahi, 2013). Since

1850, the global use of fossil fuels has increased to dominate energy supply, leading to a rapid growth in carbon dioxide emissions. Data by the end of 2010 confirmed that consumption of fossil fuels accounted for the majority of global anthropogenic greenhouse gas (GHG) emissions, where concentrations had increased to over 390 ppm (39%) above preindustrial levels (Edenhofer et al., 2011).

More than 190 countries agreed to commitments that are expected to limit global warming to somewhere between 2.7-3.5 degrees Celsius (°C). This is above the 2°C target set at Copenhagen, but countries have also agreed to regularly review their emissions reductions with the objective of limiting temperature to below 2°C. Countries agreed that greenhouse gas emissions should peak as soon as possible and achieve a balance between sources and sinks of greenhouse gases in the second half of this century.

Perhaps the biggest surprise of the Paris talks was the acceptance of a call from smaller nations, most vulnerable to climate change, to declare that warming should be halted at 1.5^{o}C and recognizing that this would significantly reduce the risks and impacts of climate change.

Table 1: Some key elements of the Paris Agreement

Area	Status / Goal	Comment
Nature of the Agreement	Legally binding International agreement Under the Vienna Convention	No legally binding targets are included, as this would have prevented the US from adopting the agreement. All countries are , however, obliged to have INDC but there are no sanctions for failing to meet goals
Differentiation	Parties will act according to their common but differentiated responsibilities and respective capabilities (CBDR-RC).in the light of different national circumstances	The CBDR-RC principle was enshrined in the united nations framework convention on climate changes (UNFCCC) to account for historical responsibility and asymmetric capacity to act. Developed countries should continue taking the lead via economic -wide absolute emission reduction commitments
Mitigation & ambition	Limit temperature increases to well below 2^{0c} aspiring to 1.5^{oc}.	The 1.5^{o} C goal has been a historic demand by small island developing state. Among others that are threatened by sea-level rise
	Emissions will peak as soon as possible and decline thereafter	Developing countries emissions will take longer to reach their peak emissions.
	Balance between GHG emissions and removal by sinks should occur in the second half of the century. This is a legal binding element of the agreement.	A quantified emission reduction target to 2050 failed to make it to the agreement .The decision on balance of emissions opens the door to the use of carbon capture and storage (CCS) but technical, environmental and economic issues are still to be resolved.
	Parties will submit their INDC every five years	Ambition has to increase in each INDC submission. Ratcheting up of ambition can occur at any time. Submissions should be made nine to 12 months in advance of COP to allow for adequate analysis of contributions.
	Parties should enhance sinks, including forest.	The inclusion of article 5 on forests in the agreement has been a welcomed development as almost a quarter of emissions come from agriculture. Forestry and other land use (AFOLU)
Progress	A global stock take will take place every five years, starting in 2023. A facilitative dialogue will occur in 2018 to analyze progress toward the long-term goal.	The global stocktaking will help parties update and enhance (i.e. ratchet up) their INDCS.
Finance	US 100 billion per annum from 2020 to 2025. A new goal will be set prior to 2025 with a floor of US 100 billion.	Developed countries must provide finance. Developing can provide finance. Less developed countries demanded intermediate finance goals that were not included in the final version of the Paris agreement. Work on different modalities for accounting for financial resources will be presented at COP24 IN 2018.

ITMOS	Cooperation among countries is fostered by the creation of internationally transferred Mitigation Outcomes.	The ITMOS are voluntary instruments that have to be authorized by parties. Double counting is to be avoided and a net mitigation impact is to be pursed.
Adaptation	Future works entails developing methods to recognize adaptation efforts by developing countries.	Significant advances in the area were achieved after first week of negotiations. The green climate fund will disburse funds for developing countries to produce their adaptation plans.
Loss and damages	The work of the Warsaw international mechanism on loss and damage will continue.	No liability can be claimed. Developed countries can assist developing countries by providing technical assistance among others.
Transparency	Periodic assessments and reviews will take place.	Parties will be subject to a common transparency framework, although agreeing on third-party oversight (a US demand) was opposed by India and China,
Capacity building	The Paris committee on capacity-building was established with a work plan for 2016-2020.	Significant advances in this area were achieved after the first week of the negotiations.
Technology development and transfer	A technology framework will analyze technology needs. Implementation and action plans, inter alia. The goal is to accelerate innovation.	Significant advances in this area were achieved after the first week of negotiations. Financial support will be provided for developing countries, especially for technologies in early stages of development.

Sources: Draft decision /CP 21. The Paris agreement , New Climate Institute (2015)

3.4 STRATEGY

This part deals with policies and strategies for RE promotion, the main actors of Ghana's energy sector as well as the regulatory framework.

3.4.1 Policies and Strategies for Renewable Energy Promotion

The Government's objective is to create an enabling environment for private investments in renewable energy (RE) projects. Distinction is made between the 'Regulated Market" which allows private parties to initiate and develop RE projects as Independent Power Producers and utility-led project development. The most active utility in this field is VRA. Government of Ghana has stated that it wants to achieve 10% renewable energy in the generation mix by 2020. RE legislation in Ghana is ruled by the Energy Commission Act of 1997, the Public Utilities Regulatory Commission Act and Renewable Energy Act. The Renewable Energy Division of the Energy Commission is responsible for developing policies and strategies, including the

Renewable Energy Act that covers all RE technologies including wind, solar, hydro, waste-to-energy and biomass.

3.4.2 Main Actors

Apart from the utilities, the main actors are the Ministry of Energy, which oversees the National Gas Company and the National Petroleum Company. These institutions deal predominantly with energy from non-renewable resources like oil and gas. In addition, Regulatory Agencies are important for renewable energy:

- The Public Utilities Regulatory Commission (PURC) was established to regulate and oversee the provision of utility services by the public sector to consumers and related matters. It has the mandate to set tariffs for consumers and producers (Feed-in Tariffs for delivery of electricity to the grid) and to balance the interests of producers and consumers alike.
- The Energy Commission (EC) was established to regulate and administrate the utilization of energy resources in Ghana. EC is responsible, inter alia, for the involvement of the private sector and to prepare and update national energy plans. The EC is the final statutory body required to issue licenses for RE business in Ghana.
- Other regulatory institutions involved in the RE industry are the Environmental Protection Agency (EPA) and the Ghana Standards Board, which respectively issue environmental permits and certification for equipment for importation and distribution in Ghana. Specific ventures such as municipal waste-to-energy, however, also require approval from the local regulatory bodies such as the Accra Metropolitan Authority and Kumasi Metropolitan Authority mandated to supervise waste management.

3.4.3 The Regulatory Framework

Specific incentives are available for investments in the RE sector:

- Exemption from import duty on RE equipment development of codes and standards for solar, wind and bio- energy systems
- Regulations and procedures exist to ensure that all RE service providers are provided with licenses/permits and Power Purchase Agreements

- Clear Feed-in Tariffs (FITs) for energy generated by renewable sources and Independent Power Producers have been published recently.

3.5 DEFINITIONS

Renewable energies are defined according to USEIA (2004), as:

- "Naturally, but flow-limited resources that can be replenished. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Some (such as geothermal and biomass) may be stock-limited in that stocks are depleted by use, but on a time scale of decades, or perhaps centuries, they can probably be replenished;"

Solar radiation is radiant energy emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy. The spectrum of solar radiation is close to that of a black body with a temperature of about 5800 K. About half of the radiation is in the visible short-wave part of the electromagnetic spectrum.

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as *global warming(America's Climate Choices: Panel on Advancing the Science of Climate Change; National Research Council, 2010).*

A **policy** is a deliberate system of principles to guide decisions and achieve rational outcomes. A policy is a statement of intent, and is implemented as a procedure or protocol. Policies are generally adopted by the Board of or senior governance body within an organization whereas procedures or protocols would be developed and adopted by senior executive officers (Nakamura, 1987).

4. LITERATURE REVIEW

This chapter reviews the major trends in renewable energy development over the past two decades, with emphasis on the past five years. It begins with an overview of sustainable development followed by developments in renewable energy investment in recent years, and past cost trends and future expected reductions. The final section provides an overview of various projections for future market development and renewable energy deployment.

4.1 OVERVIEW OF GHANA'S ENERGY SECTOR

Ghana is relatively well endowed with a variety of energy resources including biomass, hydrocarbons, hydropower, solar and wind. It also has the capacity to produce modern bio-fuels. In terms of primary energy consumption in 2011, 6,138 ktoe (54.2%) was from woodfuels, 3,767 ktoe (33.3%) from oil, 772 ktoe (6.8%) from natural gas, and 650 ktoe (5.7%) from hydro. The total energy consumption was 11,327 ktoe, which is equivalent to 0.47 ktoe per capita (Energy Commission, 2012). The vision of the energy sector is to develop an "Energy Economy" to secure a reliable supply of high quality energy services for all sectors of the Ghanaian economy and also to become a major exporter of oil and power by 2012 and 2015 respectively (Energy Commission, 2010a).

4.1.1 Electricity

Electricity generation in Ghana is from two hydro power plants at Akosombo and Kpong and some thermal plants. As at the end of 2010, the installed capacity of hydro generation was 1,180 MW whilst the installed capacity thermal generation was 989.5 MW (see Table 2). The electricity generation from the hydro source was 6,995 GWh, and the generation from thermal sources was 3,171 GWh (see Table 3). The Volta River Authority (VRA), a publicly owned power utility is the owner and operator of the two hydro plants at Akosombo and Kpong. The transmission network is owned and operated by the Ghana Grid Company.

Table 2: Generation Capacity (End of December 2010)

Plant	Fuel type	Installed (MW)	Dependable (MW)
Hydro Generation			
Akosombo	Water	1,020	900
Kpong	Water	160	140
Sub- Total		1,180	1,040
Thermal Generation			
Takoradi Power Company (Tapco)	LCO/Diesel/Natural Gas	330	300
Takoradi International Company (TICO)	LCO/Diesel/Natural Gas	220	200
SunonAsogli Power (Ghana) Limited	Natural Gas	200	180
Tema Thermal 1 Power Plant (TT1PP)	LCO/Diesel/Natural Gas	110	100
Mines Reserve Plant (MRP)	Diesel/Natural Gas	80	40
Tema Thermal 2 Power Plant (TT1PP)	Diesel/Natural Gas	49.5	45
Sub-Total		989.5	865
Total		**2170**	**1905**

*LCO - light crude oil. Source: Energy Commission, 2011

Table 3: Electricity Generation by Plant (GWh)

Source	Plant	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Hydro	Akosombo	5,557	5,524	4,178	3,210	4,404	4,718	4,690	3,104	5,254	5,842	5,961
	Kpong	1,052	1,085	858	675	876	911	929	623	941	1,035	1,035
	Total	6,610	6,609	5,036	3,885	581	5,629	5,619	3,727	6,196	6,877	6,995
Thermal	TAPCO	345	740	874	1,328	536	831	1,416	1,521	874	453	1,234
	TICO	268	510	1,363	668	222	328	1,395	1,417	1,063	1,040	1,160
	TT1PP	NA	NA	NA	NA	NA	NA	NA	-	-	570	591
	TRPP	NA	NA	NA	NA	NA	NA	NA	162	85	-	-
	ERPP	NA	NA	NA	NA	NA	NA	NA	80	456	-	-
	KRPP	NA	NA	NA	NA	NA	NA	NA	33	16	-	-
	Mines Reserve Plant	NA	NA	NA	NA	NA	NA	NA	38	46	18	20
	TT2PP	NA	NA	NA	NA	NA	NA	NA	-	-	-	28
	SunonAsogli Plant	NA	NA	NA	NA	NA	NA	NA	-	-	-	138
	Total	613	1,251	2,237	1,997	758	1,159	2,810	3,251	2,128	2,081	3,172
	Grand Total	7,223	7,859	7,273	5,882	6,039	6,788	8,429	6,978	8,323	8,958	10,166

Source: Energy Commission, 2011

Distribution of electricity is undertaken by two distribution utilities – Electricity Company of Ghana (ECG) and Northern Electricity Distribution Company (NEDCo). The ECG is charged with the bulk purchase of electricity from VRA for distribution throughout the country to all categories of consumers, with the exception of Volta Aluminum Company (VALCO), the Akosombo Township, and the mines. In 1987, following the establishment of NED, ECG's distribution activities were restricted to the six southern regions, i.e., Ashanti, Greater Accra, Eastern, Western and Volta regions. NEDCo was established in 1987, originally as a subsidiary of VRA to take over from ECG the responsibility of procurement, distribution and sale of electricity in the northern sector of the country comprising BrongAhafo, Northern, Upper East and Upper

West Regions. The share of hydro generation in the total power generation has reduced over the years from 92% in 2000 to 69% in 2010. During the energy crisis in 2007 when the water level in the hydro dam fell below acceptable figures, the share of hydro generation dropped to 53%. Though the country has been importing some electricity over the years mainly from La Cote d'Ivoire, it has remained a net exporter (mainly to Togo and Benin) since 2008.

Table 4 presents the share of electricity supplied to the industrial, residential and non-residential sectors in 2000-2010. The share of electricity supplied to the industrial sector has decreased from 68% in 2000 to 46.6% in 2010 and indeed it was the sector most severely affected during the load shedding in 2003-4 and 2007. The country underwent a nationwide load shedding from 2002-2004 due to low inflows into the Volta reservoir which culminated into reduced generation (about one-third to half capacity less) from the nation's hydropower. However, the share of electricity supplied to the residential sector increased in from 24% to 39%, dropped in slightly in 2005-2006, continued increasing in 2007-2010. As at 2010 the share of electricity supplied to the residential sector was 40%.

Table 4: Grid Electricity supply, Share and Growth to the Demand Sectors

DEMAND SECTORS												
	Industry			Non Residential			Residential			Total	
YEAR	1000 GWh	% Share	% Gr	1000 GWh	% Share	% Gr	1000 GWh	% Share	% Gr	1000 GWh	% Gr
2000	4.31	68	0	0.55	8.5	0	1.49	24	0	6.34	0
2001	4.33	66.4	0.7	0.58	8.9	8	1.61	25	7.9	6.53	3
2002	3.9	63.2	-10	0.6	9.8	4	1.67	27	3.7	6.17	-5.4
2003	2.21	48.4	-43.5	0.62	13.6	3	1.73	38	3.4	4.55	-26.3
2004	2.03	46	-8	0.6	14.6	6.6	1.78	39	3.2	4.53	-0.5
2005	2.54	49.8	25.3	0.7	13.5	5.6	1.92	37	7.5	5.16	13.9
2006	3.59	55.2	41.4	0.79	12.1	13.3	2.13	33	11.2	6.51	26.3
2007	2.7	48.2	-25.2	0.8	14.4	1.5	2.1	37	-1.6	5.59	-14.1
2008	2.97	48.4	10.3	0.93	15.1	15.6	2.27	37	8.3	6.16	10.2
2009	2.94	47.2	-1.5	0.88	14.1	-5.4	2.41	39	6.1	6.23	1.1
2010	3.16	46.6	8.1	0.97	14.3	10	2.74	40	13.7	6.77	8.7
Average Growth			**-0.3**			**6.2**			**6.3**		**1.7**

Source: Energy Commission, 2011

After its establishment in 1997, the Public Utility Regulatory Commission (PURC) became responsible for setting electricity tariffs, in consultation with key stakeholders comprising the generators, distributors and representatives of major consumers. The PURC developed a transition plan to trigger a gradual adjustment to economic cost recovery by 2003. The automatic price adjustment formula of the Transition Plan was affected once in 2003 and twice in 2004, with the adjustment in 2004 affecting only the bulk supply tariff (BST) and the distribution service charge (DSC). The sum of the BST and the DSC is the end user tariff (EUT) charged by the distribution companies.

There are different tariffs for industrial, commercial (non-residential) and residential customers. The tariff for residential customers has a lifeline tariff for low consumption, which was set at 100 kWh per month maximum in 1989/90 but was downgraded to 50 kWh per month maximum by 2000. The Government of Ghana subsidizes the lifeline consumers, and they use electricity free of charge. The average tariff for residential customers is currently about 10 US cents per kWh. A survey in 2006 conducted by the Ghana Statistical Service (GSS, 2008) observed that on the average, 4.8% of household expenditure was on electricity, LPG and other fuels. It is estimated that about 60% of this expenditure (2.9%) would be directly for paying electricity bills.

4.1.2 Petroleum Fuels

LPG is produced by the nation's single oil refinery, the Tema Oil Refinery, together with other petroleum products such as gasoline and kerosene. LPG production levels have fluctuated over the years, ranging from 75,300 tonnes in 2005 to 31,600 tonnes in 2010. The shortfall in supply is compensated for through imports.

The consumption of LPG has been rising steadily from 45,000 tonnes in 2000 to 178,400 tonnes in 2010 (see Table 5). Gasoline, gas oil and other petroleum products also rose over the period. The consumption of kerosene however showed some fluctuations over the years.

Table 5: Consumption of LPG compared to other Petroleum Products (kilotonnes)

PRODUCT	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
LPG	45	42.5	50	56.7	65.7	70.5	88	93.3	117.6	220.6	178.4
Gasoline	524.4	535.1	570.2	479.8	575.6	70.5	511.9	554.2	545	701.4	737.8
Premix	30.6	27.0	26.8	28.9	27.5	537.8	33.7	41	50.7	55.1	32.4
Kerosene	67.6	70.5	74.8	68.8	73.3	31.4	76.5	63.3	34.6	89.3	49.3
ATK	96.9	76.4	90.5	89.8	107.4	74.3	114.7	122.8	119.2	124.7	108.4
Gas oil	665.8	685.4	717.8	755.3	848.9	119.3	934	1147	1092.1	1280	1271.9
RFO	57.1	52.0	51.9	45.7	45.4	880.4	56.8	51.3	47.1	40.3	30.9
Total	**1,487.4**	**1488.8**	**1,581.9**	**1524.9**	**1,743.5**	**1,761.5**	**1,815.6**	**2,062.9**	**2,007**	**2511.4**	**2,409.1**

Source: Energy Commission, 2010

A study on energy intensity in some sectors of Ghana's economy observed that the Industrial sector was the largest consumer of diesel fuel, followed by the services sector; the agricultural sector's share was negligible. The most common use of diesel fuel in industry varied from sub-sector to sub-sector. In general, the diesel fuel was used in operating excavators, forklifts and dump trucks and equipment of machinery for drilling, crushing, hoisting, loading and transfer to haulage trucks, as in the mining and construction sub-sectors. Gasoline was also predominantly used in the services sector, particularly in the transport and haulage sub-sector (CEPA, 2002).

Residual fuel oil was widely used in production processes of the manufacturing sub-sector of Industry. It was principally used for generating heat in equipment of machinery such as boilers and compressors mostly in the food processing, alcoholic beverages, textiles, iron and steel, and the non-ferrous metal industries. The bulk of woodfuels (charcoal and firewood) used in the non-household sectors was fuel for boilers of sawmills and in ovens in brick and tile and ceramic factories. Educational institutions and hospitals accounted for a smaller proportion of firewood consumption for cooking and food preparation purposes. Charcoal consumption, on the other hand, was mostly common in small-scale restaurants and eating places, but educational institutions also accounted for a relatively smaller proportion.

Kerosene was also limited in use across economic sectors other than in health and educational institutions. A fair amount of this fuel type was used in the non-ferrous metal industries and the manufacture of professional and scientific products – basically used in boilers, ovens, and furnaces, and also as a polishing detergent. In the manufacturing sub-sector of industry, the food processing and the printing and publishing sub-divisions were key LPG-consuming activities. The Volta Aluminium Company (VALCO) and the services sector closely trailed the manufacturing sub-sector, while the contribution of the agricultural sector was negligible. The health and educational institutions were among the key consumers of LPG within the services sector — the principal uses of gas were in ovens and stoves for cooking and food preparations. Within the mining and quarrying sub-sector of industry, considerable amounts of LPG was used in furnace treatment plants, particularly in gold and diamond production, for molding and cutting processes. Larger quantities still were used in furnaces and dryers as part of the production processes involving the smelting of aluminum and in metallurgical industries.

4.1.3 Woodfuels

The bulk of energy supply in Ghana is met from woodfuels, i.e. firewood and charcoal. Woodfuels account for over 70% of total primary energy supply and about 60% of the final energy demand. The supply of primary woodfuel in 2009 was estimated to be 20 million tonnes. The supply of firewood was estimated to be 9.2 million tonnes, whilst that of charcoal was estimated to be 2.2 million tonnes in 2009.

The bulk of woodfuels amounting to 90% is obtained directly from the natural forest. The remaining 10% is from wood waste i.e. logging and sawmill residue, and planted forests. The transition and savannah zones of Ghana, mainly the Kintampo, Nkoranza, Wenchi, Afram Plains, Damongo districts provide the bulk of dense wood resources for woodfuels. However, woodfuel resources are depleting at a faster rate as a result of unsustainable practices in the production and marketing of the product that incurs high levels of waste. According to the UN Food and Agriculture Organization (FAO), the rate of deforestation in Ghana is 3% per annum (FAO, 2002).

In 2000, the annual production or yield of wood was about 30 million tonnes of which about 18 million tonnes was available and accessible for woodfuels. Although the exploitation of wood resources for woodfuels is not the main cause of deforestation, there are indications that the preferred woodfuel species are gradually disappearing. The major charcoal production areas of Donkorkrom, Kintampo, Nkoranza, Wenchi, Damongo show physical signs of depleted woodfuel resources. As a result, producers have to travel longer distances in search of wood for charcoal production.

Charcoal and woodfuel are normally transported from the production centers (mainly in the rural areas) to the major cities and other urban centers where they are sold by wayside retailers to final consumers. A fraction of the charcoal produced is, however, exported to West African and European markets. The woodfuel industry is handled almost exclusively by private individuals with little regulation by the Government. The most recent regulatory measure introduced by the Energy Commission is the ban on the export of charcoal produced from unapproved sources, that is, sources other than sawmills residue or forest planted for that purpose. Thus, exporting charcoal produced from the direct wood sources, that is, wood harvested from the natural forest, is not allowed. Since July 2003, all exporters of charcoal are required to obtain a permit or license from the Energy Commission.

It is estimated that 20 million tonnes of woodfuels are consumed annually in the form of firewood or converted for use as charcoal. A majority of households (about 80%) in Ghana depend on woodfuels for cooking and water heating in addition to commercial, industrial and institutional use, and the demand for woodfuel has for the past years been on the increase. If this trend of consumption continues, Ghana is likely to consume more than 25 million tonnes of woodfuel by the year 2020. Most of the woodfuel supply will come from standing stocks i.e. 15 million tonnes from standing stock and the rest 10 million tonnes from regeneration or yield. This means that woodfuel supply will no longer come from regeneration but from standing stock. The implication is a direct depletion of standing stocks hence an increase in the rate of deforestation.

4.2 GHANA- COUNTRY PROFILE

Ghana covers an area of 239,000 sq km and has a population of 24.9 million with a fairly high yearly growth rate of 2.4% compared to 1.6% for other lower-middle income countries, but in line with the 2.5% average for Sub-Saharan Africa. The country has a varied and rich resource base made up of gold, timber, cocoa, diamond, bauxite, and manganese. In 2007, an oilfield likely containing up to 3 billion barrels of light oil was discovered, and production of oil at the offshore Jubilee field began in the middle part of December 2010 (Energy Commission, 2012).

In 2010, the economy experienced growth of 14.4% and the total value of goods and services produced amounted to US$35 billion. The services sector still remained the backbone of the economy, accounting for about 48.5% of goods and services that were produced in 2011, with industry following with 25.9%, and agriculture with 25. 6%. Industry achieved the highest in growth terms with 41.1%, with services following in second with a value of 8.3%. Agriculture had the lowest growth of 0.8%. Primary activities of mining and quarrying helped propel industry's growth with 206%. All the various sub-sectors under services recorded some substantial growth but agriculture performed woefully, with the exception of cocoa, which grew by 14% (ibid).

So the Ghanaian economy's steady growth over the last ten years is partly as a result of the high prices in primary commodities like cocoa, timber and gold and oil since 2011. The rate of growth of the economy of Ghana slowed down in 2012 reaching 8% compared to 15% in 2011. This situation continued, leading to 7.3% in 2013, a 5% growth in 2014 and an estimated 3.7% in 2015. As a way of countering this decreasing growth in the economy, the Ghana Government will have to speed up reforms, including measures to budget more realistically and expand its tax base by including the informal economy, which makes up a large share of economic activities, so as to increase revenues. Forecasts for the next 5 to 10 years are relatively positive; most likely the country will continue to grow as the main conditions underlying growth are likely to see improvement. That notwithstanding, the Government of Ghana needs to demonstrate its ability to deal with the country's energy crisis and rising inflation (Netherlands Enterprise Agency, 2015).

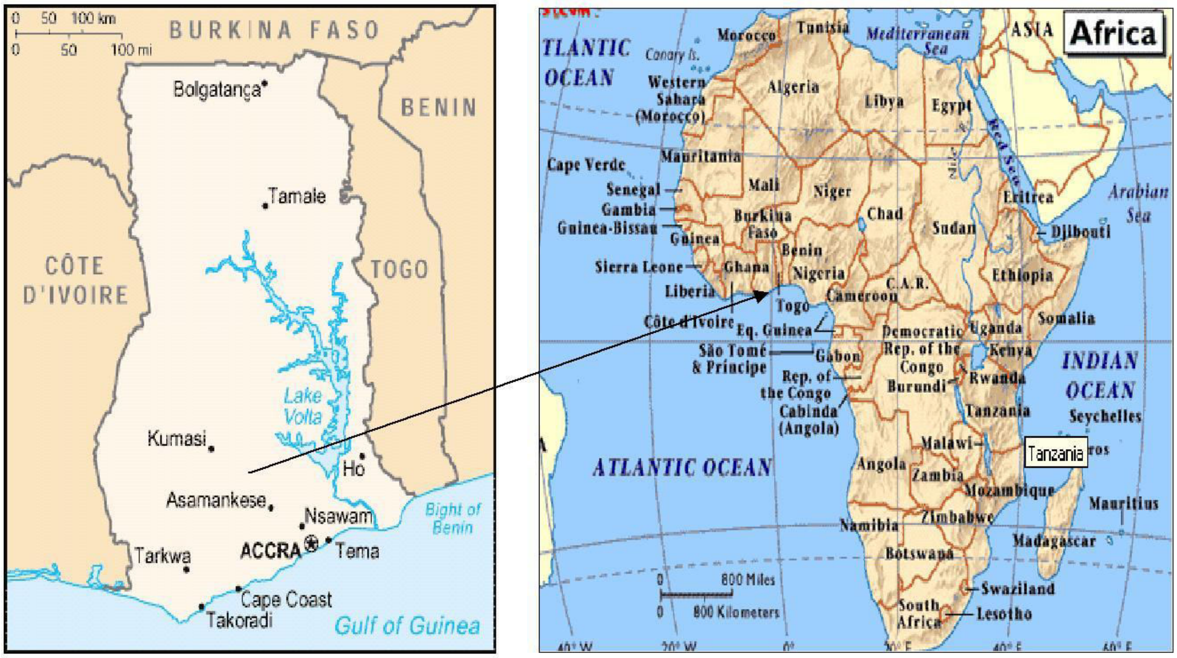


Figure 1: Geographical Map of Ghana

Source: Map of Ghana from Ghana's Official website, 2005

4.2.1 Energy resources available in Ghana

The energy resource potential of Ghana has not been extensively conducted, with present surveys of Ghana's natural energy resources showing that the country has immense, untapped wealth in this regard. The energy resources currently available to the country are wind, solar, natural gas, oil reserves and renewable energy. Other sources such as geothermal and nuclear have not been identified.

The readily available data (excluding biomass, hydro) (Table 6) obtained shows that wind potential of the country is class 3-7 estimated at 1,128 km2 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).

Table 6: Summary of available energy resources (excluding biomass and hydro)

Resource	Value	Units	Period
Wind Potential	1,128	Area(km²) 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)

4.2.2 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 neighboring countries (Volta River Authority, 2009).

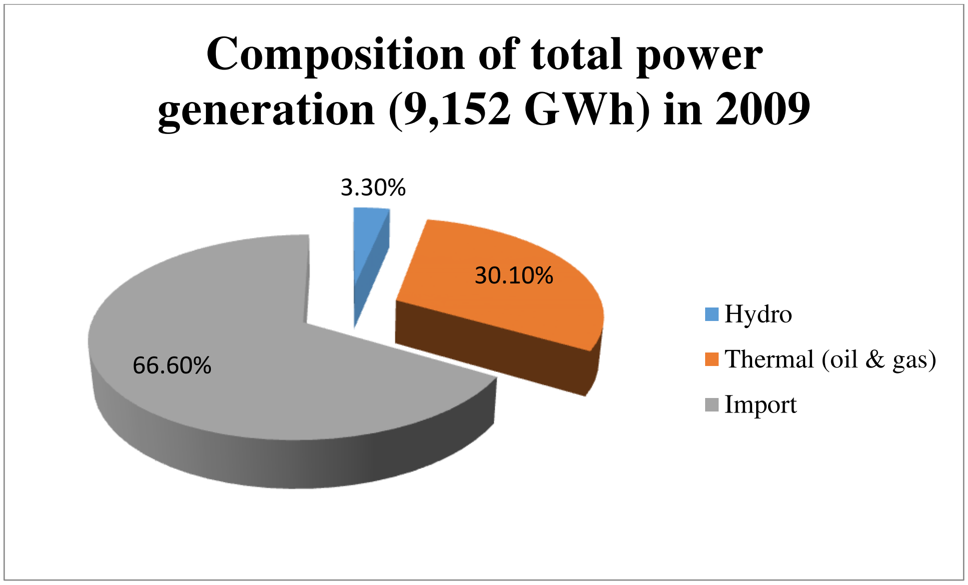


Figure 2: Composition of Ghana's total power mix in 2009
Source: (Volta River Authority, 2009)

4.2.3 Synthesis of energy resource availability and consumption

UNEP et al., (2013 pp 1-5) advises that 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, it will be the priority of the government to explore the cheap forms of energy to aid in its development and alleviate energy poverty.

4.2.4 Energy resources usage

Per the available energy resource, biomass continues 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.

4.3 TRENDS IN GHANA'S ENERGY SECTOR

Developments in the energy sector of Ghana with particular emphasis on energy at the household level, namely, electricity, LPG, kerosene, and renewable energy including woodfuels (firewood and charcoal) are considered in this section.

The African continent is endowed with abundant renewable energy resources (Deichimann, 2011; Bugaje, 2006) and Ghana is no exception. Ghana‘s renewable energy resources that have been extensively studied as potential sources for energy production and utilization are bioenergy (particularly, solid biomass and biogas), solar, wind and small hydro.

4.3.1 Policy framework for increasing energy access

This section talks about the increasing energy access and it embodies policies, plans and projects up to and after the year 2000.

4.3.2 Policies, Plans and Programs up to 2000

The first attempt to develop a modern legal framework for the energy industry in Ghana was in 1920, when the Electricity Supply Ordinance was passed (Botchway, 2000). The ordinance provided for private generation, regulation of diesel-based power and the inspection of generation activities by government officials. Under the Ordinance, the

Electricity Department was established as the state regulatory agency. However, due to lack of private sector involvement in the industry, it became the sole power utility responsible for the generation, transmission and distribution of power. Though the idea of the Volta River Scheme originated as far back as 1915 in the colonial era, it was the first Government of Ghana that initiated the Volta River Project and saw to its completion (Botchway, 2000).

An aspiring rural electrification program was embarked upon in 1972, which had the objective of increasing electricity access for the rural population. It was pursued within what is understood from some authors as a comprehensive rural development policy (ibid).

The NES was introduced in 1989/1990 in which the Government of Ghana committed the country to increase electricity access to all communities with population above 500 by the year 2020 (EC, 2004; 2005). The NES was planned to proceed in six 5-year phases over the period 1990 – 2020. The electrification of the several thousand villages in the country has been assumed to be by grid extension, with community participation under the Self-Help Electrification Program (SHEP). Challenges envisaged within this program include: low density of potential consumers of rural areas (especially in Northern Ghana); low income levels in rural communities; significant distances required for medium-voltage lines; the costs of medium and low-voltage; cost of transformers, and service drops. In the 1990s concerns arising out of the escalating consumption of woodfuels resulted in several bio-energy programs including the Improved Charcoal Cookstove Project, Improved Charcoal making Project, Biogas Project, and National LPG Promotion Program (ibid).

These programs and projects were inter alia aimed at reversing the rapid environmental and ecological damage, as evidenced by perceptibly high rates of deforestation and desertification as well as the worsening effects of global warming and other atmospheric pollutants from the inefficient production and use of wood fuel (Abakah, 1993). The immediate objective of the national policy on wood fuel production and utilization was to ensure sustainable production, marketing and consumption of wood fuels. A key recommendation of the policy was that government should support the promotion and development of sustainable management of the country's natural forests and woodlands for sustainable supply of wood including wood fuels (EC, 2006).

4.3.3 Policies, Plans and Programs after 2000

Between 2000 and 2005, government adopted a formal energy policy, which recognized the provision of adequate energy supply for meeting development objectives of poverty reduction and economic growth, emphasizing private sector participation to overcome funding constraints. The overall Government policy was aimed at facilitating a ―Golden Age of Business‖ and stressed on improved availability, accessibility and affordability with special focus on rural areas (NDPC, 2007). The Ghana Poverty Reduction Strategy (GPRS) documentation also emphasized reliable supply of high quality energy to boost industrial development and cost recovery pricing while protecting the poor, continuation of rural electrification, promotion of energy efficiency and renewable energy. The introduction of the GPRS brought new policy directions to expand the use of renewable energy in rural electrification programs in Ghana.

In 2006, the Strategic National Energy Plan (SNEP) was prepared by the Energy Commission. The SNEP took a complete look at the available energy resources of the country and how to tap them economically and in timely fashion to ensure a secured and adequate energy supply for sustainable economic growth up to 2020 (EC, 2006). The goal of SNEP was to contribute to the development of a sound energy market that would offer sufficient, feasible and efficient energy services for Ghana's economic development. This is to be achieved through the formulation of a comprehensive plan that would identify the optimal path for the development, utilization and efficient management of energy resources obtainable to the country. The SNEP identified key energy sources for long-term development and sustainability of electricity supply to include hydro-power, gas-powered thermal plant, renewables (such as wind, solar energy and biomass) and nuclear energy technologies.

Unfortunately, the SNEP was not adopted formally by the Government and one of the challenges for the energy sector today is how to redress this situation and make the SNEP a binding policy document.

4.4 SOURCES OF RENEWABLE ENERGY

Even though the earth continues evolving, the resources used by humans will eventually become scarce. Over decades, fossil fuels were and are still being used as the major energy source for households, industries and service providers. However, due to the limited amount of fossil fuels, energy is becoming more and more expensive, and the consequence of their consumption is having an impact on our environment and climate. The major impact is called the Greenhouse Gas Effect, which is in other words "gases that trap heat in the atmosphere" (United States Environmental Protection Agency, Greenhouse Gas Emissions report, 2014). The trapped heat does not leave the earth without severe consequences. Global warming is one of the terms often used to describe the reason for many natural catastrophes. One of the major consequences resulting from the greenhouse gas effect is called Climate Change which causes the melting down of major glaciers and the poles resulting in the rise of the sea level.

Due to the trapped heat, extreme weather conditions occur, such as droughts and floods. (British Geological Survey, Consequences of greenhouse-effect temperature rise). Due to the dangerous and life threatening factors, many countries are investing therefore in renewable energy, such as solar energy, windmills, hydropower or biomass energy. This shift to a "cleaner energy" should result in the reduction of greenhouse gases and therefore mitigating climate change.

Many countries are nowadays investing in renewable energy sources. There are several methods in order to gain heat and electricity. Germany increased the annual production of renewable energy from 7% (2000) to 24% (2013) of the national gross electricity production.

Germany was even able to turn off several nuclear power plants in the past years. (StatistischesBundesamtBruttostromerzeugung, 2013). This firstly brought in a lot of skeptical opinions and fears of power shortages due to the infrequent amount of renewable energy sources. Yet however, due to the high amount of energy created, Germany is even able to export its energy to other countries, proving many theories about energy shortages wrong. This mainly shows that when energy is being used and stored properly, using renewable energy can be highly efficient and to an advantage for producers, consumers and nature (Birkenstock, 2012). However, it is important to also mention that the need for sufficient infrastructure is a major steppingstone for the productive path of using renewable energy resources. Many developing countries lack the strong power net other countries have, and hence cannot distribute the energy to the households.

Renewable Energy Sources are usually referred to energy produced through sun, wind or water power. There are special ways in capturing the mentioned natural energy and transforming it into energy we can actually use at home.

4.4.1 Solar Energy

The widely used mechanism is the utilization of solar panels, by using the sun to generate electricity. A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring. Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light).

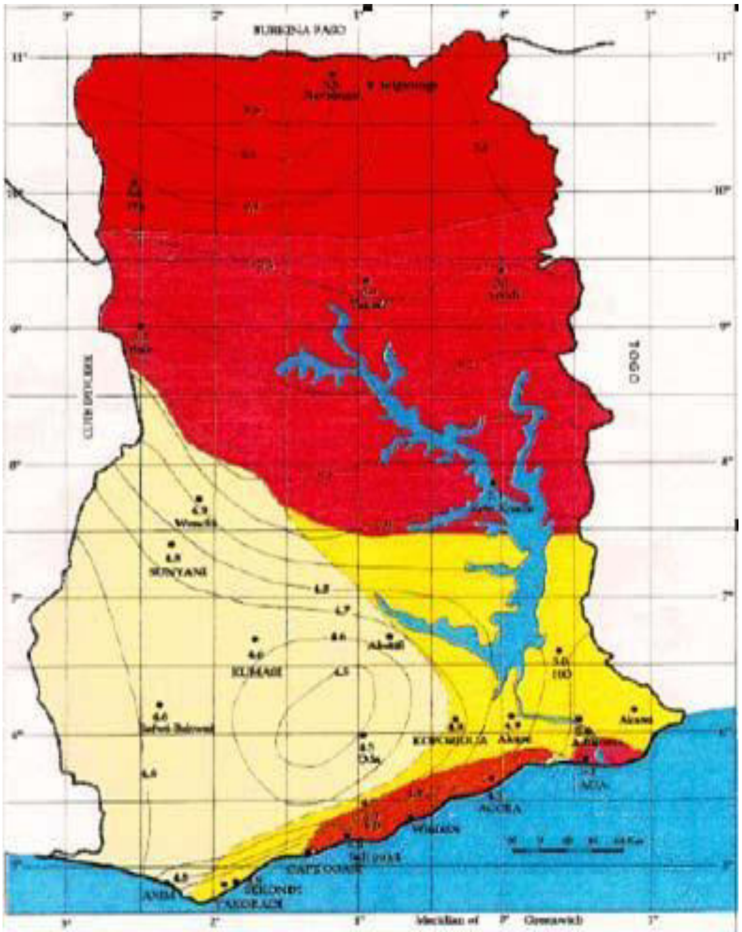
Hence much of the incident sunlight energy is wasted by solar modules, and they can give far higher efficiencies of illuminated with monochromatic light. Therefore, another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to those ranges. This has been projected to be capable of raising efficiency by 50% (Max – Planck – Institute in Germany).

Currently the best achieved sunlight conversion rate (solar module efficiency) is around 21.5% in new commercial products typically lower than the efficiencies of their cells in isolation.

Solar panels can be installed on roofs or on the ground. Additional trackers sense the direction of the sun and tilt the modules as needed for maximum exposure to the light. There are two main types of catching solar energy easily, one which absorbs the direct sunlight and transforms it into energy, and the other method is by using the sun’s heat as an energy source. The invention of affordable solar stoves has been used since few years in Madagascar. With Only 15€ for these stoves, households use the sunlight for cooking and are even able to store energy in a battery for later use (Hamm, 2014).

4.4.2 Solar Potential in Ghana

This section presents the potential of solar energy in Ghana. The solar radiation map is presented in Figure 3. The red part is the three northern regions, namely Northern region, Upper East and Upper West with the most solar energy potential followed by Greater Accra region with a lot of solar possibilities but not as compared to the three northern regions. The deep yellow and the light yellow represent the region with least solar energy possibilities (See Figure 3).



Very low Diffuse Radiation (32%)	Global (Total) Radiation (kWh/m^2/day)
Low Diffuse Radiation (36 -40 %)	Very Diffuse Radiation (45-48 %)
Moderate Diffuse Radiation (41-45 %)	Very High Diffuse Radiation (48-55 %)

Figure 3: Solar Resource Potential of Ghana
Source: Ministry of Energy, 2011

Table 7: Solar PV Installations in Ghana

Solar PV Systems	Installed Capacity, kW	Average Annual Production Growth
Rural home system	450	0.70-0.90
Urban Home system	20	0.05-0.06
School system	15	0.01-0.02
System for lighting health centres	16	0.01-0.10
Vaccine refrigeration	42	0.08-0.09
Water pumping	120	0.24-0.25
Telecommunication	100	0.10-0.20
Battery charging system	10	0.01-0.02
Grid-connected system	60	0.10-0.12
Solar streetlights	10	0.04-0.06
Total	**843**	**1.34-1.82**

Source: Energy Commission, 2011

Table 8: Advantages and Disadvantages of using Renewable Solar Energy

Advantages	Disadvantages
Resources (if well maintained) are infinite and will not extend regardless of the amount of consumption Climate friendly Profitable investment No toxic gas production Every area has access to sunlight even if not regularly No noise pollution	Expensive for household. Produces sufficient energy, but storage problematic (sometimes need for public energy supply). Cost of maintenance Weather dependent

Source: International Conference for Renewable Energies, (ICRE 2004)

4.4.2 Wind Energy

Countries rich in wind often refer back to the installation of windmills on wide and open fields. Around 90 countries are supporting the consumption of electricity through windmills since a few years, and more and more countries are following this new boom of eco-friendly technology (Renewable Energy Sources in Figures-National and International Development, 2013). Windmills can be also installed off shore, in areas using the sea and ocean wind for generating electricity. However, whether on-or-off shore, the windmills cannot be working properly when the amount of wind is either too low or too strong. Windmills are always installed in certain fields and areas, mostly far from cities and villages due to the noise pollution and the need for open fields with wind. Municipalities therefore obtain regional planning on fields away from farms and even protected areas, since windmills can become a threat to wild birds.

While fans use electricity to generate wind, the windmill does exactly the opposite. The blades of a windmill rotate once wind is present, which have a shaft connected to the generator to create electricity (Energy.gov. How do Wind Turbines Work?, 2014).

Table 9: Advantages and Disadvantages of using Renewable Wind Energy

Advantages	Disadvantages
Creates many job opportunities (e.g. installation, maintenance etc.) Climate friendly Low maintenance cost No air, ground or water pollution Reduces CO2 emission Can be installed off-shore and on land Resource is infinite	Expensive Storage of energy Difficult maintenance Infrastructure to transport energy Weather dependent Surrounding wild life may be disturbed Noise pollution in the installed areas Land disputes

Source: International Conference for Renewable Energies, (ICRE 2004)

4.4.3 Hydro Energy

Water energy can come in different forms and variations. One type of renewable energy source is the building of dams, as done at the Volta River (Fiagbe and Obeng, 2013). The first dam built in Ghana was the Akosombo Dam in 1965, followed by the Kpong Dam which was completed in 1982 and the newer Bui Dam which construction was completed in 2013 (Government of Ghana, 2014). While the Akosombo and Kpong Dams are purely hydroelectric dams, built in order to generate electricity through water power and strong flow, the Bui Dam has also other functions. Next to the generation of electricity, it also provides a certain protection from floods provides water for irrigation and improved the fishing industry as well. (http://www.watertechnology.net/projects/bui-dam-hydro-power-ghana/, accessed April 4, 2016). Dams transform the strong water flow through pipes into energy and provide electricity. But the strong stream can also be used in rivers by installing water wheels or the use of turbines in seas and oceans for the water current.

Even though the majority of dams are immense in size, their process to generate electricity is however simple. “The water in the reservoir is considered stored energy.

When the gates open, the water flowing through the penstock becomes kinetic energy because it’s in motion”. (Bonsor, 2014). The faster and stronger the flow of the water, the more energy is generated. There are also other ways to generate energy through water power. Wave energy, tidal energy and ocean thermal energy, however, need wide and open areas to get its full potential.

Wave energy, as the name already points out, is energy generated through the waves. The wave flows inside a chamber connected to the turbine, and causes the turbine to rotate, generating energy. It is however not a high amount of energy, therefore it is often used to light up a light house or for the warning buoy as observed by (Bellis, 2014).

Another type of energy is generated through tidal power. This works by tides being trapped behind a dam into a reservoir which can be let out again when the tide decreases.

Another option is the installation of turbines offshore in the sea. Countries, such as France or Norway, are using tidal energy. France generates energy through tidal power which provides approximately 240,000 households with energy (Bellis, 2014).

Another way to generate energy is through the temperature difference between the surface temperature and the temperature below the surface. There are many power plants around Japan and Hawaii who use the Ocean Thermal Energy Conversion in order to generate power.

Table 10: Advantages and Disadvantages of using Renewable Hydro Energy

Advantages	Disadvantages
Long term profit Climate friendly No water pollution No dangerous work place for labour Helps reduce greenhouse gas emission	Cost of building dams, Cost of equipment and machines. Equipment might change water flow. Structural change through installation of required infrastructure. Cost of maintenance. Flow/tide/wave dependent. Wildlife disturbed by turbines under water.

Source: International Conference for Renewable Energies, (ICRE 2004)

4.4.4 Biomass Energy

Biomass is the most common form of RE widely used in the third world countries and is Ghana's main energy resource in terms of endowment and consumption (IEA, 2014). Biomass resources cover about 20.8 million hectares of the 23.8 million ha land mass of Ghana, and is the source of supply of about 60% of the total energy used in the country (Energy Commission, 2004).

Biomass is ideally produced in rural areas and provides a sustainable alternative to grid electricity. This is because the resource is readily available in the rural areas of Ghana. In most rural Ghanaian homes, large quantities of biomass in the form of firewood and charcoal are used for domestic activities such as lighting, heating and cooking. In the urban centers, however, the type of biomass required is mostly determined by the energy conversion process and the form in which the energy is required, for instance, charcoal is used as a viable substitute to replace liquid petroleum gas for cooking, which in nut shell provides high-energy outputs, to replace conventional fossil fuel energy sources (Karekezi et al., 2003). In 2008, Ghana's biomass energy consumption was 11.7 million tonnes; and this was as a result of the fact that the economy depends heavily on climate sensitive sectors such as agriculture, forestry and hydropower. While petroleum products and electricity consumption were 2.01 million tonnes and 8059 GWh, respectively. In terms of total energy equivalents, biomass (woodfuel and charcoal) constituted 65.6%, with petroleum products and electricity accounting for 26.0% and 8.4%, respectively (Nketia, 2010).

The development and use of RE and waste-to-energy resources have the potential to ensure Ghana's energy security and mitigate the negative climate change impacts.

Even though biomass provides sustainable and substantial amount of energy, in the long-run it results in deforestation and damage the ecosystem. It is in this regard that, the Ghana biomass group and biomass UK Limited carried a comprehensive study in 2009 to identify other means of the generating biomass without necessarily cutting down trees (Union of Concerned Scientists, 2014).

Even though biomass provides sustainable and substantial amount of energy, in the long-run it results in deforestation and damage the ecosystem. It is in this regard that the Ghana biomass group and biomass UK Limited carried a comprehensive study in 2009 to identify other means of the generating biomass without necessarily cutting down trees (Union of Concerned Scientists, 2014).

Table 11: Advantages and Disadvantages of using Renewable Biomass Energy

Advantages	Disadvantages
Resources (if well maintained) are infinite and will not extend regardless of the amount of consumption. Low cost. Well utilized resource. Most plentiful resource. Can be used in different forms (liquid, solid or gas). 10 MW biomass power project can create approximately employment for 100 workers during the 18-month construction phase, 25 full-time workers employed in the operation of the facility, and 35 persons in the collection, processing, and transportation of biomass material. Not weather dependent. Reduction of landfill disposals.	Produces a small amount of CO_2 emission Increases the price for wheat and corn Land needed to produce biomass High cost of transportation Competition for land use

Source: International Conference for Renewable Energies (ICRE 2004)

Referring back to Ghana, it is obvious that the intention exists for using renewable resources, and that needed energy is available. Installing the tools for generating electricity for many households and companies through solar energy, wind, water, or biomass needs close observation however, on where to appropriately installing the panels, mills, turbines and power plants. (West, L. Top 7 Renewable Energy Sources, 2015 accessed on 5th April, 2016). Considering the high state of mismanagement and inefficient funds, it will probably be not easy to finance this eco-friendly technology and hence provide people with electricity. The installation of the renewable resource tools would not only cost a fortune for the object itself, but also the deployment. The first step of observing different areas for different types of potentials is already being conducted by the Ghana Energy Commission with support from the United Nations Environment Program (UNEP) for on-and off shore wind energy. (http://www.arrakisgroup.com/energy/renewable-energy-what-is-ghanas-wind-power-potential accessed on 5th March, 2016). After Ghana's Parliament passed the Renewable Energy Bill in November 2011, many people became enthusiastic about the future of

Ghana regarding electricity and the environment. According to the Solar and Wind Energy Resource Assessment, solar energy technologies to produce hot water throughout the year became very useful equipment in Ghana. "The Ministry of Energy estimates that over 6,000 solar systems have been installed in the country."

4.4.5 General Advantages and Disadvantages of Renewable Energy

Since the use of renewable energy is a rather new development, it carries the weight of critics and careful long term observation.

Many advantages and disadvantages have already been pointed out under each section of renewable energy resources discussed above. Below are few general advantages and disadvantages which are related to all the mentioned types of resources.

Table 12: General Advantages and Disadvantages of using Renewable Energy Technologies

Advantages	Disadvantages
No dangerous work places for workers anymore (such as coal mines, oil drilling stations etc…) Resources are infinite and will not finish regardless of the amount of consumption. No political and economic conflicts regarding rare fossil fuels (petroleum, coal, etc…). Does not produce toxic gases, reduction of smog.	High cost of equipment, tools and machines. Equipment has to be spread on wide areas. Competition for land and empty areas. Structural change (Natur, 2013).

Source: International Conference for Renewable Energies, (ICRE 2004)

4.5 RENEWABLE ENERGY IN GHANA

As mentioned above, Ghana already started investing in renewable energy even if it is still in a slow process. Aside from the Bui, Kpong and Akosombo Dams in Ghana, the first Solar Power Plant was introduced at Navrongo, in the Upper East Region of Ghana in May 2013 (http://www.vraghana.com/media/2013/may/news, accessed on April 5, 2016). The Navrongo Solar Power Plant cost the Volta River Authority an estimated 8 Million US Dollar budget. It is already reported that the plant is not working efficiently. Problems have occurred while storing energy and delivering energy to the households.

Another big investment planned is the Pwalugu Multipurpose Hydropower Dam, in the Upper East region at the White River in Ghana. The construction of this project will start in 2017 and is planned to finish in 2022. (http://www.ghana.gov.gh accessed on 5thApril, 2016). The Pwalugu Dam is considered to function as a multipurpose dam for several purposes, such as for generating electricity as the major function, and for flood control. The construction and operation of the dam will provide many job opportunities as planned. It will however also affect the surrounding environment with traffic noise, dust and exhaust emissions. Many people might feel threatened by that and have to relocate, for which the Volta River Authority plans on consulting the public and raise awareness of the project, its benefits and its effects (http://vraghana.com/about_us/images/pmd_project_brochure.pdf [accessed 6th April 2016].

Renewable energy is one arguable topic on whether it could succeed in Ghana or not. Many steps are however being taken and using renewable energy would mean the prices of electricity and heat would decrease, since the energy comes from an infinite source. Electricity would not only become cheaper, but also more regularly provided than at the current state. It is in fact an expensive investment for the government and the investor companies, but with the financial support coming from developed countries it is not farfetched. Even solar street lights are being used in several areas in Ghana, and seen as a step forward to an eco-friendlier country (Ministry of Energy and Petroleum, 2013).

In order to promote and invest in renewable energy resources, and support our climate, several countries hence donate or support foreign governments in financing and training to take the step towards an eco-friendly environment. One major investor in Ghana is Germany. In the previous year, Germany has boosted Ghana's energy sector with 1.8 million Euro via the Deutsche GesellschaftfürInternationaleZusammenarbeit (GIZ) after the ratification of the Renewable Energy Act in 2011 (Ministry of Energy and Petroleum, 2013). The German-Ghanaian bonds grow stronger through the frequent financial investment in biomass projects and climate change opportunities as well (SpyGhana, 2012). It is important to mention that financial support and investment alone cannot aid the environment and help the Ghanaian climate if there are no awareness campaigns and projects provided. People have to become aware of the dangerous impact fossil fuels have on a long term, and how important it is to shift slowly to renewable energy resources.

4.6CONSTRAINTS ON RENEWABLE ENERGY INVESTMENT IN DEVELOPING COUNTRIES

In most instances, constraints on renewable energy investment in developing countries are the same as those described in the previous section, only more acute. There are also a small number of constraints that are particular to developing countries.

4.6.1 Economic and financial constraints in developing countries

The rapid decline in technology costs that we have seen in recent decades has led some to suggest that grid parity is achievable (Lilliestam, Battaglini*et al.* 2012). While a case can be made to support this for some technologies in some resource-rich locations in developed countries, this is not often the case for most renewable energy technologies in developing countries.

These effects are driven by the higher cost of finance in developing countries and the capital-intensive nature of renewable energy investments. In the example above, the cost of developed country debt is assumed to be 5 per cent, compared with 10 per cent in developing countries. The figures for equity are 10 per cent and 18 per cent respectively.

The reason why the cost differential in wind is so much greater than for gas is because of the capital intensive nature of the investment: most of the financing for wind has to be raised at the outset, so the fact that it is much more expensive in developing countries has a disproportionate impact on overall energy costs (Waissbein*et al.,* 2013).

It is certainly the case that finance is much more expensive in developing than developed countries. Indeed, in many low-income countries, the cost differential may be even greater than is assumed here, with equity investors seeking returns of 25 per cent or more (Spratt e*t al.,* 2013).

The cost of finance is a function of risk and return. As reflected in different sovereign credit ratings, the perception is that developing countries are riskier places to invest than developed countries. Generally speaking, the lower the income-level of a country, the riskier it is perceived to be, so that – as with individuals – the poorest pay the most for finance. In addition to being more expensive, there is less long-term finance in most developing countries. Wind projects in developed countries can now obtain loans of up to 18 years maturity, which is close to a projects' lifetime (Tan, 2012). In developing countries, the typical loan maturity is less than half of this (Waissbein*et al.,* 2013).

As a result of the higher perceived risks, debt investors in developing countries demand a larger share of equity than is the norm, with debt equity ratios of 60/40 being common, compared to the normal 70/30 in developed countries (IRENA, 2012). As equity is more expensive than debt, this serves to further inflate funding costs, and the scarcity of equity finance in most developing countries acts as a further constraint. Finally, revenues may also be depressed, as many countries keep the cost of power artificially low for developmental reasons (United Nations Environment Program, 2012). Many developing countries show a history of manipulation of electricity prices for political reasons, typically aimed at keeping prices artificially low hence damaging the financial sustainability of the sector (*ibid*). Additionally, many countries spend large amounts in fossil fuel subsidies which damage the competitiveness of renewable energy alternatives.

Apart from this, limitations in utility's credit quality and payment track record raise nonpayment risks. For example, in Kenya: investors view KPLC's11 credit profile and the overall risk of non-payment by the utility, as a serious impediment to arranging financing. Investors have been seeking to obtain, with varying success, government guarantees, support letters and derisking instruments such as MIGA political risk insurance to mitigate this risk. (Waissbein*et al.,* 2013)

To summarize, while the economics of renewable energy projects in developing countries are often challenging, the situation is worse in developing countries, and particularly acute in low-income environments. This is caused by: a) the capital intensive nature of renewable energy projects, which amplifies funding cost differentials; b) the higher level of perceived risk, which raises costs through the higher cost of finance and the larger share of equity in project's finance structure; c) the lack of domestic debt-finance of suitable maturity and scarcity of equity finance, particularly private equity; d) low prices of electricity that prevent cost-recovery.

4.6.2 Regulatory and political constraints in developing countries

As measured by the World Bank's 'Doing Business' surveys, the time and resource costs associated with regulation are often higher in developing than developed countries (World Bank, 2011). The intricacies of negotiating access to domestic grids may also be more difficult, with incumbent energy producers attempting to protect their market positions (United Nations Environment Program, 2012). This is a particular feature of African power markets with uncertain allocation of responsibilities for power planning, ensuring adequate and reliable supply and organizing procurement processes across public institutions and with the private sector. Hybrid power markets, where the state-owned utility occupies a dominant market position and private sector participation compensates for the lack of public investment were the result of the ineffective power sector reform prescriptions in Sub-Saharan Africa in the 1990s (Eberhard, Rosnes, Shkaratan and Vennemo 2012). Reform involving utility unbundling and privatization followed by wholesale and retail competition was impractical for the region, as most power systems were too small to support meaningful competition. In the resulting hybrid model monopolistic and vertically integrated power utilities have no incentives or flexibility to provide easy access to third parties (United Nations Environment Program, 2012). This model poses multiple policies, regulation, planning and procurement challenges.

While such issues will increase costs and potentially constrain private investment, another significant risk is that government support will not be maintained, undermining the economic viability of projects. As described above, the economics of renewable energy investment make financial support essential. Given that these economics can be considerably worse in developing countries due to high financing costs; this support is even more needed.

Credibility is key. It is simple for a government to announce a FIT (feed-in-tariff) at a suitable rate for a long time period. The question is whether this commitment will be met, especially in difficult times. Investors may take confidence from the presence of long-term renewable energy targets, but this also depends on the credibility of this commitment (Spratt *et al.,* 2013).

While many developed country governments have reneged on commitments, investors generally assign more risk to governments from developing countries where sudden policy changes – not least in the energy sector – have not been uncommon: In South Africa, for example, investors began preparations for preliminary investments after a feed-in tariff was announced by the government, which was subsequently cancelled and replaced by an auction scheme (IRENA, 2012).

In this example, the FiT was scrapped before the project began. A greater fear than policy inconsistency for investors is that that this will happen at a later stage, after the (very large) initial capital investment has been made. At the most extreme, investors may fear the expropriation of assets. As with the previous material considered, such risks tend to loom larger in lower-income countries, particularly those with a history of political instability.

It is these concerns which largely explain the higher cost of finance in developing countries, where investors demand higher returns to compensate them for higher risks.

The fact that renewable energy projects are dependent on government support makes them much higher risk than other investments in the same country, amplifying the cost differential with other forms of energy. This can make it difficult for governments to justify continued support for renewables, particularly as: *"...many developing country populations lack an affordable and consistent basic energy supply, which can complicate the ability of the national government to justify a focus on renewable energy* (IRENA, 2012).

This is particularly the case in Africa, where electrification is a much higher political priority than renewable energy or cogeneration (Tenenbaum, 2014).

4.6.3 Technical constraints in developing countries

Developing countries face the same technical constraints described above with newer, untested technologies carrying more risks than more established forms of energy generation. Other technical constraints are particular to lower-income countries, however. From a connectivity perspective, technical constraints include: lack of standards for the integration of intermittent, de-centralized renewable energy sources into the grid; limited experience of the utility or grid operator with intermittent sources which prevents an appropriate system design enabling minimization of system balancing costs; lack of readily available transmission lines from the renewable energy source to load centers; and delays in timely completion of these (Glemarec*et al.* 2012). For example, in the case of Mongolia: With coal dominating the country's energy mix, investors comment on the transmission company's clear lack of experience with wind energy. Investors also raise additional concerns regarding overall grid stability due to the Mongolian grid's antiquated, Soviet-era technology. Another barrier is the lack of a public grid code for wind, without which manufacturers have been prevented from tailoring turbines (Waissbein*et al.* 2013).

As well as constraints caused by problems with physical infrastructure (i.e. lack of roads or transmission lines), many developing countries suffer from local knowledge and experience gaps with respect to project design, construction, operation and maintenance and financial structuring, particularly for immature sectors such as renewable. Investors may find that there aren't any local firms that can offer construction and maintenance services or any local staff that can operate the plants. The lack of local manufacture of hardware would require that all parts are imported, which would add to the time and cost of repairs.

There is less experience with project finance structures, limited equipment operations and maintenance expertise, and a greater need for technology transfer support. Bankers often do not understand renewable energy technologies and are unwilling to approve financing due to an inability to assess the risk of the project (IRENA, 2012).

To summarize, renewable energy investments face three types of constraint: economic/financial; regulatory/political; and technical. In each case, these constraints are more severe in developing countries, which also face technical constraints that do not arise in developed country contexts.

As well as being harder to deliver logistically, renewable energy projects in developing countries are perceived to be riskier. Consequently, investors demand very high returns to compensate for these risks, making it much harder for projects to be economically viable.

To offset this, tariffs need be set very high, and/or government support needs to be proportionally larger than is the case in developed countries (Spratt *et al.* 2013). Given poverty levels in many developing countries and the limited ability of governments to maintain financial support at the levels required, it may be difficult to justify renewable energy projects in the absence of mechanisms to address these constraints and alter these dynamics.

4.7 OTHER COUNTRY'S EXPERIENCE: A CASE STUDY OF SWEDEN

A case study of Sweden is presented in this section with some of the achievements they have chalked so far as RE is concerned.

Sweden- Brief Description

The Kingdom of Sweden is the fourth-largest country in the European Union with an area of 450 295 km² and has a population which passed the 9.5 million mark in 2012. It has a low population density with 21 inhabitants per km², as the majority lives in Southern Sweden, Öresund Region, along the western coast to central Bohuslän, in the valley of Lake Mälaren and Stockholm, the capital city. Approximately 65% of Sweden's total land area is covered by forests and sparsely populated, with 15% of the territory being located north of the Arctic Circle. The country shares borders with Norway and Finland and has maritime borders with Denmark, Poland, Germany, Lithuania, Latvia, Russiaand Estonia. It is connected to Denmark by a bridge-tunnel across the Öresund (IEA, 2013). The Swedish economy has withstood most of the turbulences of the recent global financial and economic crunch, thanks to strong economic fundamentals with a sound fiscal position. In the year 2011, Sweden ranked fifth among European OECD countries in terms of GDP per capita (USD 41 242 per capita, PPP), after Luxembourg, Norway, Switzerland and Denmark. In the 2008/09 recession, Sweden faced a 7.5% reduction of its output, but strongly recovered by the end of 2010, almost reaching pre-recession GDP levels (ibid).

Sweden's Human Development Index value for 2014 was 0.907, which puts the country in the very high human development category—positioning it at 14 out of 188 countries and territories. Between 1980 and 2014, Sweden's HDI value went up from 0.786 to 0.907, an increase of 15.4 percent or an average annual increase of about 0.42 %. The rank is shared with the United Kingdom (UNDP, 2015).

The Kingdom of Sweden is a parliamentary democracy with a constitutional monarchy under the King and Head of State, King Carl XVI Gustaf. Sweden is a unitary state with 21 administrative counties. The development of energy policy is the preserve of the central government, supported by several implementing national authorities and active local authorities. The county administrative boards, which represent the national government at the regional level, have an assignment from the government to formulate regional energy and climate strategies in partnership with regional actors (IEA, 2013).

Content of the National Sustainable Development Strategy

The "Swedish Strategy for Sustainable Economic, Social and Environmental Development (Communication 2003/04:129)" is a revised version of the national strategy for sustainable development presented in 2002. The single, multi-dimensional strategy builds upon the 2002 World Summit on Sustainable Development, the EU strategy for sustainable development, and addresses the three dimensions of sustainable development: economic, social and environmental (Swedish Government 2004, p. 5).

Sweden's policies place a great deal of emphasis on sustainable development. Environmental concerns began in Sweden with nature protection in the first half of the twentieth century, and dealing with local effects of industrial emissions had already become important in the 1960s. Sweden hosted the first UN Environment and Development Conference in 1972 and has been active in promoting international agreements for addressing cross-border environmental problems (Roseveare 2001, p. 4).

This longstanding national history of commitment to the environment and to sustainable development precedes the many initiatives undertaken in the country, which are now packaged in the Swedish Strategy for Sustainable Economic, Social and Environmental Development. This strategy is just one more step in a long list of sustainability initiatives.

Strategy Content

Sweden's *vision* of sustainable development is based on seven fundamental principles which are outlined in the strategy. The achievement of this vision rests on three key premises around which the strategy has been created:

Sustainable development in Sweden can only be achieved within the context of global and regional co-operation.

- Sustainable development policies, measures and concerns must be mainstreamed, i.e. integrated into all existing policy areas
- Further action at national level will be needed to ensure long-term protection of the critical resources that constitute the basis for sustainable development (Swedish Government 2004, p. 4)

The strategy also specifies the policy instruments, tools, future strategic issues and processes that are necessary to implement the vision and values.

The 2004 Swedish then identifies four *future strategic issues* that the government has prioritized for the mandate period of the report (2004-2006). These issues, listed below, take one more step towards integrating the three pillars of sustainable development (Lofgren 2004):

- Environmentally driven growth and welfare
- Good health – our most important future resource
- Coherent policies for sustainable community planning
- Child and youth policies for an ageing society (Swedish Government 2004, p. 10).

The remainder of the strategy reports on the actions taken and those planned in the eight strategic core areas originally defined in the 2002 strategy as the most important elements of a sustainable society, including:

- The future environment
- Limitation of climate change
- Population and public health
- Social cohesion, welfare and security
- Employment and learning in a knowledge society
- Economic growth and competitiveness
- Regional development and cohesion
- Community development

For each of these core areas, the strategy includes concrete objectives and measures (Lofgren, 2004).

Currently Sweden has a high share of renewable energy in the energy mix compared to many other countries. Over 47 % of all energy that is used in Sweden comes from renewable energy sources. This is by far the largest in comparison with other countries in the EU. Hydro power and bio energy are the two main reasons. Today, the heating sector in Sweden - to a large extent district heating - is practically fossil fuel free as a result of the increased use of biomass and heat pumps. The same is true for the electricity sector, where hydro power and nuclear stands for the bulk of the production and wind power is increasing rapidly. The growth in renewable energy and decline in the use of fossil fuels has happened at the same time as the positive development of the Swedish economy. Since 1990, the emissions of greenhouse gases decreased by 15 % while GDP increased by 51 %.

Since the last in-depth review in 2008, Sweden has made further progress towards its long-term goal of an economy based on sustainable energy, and today is among the leading IEA member countries in terms of low-carbon intensity and high share of renewable energy in total energy supply, with strong growth coming from solid biofuels and onshore wind.

This is the result of continuous political efforts: a stringent carbon dioxide and energy taxation, emissions trading and the promotion of renewable energies under the electricity certificate system.

In 2009, ambitious new targets were adopted under the "integrated climate and energy policy" framework. They support and even go beyond European Union and international obligations and require by 2020:

i) the reduction of energy intensity by 20%;

ii) *ii)* a share of at least 50% renewable energy in gross final consumption and 10% in transport, and

iii) a reduction of GHG emissions by 40%, two-thirds of which are to be implemented by domestic measures outside the EU Emissions Trading Scheme and the remainder by EU and international efforts.

For the longer term, Sweden put forward two ambitious priorities:

i) a fossil fuel-independent vehicle fleet by 2030, and

ii) zero net greenhouse gas (GHG) emissions by 2050.

Also in 2009, Sweden decided to annul the nuclear phase-out and to allow for the replacement of its nuclear reactors at the three existing sites at the end of their operational lifetime.

Commendably, Sweden has opened the door to an additional option to shape the transition to a low-carbon economy. Nuclear power currently supplies about 41% of domestic electricity production. Greater certainty is however needed as to if, when and how nuclear capacity can be replaced by the industry on the horizon to 2030.

Sweden can reduce those uncertainties by developing comprehensive decarbonisation pathways to guide policy making and ensure long-term visibility for all market participants beyond 2020. These pathways allow to evaluate the likely implications and to test the robustness of different levels of renewable energy, nuclear, interconnections and energy efficiency.

In 2011 Sweden's total primary energy supply (TPES) was 48.9 million tonnes of oil equivalent (Mtoe), a level which has remained fairly stable over the last three decades with a sharp drop in 2009 amid the global financial and economic crisis. Fossil fuels, oil, coal and natural gas, represented 31.8% of TPES in 2011. Sweden is the IEA member country with the lowest share of fossil fuels in its energy mix (without nuclear). Nuclear makes a large contribution to the Swedish electricity mix, accounting for 15.9 Mtoe or 40.5% of its electricity generation in 2011 (IEA, 2013).

In 2012, production of electricity broke the record for the largest amount of energy ever produced in one year. Total electricity production rose to 162 TWh, which represented an increase of about 10%, compared to 2011. Hydro-electric production was responsible for the greatest proportion of the increase, 18.1%, which represented an increase of 12 TWh. After hydro, wind power had the second largest percentage increase, 18%; which corresponds to an increase in production of 1.1 TWh. Of all electricity produced, a total of 142.2 TWh were consumed in Sweden. This represents an increase of about 2% in electricity consumption, compared with 2011. The high internal production resulted in a net outflow of electricity from Sweden of 19.6 TWh, which was more than double the previous year's net exports, 7.2 TWh. This part of the Swedish electricity balance was also a record (Lofgren, 2004).

4.7.1 Some of Sweden's Achievements

Since 2008, the Swedish government has implemented many of the recommendations contained in the IEA review, that is, to adopt a comprehensive energy and climate strategy, to clarify the future of nuclear, to foster renewable energies and to spur commercialization of energy technologies.

Commendably, Sweden adopted an integrated climate and energy policy framework in 2009 with defined targets for 2020 and decarbonisation priorities for 2030 and 2050.

This has helped guide both policies and markets. The country is on track to achieve or even exceed its 2020 targets. Sweden's integration into the Nordic electricity market deepened over the last years. The country improved congestion management and capacity allocation by introducing market coupling on the interconnections and by splitting Sweden into four electricity price zones. With the integration of the Baltic

States into Nord Pool, this market has expanded into a Northern European electricity market (Sweden Energy Agency, 2015).

On the retail market, the country has rolled out the first generation of smart meters to almost all household consumers and introduced the choice of hourly metering of their electricity consumption. Sweden is regarded as a leader in smart grid technologies with large-scale demonstration, EU-wide and international technology co-operation. The government set up a Smart Grid Council to prepare a national action plan. The IEA applauds these achievements.

Commendably, Sweden clarified the conditions for the use of existing and future nuclear power capacity at its three existing sites. It allows for the replacement of a reactor once the old reactor is closed, if industry so decides. The government does not provide for any direct or indirect subsidies and relies on incumbent operators' capacity to invest into the replacement. Sweden's utilities continuously support the modernization of their nuclear fleet to ensure safe performance for 50 years or more (ibid).

Competition at wholesale level continues to be determined by the incumbent generators who hold cross-ownership in nuclear power plants. This situation has not changed since the last review. Sweden's decision in the 2009 energy policy framework to strongly promote renewable energy as the third pillar in the electricity mix can act as stimulus for potential new producers. It also supports security of supply in the medium to long term.

Sweden is strongly committed to reducing oil use in heating and transport sectors by strappingly increasing the share of renewable energy, which reached an outstanding share of 9.8% in 2011 (calculated in accordance with the EU Renewable Energy Directive).

The country is close to reaching its 10% target for 2020, thanks to the promotion of efficient and environment-friendly vehicles, allowing for the flexible use of biofuels, through fiscal incentives, including motor vehicle tax breaks, and strong R&D activities. But, in the medium term, Sweden aims to have a vehicle fleet independent of fossil fuels by 2030.

The same trends hold true for the overall share of renewable energy. In 2011, 35% of total energy was supplied by renewable energy sources, well beyond the IEA average of 8%. This growth from 28% in 2006 was mainly the result of additions from solid biofuels and onshore wind power in recent years. In gross final energy consumption, Sweden reached a share of 48% of renewable energy (calculated in accordance with the EU Renewable Energy Directive). The IEA commends Sweden's stable framework to support renewable electricity production which enables these developments. The technology neutral and market-based electricity certificate system provides investors with a long-term horizon until 2035. Since January 2012, it also provides for further cost-effectiveness in the joint market with Norway and, more importantly, it does so at moderate cost to consumers. Other countries can learn from this advanced co-operation and this first joint renewable market in the European Union (Sweden Energy Agency, 2015).

Sweden has strengthened the demonstration and market deployment of energy technologies, such as smart grids and second-generation biofuels, fostered by a special demonstration funding, a soft loan program and the new CleanTech Strategy, which are promoting innovative enterprises, innovation clusters and supporting technology incubators with the aim to facilitate the development and deployment of clean technologies. Commendably, the government's new Research and Innovation for a Sustainable Energy System Bill provides increased public funding for the period 2013-16 and guarantees continuity for private-sector investment (ibid).

Sweden has also made further progress in reforming the electricity retail market to enhance the role of the consumer. The country has rolled out the first generation of smart meters to almost all household consumers and introduced the choice of hourly metering of their electricity consumption (Sweden Energy Agency, 2015).

4.8 CHALLENGES TO THE DEVELOPMENT OF RENEWABLE ENERGY IN GHANA

This part presents some of the challenges Ghana faces in the development of her renewable energy.

4.8.1 Limited Renewable Energy Resources

Renewable energy sources in Ghana consisting of small and mini-micro hydro, wind, solar, biomass and municipal solid waste would only be able to supply between 380 and 500 MW delivering between 2,500 and 3,500 GWh competitively.

This will form about a tenth of the energy requirement of Ghana by 2020. More than 10% of renewable energy in the energy mix would increase the cost of generation significantly.

1. The potential of generating grid electricity from Solar PV is limited by capital rather than resource.
2. Wind may have the largest capacity for development among the options and has the potential of contributing significantly to grid power by about 200-300 MW producing 600 GWh.

4.8.2 Cost per Kilowatt Hour

One of the critical challenges to the adoption of renewable energy sources is the cost per unit to consumers compared with energy from other sources (fossil fuels).

1. The cost of grid connected solar energy per kWh is over US$0.30 compared to US$ 0.04/kWh.
2. The cost of a solar panel facility in Ghana is about US$ 7000/kW compared to US$500-1000 for a gas fired thermal power plant.

4.8.3 Investment Risk

The volatility in the pricing of oil and gas on the international market increases the risk of investment in renewable energy facilities. A drop in hydrocarbon prices erodes enthusiasm for investment in renewable energy sector.

4.8.4 Competing Technologies

There is intense competition to achieve hegemony within the sub sectors of the renewable energy market. In bio-fuels, lobbyists for a corn-based solution vie with those championing cellulose, ethanol, and bio-diesel. Within the solar market, concentrating solar power systems compete with the much more popular photovoltaic systems.

4.8.5 Not in My Backyard Syndrome

Renewable energy although provide less pollution compared to energy from fossil fuel, there have been significant backlash from communities regarding the constructing of facilities to produce renewable energy.

4.8.6 Intermittent Nature of Renewable Energy and Storage Difficulties

Many renewable energy sources are often dismissed because they cannot be stored and also because they are intermittent.

4.8.7 Constraints to Bio-fuel Development

The development of an alternative to existing fuel requires policy directives and strategies.

The main constraints are: Feedstock availability, local processing capacity, technology development relating to end use, consumer acceptance of new fuel and cost competitiveness.

4.8.8 Feedstock for Bio-fuel Production

Different feed stocks are used for bio-fuel production in different countries. The general trend is that countries choose feedstock plants which are already being produced on large scales locally and which have other commercial value other than the production of fuel.

In Ghana, Palm oil, Jatrophacurcus and Sugar cane offer significant advantages for bio-fuel production.

4.8.9 Cost Competitiveness of Bio-fuel

The bio-fuel market worldwide is not well developed and bio-fuels are not competitive even with crude oil at US$73.00 per barrel. The global market for bio-fuel is politically driven and relies on tax rebates.

Renewable Energy can be harnessed to support and supplement conventional energy supply. However, significant cost, technology and attitudinal barriers need to be surmounted before any meaningful penetration could be achieved.

5. OUTLINE OF GHANA'S ENERGY SITUATION

Energy is daily in the news in Ghana and it has been in the headlines for many years. As the economy has been growing in the last decennia, demand for energy has increased rapidly. The current electricity generation level is simply too low to supply the whole country reliably. Industries need adequate energy levels to facilitate the production of goods and services; household consumers demand a reliable power supply without load shedding. An electricity crisis is perceived at present, has been experienced in the last years and will likely persist a few more years. Some power plants are under construction, others are in the planning stage, but, given the rapidly rising demand, it is unlikely that consumers can expect a reliable supply in the near future.

Ghana's Vision 2020 comprises the National Electrification Scheme (NES) targeting 100 % electrification by the year 2020 (as opposed to presently 54 %). This forces policy makers to not only plan for expansion of generation capacity, but also to promote alternative energy sources for an overall and balanced growth of the energy sector, based on a mix of sources, including renewables.

The Ghana Investment Promotion Center (GIPC) was established in 1994 to adopt and implement an investor friendly set of rules and regulations to boost private sector investments. With the introduction of macroeconomic and sectoral reforms in recent years, overall government policies and institutions now form a conducive environment for private sector involvement, including those interested in the renewable energy sector.

The main government objectives for the energy sector are to develop Ghana's oil and gas reserves for domestic use (including for electricity generation) and for export, and to provide grid access for the whole population as soon as generation capacity allows. The Government of Ghana target for electricity generation capacity is an optimistic 5000 MW by 2016 (up from around 2400 MW at present). At the same time, the Government of Ghana seeks to reduce the huge subsidies on fuel and electricity that now characterize the power sector.

Until 1998, the supply of electricity in Ghana was mainly from hydropower sources (the Akosombo Dam was built in 1966). Since then about 1,000 MW thermal generations capacity has been added. Currently, the installed generation capacity is 2,412 MW, made up of about 50% hydro and 50% thermal (from fossil fuels). The installed generating capacity includes 1,180MW of hydropower generation (Akosombo, Bui and Kpong plants), 330MW from Takoradi Power Company (TAPCO), 220MW from Takoradi International Company (TICO), 200MW from SunonAsogli, 80MW diesel plant from Tema and 110 and 49.5 from Tema Thermal 1 Power Plant and Tema Thermal 2 Power Plant respectively. The CENIT Power Plant adds a further 126 MW. The Dutch bank FMO is involved in the financing expansion of the plants in Takoradi and Tema. The electricity sector is basically run by four utilities: the Volta River Authority (VRA), the Northern Electricity Distribution Company (NEDCo), Ghana Grid Company Limited and Electricity Company of Ghana Limited (ECG). These utilities are financially in dire straits and continue to depend on government subsidies. Institutional reform processes to enhance efficiency and reduce costs are underway for these utilities, led by the World Bank. Recently a new utility was formed to run the new Bui hydropower plant (Bui Power Authority, 2012).

Ghana's power generation trend has been erratic, influenced by rainfall conditions, mishaps and delays in construction of new plants and pipelines. For example, the accident with the West African Gas Pipeline disrupted normal gas supply to power plants in Ghana for more than a year. Presently, generation increase cannot keep up with increase in demand, which is now estimated at 2500MW. As a consequence, load shedding is frequent throughout the country, in particular affecting small towns and rural areas. Given the large dependency on Akosombo dam, production is vulnerable to low levels of rainfall in the Volta catchment. The main consumers of electricity are households, industry, educational institutions and health facilities. A very big consumer is the VALCO aluminum company, using 6% of the nation's electricity. Despite shortfalls and bound to contracts, Ghana also exports electricity to neighboring countries such as Togo, Benin and Burkina Faso (Bui Power Authority, 2012).

6. ANALYSIS

The analyses of the interviews and documents used in this study are presented in this chapter, and through that process, answers to the research questions come out. These results lay the foundation for discussion and recommendation.

6.1 SUMMARY OF INTERVIEWS

I started the analytical process by conducting a pilot study; with leaders in the private RE sector using an abbreviated version of the full interview protocol. This was to determine whether the importance of government's role for investors was appropriate and understandable as stated by policy makers. Pilot interviews with five people from private RE were conducted to help validate the full protocol. Some of these interviews took place between June and August 2016 during my data collection period in Ghana. I attempted to identify whether the primary premise of the interviews was feasible and whether there were any particular issues or identified challenges to subsequently focus more on in depth.

Data from regulatory bodies were also collected through in-depth interviews. Both structured and unstructured interviews were used. This was to ensure that interviews are more scientific in nature for the structured introduce controls that are required to permit the formulation of scientific generalizations (Sidhu, 2003). However, to allow for respondents to express themselves fully, unstructured interviews were used in some cases.

Some of the institutions contacted included; Environmental Protection Agency (EPA), Ghana Energy Foundation, Ghana Investment Promotion Centre (GIPC), Ministry of Energy and the Energy Commission of Ghana.

6.1.1 Thematic Analysis

The energy insecurity dilemma in Ghana where demand for energy services is desperately needed for survival and sustainable development, coupled with high deforestation rate (22,000 hectares or 2.1% per annum) (Hagan, 1994) partly due to energy utilization; threat of desertification and land degradation (soil erosion) leaves Ghana with no other option than to exploit utilization of its renewable energy resources. RETs exploitation can offset significantly the proportion of foreign exchange used in importation of electricity from neighboring countries and oil for electricity generation. RET applications utilize locally available resources and expertise and therefore provided employment opportunities for the locals in Ghana.

However, the success of RETs in the Ghana has been limited by a combination of factors which include: poor institutional framework and infrastructure; inadequate RET planning policies; lack of co-ordination and linkage in the RET program; pricing distortions which have placed renewable energy at a disadvantage; high initial capital costs; weak dissemination strategies; lack of skilled manpower; poor baseline information; and, weak maintenance, service and infrastructure.

Energy Policies in Ghana

Exploitation of Ghana's renewable energy resources has been carried out under two main policy regimes – PNDC Law 62 (1983) and the Energy Sector Development Program (ESDP). The PNDC law established the National Energy Board (NEB) and mandated the NEB to direct the development and demonstration of renewable energy projects throughout Ghana. The NEB initiated a number of projects in the areas of renewable, electricity, petroleum, energy conservation and demand management; and policy analysis, planning and institutional management. The NEB was abolished in March 1991 and its function taken over by the Ministry of Energy. Some four years later, an Energy Sector Development Program (ESDP) was instituted by the Ministry of Mine and Energy (MME) in 1996. The ESDP is the overall energy policy framework that has been guiding the development of RETs also since 1996. The Renewable Energy Development Program (REDP) under ESDP includes evaluation, support and demonstration of potential RETs, promotion of renewable energy industries and development of information data base on renewable energy sources, technologies, end use patterns etc. The REDP has supported a number of biomass and solar energy projects in Ghana. ESDP has come to an end and a new National Renewable Energy Strategy (NRES) is being formulated under the Renewable Energy Component (REC) of the DANIDA Energy Sector Program Support (ESPS).

As a part of the institutional reforms program, an Energy Commission (EC) and a Public Utilities Regulatory Commission (PURC) were set up in Ghana in 1997. This also had provision for establishment of an Energy Fund under the Energy Commission. One of the end uses of the Fund money was to promote RETs. But the allocation for promotion of renewable from the fund has been insufficient. PURC on the other hand has been engaged in rationalizing electricity tariffs as a part of its mandate, a measure that may help promote RETs also. Other significant policy measure included the reduction of import duty on solar panels in 1999.

Thus, several measures and instruments have been employed to implement renewable energy policies in Ghana. Some economic instruments, such as subsidies, taxes, and duty waiver/reduction have also been used to a limited extent. However, existing renewable energy policy framework is not potent enough to ensure the commercialization and widespread utilization of RETs. This is because the policy framework relies heavily on government budgetary allocation and donor funding which is not likely to be sustainable. The policy framework also does not provide for development of small hydropower in Ghana.

RETs selected for Barrier analysis

_Some biomass and solar technologies and small hydro were selected for preliminary analysis of barriers in Ghana. In the biomass category, barriers to use of biomass fired dryers; sawdust briquetting, sawdust stoves and biogas were studied and based on the findings biogas was analyzed in detail. In case of solar, barriers to Solar Crop Dryers (SCDs), Solar Water Heaters (SWHs) and Solar Water Pumps (SWPs) were studied and finally solar water pumps was subjected to detailed barrier analysis.

Potential for small hydropower development has been identified in Ghana but no project has been commissioned so far. Therefore, barriers for this technology were also explored in the study. The selection of these technologies was based on their potential contribution to socio-economic development, potential for application, and availability of information on barriers, environmental impacts and benefits.

The choice of biogas for detailed barrier analysis was mainly because a lot of efforts have already been put into developing projects employing this technology and biogas is still receiving significant attention from both government bodies and the private sector. It is perceived to have huge environmental/sanitation and agricultural benefits. Solar Water Pump (SWP) technology was selected for detailed barrier analysis because among the solar energy technologies studied, this had least number of barriers. It was also considered most promising of the three solar technologies on account of its potential to address rural drinking water needs. Small hydro power was also selected for detailed barrier analysis due to its uniqueness; potential exists and technology is well known, yet it has failed to penetrate.

Information on barriers and how to remove them were solicited from local experts and institutions, manufacturers, installers and users/consumers of the products through interviews. Site visits were also made in some cases. As part of the barrier analysis process, participants were given the opportunity to rank the barriers identified through questionnaires and interviews.

6.1.2 Summary of the Interviews Analysis

Evaluation of these initial interviews strengthened the questions used for the main study. For instance, I found out that some questions were not important for this study and a number of questions were not clear to the interviewees. Therefore, some interview questions later evolved in the light of the findings from the pilot study.

As a first step for the main data collection process, a database of potential interviewees was developed. To guide selection of policy makers and RE company leaders, a systematic approach was developed. I contacted 9 people from; Energy Commission of Ghana, Ministry of Energy and Natural Resources, RE companies and educational institutions. This yielded 6 volunteers agreeing to be interviewed. They consisted of policy makers, lecturers and private sector individuals working in the Energy Commission, leaders in the sector, and RE investors in Ghana.

Interviews were recorded and transcribed from the six participants. Because of confidentially concerns three participants wouldn't allow audio recording, but allowed me to take notes. Notes and transcriptions were converted into a case study for each participant within 24 hours of the interview.

I conducted a content analysis of the interview content and discovered the following general themes: policies, technology, government support, investor experience, RE targets, and quality of RE institutions. Furthermore, the choice of policy makers and leaders of RE companies for investigation was validated in the content because they were key players with a desire to establish new RE markets and were determined to make an impact on renewable investment.

Motivation for supporting RE, according to the interviewees, are policies, fostering technology, government support, investor experience, RE targets, quality of RE institutions, energy security, protecting the environment, and economic improvement.

For some technologies in Ghana, the case study recommends that the government support is enough, but some technologies, such as wave and PV (Photovoltaic) need financial support. Furthermore, a respondent from the Renewable Energy Division of the Energy Commission suggested that **"***regulation to try to remove barriers to investment or to engender a return can also have an impact. Government does need to encourage investment in particular directions since some outcomes will better serve the needs of the public and the market is not effective at delivering these."* Pioneering and large companies are active because RE is now a multi-billion dollar industry, but it does not follow that all the investment comes from big companies. There are a number of small companies involved in developing, constructing, and operating RE technology in the country.

Some private RE company owners suggest that long payback is a barrier to renewable investment. Uptake rate of renewable technology is still relatively modest, partly due to initial installation costs. Investments for RE development are currently ongoing in

Ghana, and it is expected that RE sources will be affordable. Even so, without incentives from government, the uptake rate of renewable energy technologies will be low. Only few individuals invest for energy generation purposes because of the relatively high initial installation costs.

However, such pressure does not exist within local companies as compared to bigger companies. To encourage local companies, policy instruments shouldn't be so complex that local companies are forced to hire consultants to understand them.

Ghana's target is to have 10% of its energy needs generated from RE sources, with 15% of electrical generation from RE. In some participants' opinion, these target goals will be difficult to achieve. An energy expert at the Energy Commission emphasized that *"I am not convinced that the Ghana will achieve the 10% target, the current government certainly lacks the will for it, since it will require onshore wind, biomass and offshore wind, with onshore being the cheapest but facing increasing social barriers, such as the recent government commitment to stop building onshore wind."*

However, these targets are possible and realistic with more renewable projects and incentives. If the government desires to encourage the use foreknowable, according to economic theory perspective, the best alternative would be to impose a tax on fossil fuels so politicians prefer to subsidize RE sources. In general, the participants' idea about the future of Ghana's renewable is positive: "*It will keep growing."*

The Regulatory Bodies during the interview revealed the following barriers:

- Mini-Grid connected systems involve very high investment and transaction cost.
- Institutional capacity limitations (R&D, demonstration & implementation)
- There is difficulty in assessing affordable and appropriate financing schemes.
- The high upfront cost of SHS and lanterns systems is a barrier to commercializing solar photovoltaic.
- The problem is further compounded by the fact that a significant part of the price build-up for solar products is accounted for by challenges in the implementation of legislation on import taxes, duties and other charges on imported renewable energy equipment.
- Limited involvement of women in the planning and implementation of energy interventions such as promotion and usage of renewable energy systems.
- Lack of access to the technology, inadequate maintenance facilities, bad quality of product.

6.2 ANALYSIS OF DOCUMENTS

Green economy, the Sustainable Development Goals and the Paris Climate Agreement have been extensively discussed in this section at both the national and local levels.

6.2.1 Green Economy

Green economy is an omnibus term like sustainable development but it nevertheless comprises economic policies and instruments to harness economic activities in a given country in support of one or more of its sustainable development goals.

Policy makers in Ghana have officially not come into consensus on the meaning of the term ‘green economy’. However, there is a general understanding that Green economy or green growth pathways seek convergence between the social, economic and environmental pillars of sustainable development.

The concept should also reflect the goals of the country’s National Sustainable Development Strategies (NSDSs), and should have a generally integrative policy and planning direction in relevant sectors, particularly pro poor approaches, sustainable urban management and a program for sustainable consumption and production.

From a Ghanaian perspective, transformation to a green economy means having sustainable recourse for policy direction in specific sectors such as energy, transport, agriculture, urban environmental management and infrastructure- roads, buildings and industrial installations.

Ghana has undertaken several green economic policies over the years. Government since 2005 has been undertaking consultations on how to green the national budget. In the area of energy, energy efficiency programs such as opting for renewable choices, retrofitting existing buildings and other infrastructure to make them more energy efficient has been undertaken. The country has also provided support for research and development on environmentally friendly technologies using the Energy Fund.

In the area of forestry there has been substantial public investment to restore, maintain and enhance the stock of natural capital. Incentives have also been provided for the private sector to invest in green sectors, especially forestry. The government has also undertaken subsidy reform, pricing of pollution, public procurement all in an effort to green the economy.

Some of the measures Ghana has taken include:

At the National level,

- Policies, legislations and programs have been put in place (Water Act, Forest and Wildlife policy, Mining Act, Timber Resource Management Act, and Use of SEAs as a requirement in public policy processes).
- Environmental management has been mainstreamed at all levels · FASDEP II - Agriculture sustainable land management strategy and Action Plan has been developed.
- Ghana Investment Framework for Sustainable Land Management has been enacted.
- Environmental Sanitation Policy and Strategy has been enacted.
- EPA air quality guidelines has been developed, EPA has developed *Akoben,* a 'measuring rod' for environmental practices in the productive and extractive sectors.

At the Local level,

- EIA has been designed as a pre requisite for the establishment of all projects.
- EPA has established environmental management committees in MMDAs.
- Ghana Sustainable Land and Water Management project has been developed.
- District Assemblies and NGOs have been involved actively in addressing environmental degradation in the country.
- Environmental bye-laws have been enacted for all MMDAs.
- District Assemblies have departments for environmental sanitation officers.
- Mass media has been involved in awareness creation programs e.g., the Africa Farm Radio Network.
- Extension officers are mainstreaming sanitation awareness at all levels especially at the local and district levels.

6.2.2 The Sustainable Development Goals

At the institutional level government has developed a lot of institutions, instruments, policies and frameworks to ensure that national political commitment to achieve sustainable development goals is effective. These among others, include:

- Establishment of the Ministry of Environment Science Technology (MEST);

- Transformation of EPC, hitherto an advisory body to EPA, an implementing agency with powers to prosecute.
- Setting up of ENRAC with the Vice President of the Republic as its Chairman.
- Mainstreaming Gender into1 budget preparation and allocation.
- Institutionalization of public disclosure policies, e.g., *Akoben* and the Extractive Industry.
- Transparency Initiative (EITI) to play the role of 'measuring rod' to measure environmental practices in the extractive and productive sectors.
- The use of Strategic Environmental Assessment (SEA) and Environmental Impact Assessment(EIA) as a tool to ensure sustainable development;
- Preparation of the National Climate Change Policy Framework;
- Development of National Biodiversity Framework;
- Development of Science, Technology and Innovative programs and projects.
- Setting up of the National Appropriate Mitigation Action (NAMA) for Climate Change.
- Setting -up of the National Committee for Sustainable Development (NCSD).
- Development and implementation of the GPRS 1 and GPRS II and the GSGDA.

There are also specific sectors where national political commitment to achieving the Sustainable Development Goals has been strong. These include water, energy, transport, E-waste among others.

In the area of Water and Sanitation, there have been some political commitments in sustainable development. Government has established the Ministry of Water Resources, Works and Housing; Community Water and Sanitation (CWSA), Water Resources Commission to provide governance in water management. Also, government has established Water and Sanitation Committees at the Districts to ensure that quality water is constantly provided at the District level. Water Resource Management (WARM) studies have also been undertaken to guide policy formulation. Restructuring of utility provision led to the establishment of the Public Utility Regulatory Commission (PURC) which regulates utility provision in urban areas including water.

In the area of energy, national political commitment to achieve the Sustainable Development Goals has also been strong though more could be done. Developments in this area include:

- Creation of Renewable Energy Division and Directorate in the Ministry of Energy
- Formulation of Renewable Energy Policy
- Subjecting the Energy Policy to SEA

- Setting renewable energy target of 10% in 2015
- Reducing biomass share in total energy consumption to about 66%
- Encouraging the use of LPG
- Introduction of energy efficient charcoal production and utilization technologies e.g. “KasamanKiln”
- Encourage tree planting at the local level (Community, Schools, Individuals, Organizations)
- Promulgation of the Renewable Energy Law
- Promotion of energy efficiency (E.g. CFL bulbs, fridges, air conditions and capacitor banks for industry) and awareness creation on energy saving tips
- Establishment of the Green Energy Fund; whereby those who generate green energy from their homes are supported. Currently, importation of solar energy panels is tax free. However, those in the rural areas do not have the capacity to bring these solar panels and are seriously exploited by businesses in this area.

In the area of environment, the Government of Ghana and Development Partners have initiated the Natural Resources and Environmental Governance (NREG) program with prioritizes activities and time-bound targets in order to reverse the persistent trend of high environmental degradation in a coordinated and sustainable manner. The Voluntary Partnership Agreement has been initiated between the Government of Ghana and the European Union which is aimed at ensuring that timber products are obtained from certified sources. To increase the country’s forest cover, the Forestry Services Division (FSD) has demarcated 1,440 hectares under the Community Forest Management Project (CFMP) and 178 hectares under FSD model plantation program.

To reduce emissions of carbon and nitrogen gases from inefficient combustion of old vehicles, the government has introduced high taxes on importation of old vehicles/engines. This has led to a reduction in the importation of second hand vehicles and consequently emissions. The Ministry of Transport also took its transport policy through a Strategic Environmental Assessment and climate change mainstreaming.

To avoid Ghana being used as a dumping ground for e-waste, there is a draft legislation that bans the importation of E-waste into the country. Targets have also been set to phase out particular electrical goods. For example, there is a ban on the importation of used fridges and air conditioners.

Furthermore, Government is promoting alternative sources of energy use such as solar, wind, mini hydro, biomass, gas and waste to energy, which are environmentally friendly and have the capacity to mitigate climate change.

6.2.3 The Paris Climate Agreement

The Paris Agreement is a bridge between today's policies and climate –neutrality before the end of the century.

Mitigation: reducing emissions- Governments agreed:

- To a long term goal of keeping the increase in global average temperature to well below 2^{o}C above pre-industrial levels;
- To aim at limiting the increase to 1.5^{o}C,since this would significantly reduce risks and the impacts of climate change;
- To undertake rapid reductions thereafter in accordance with the best available science.

Before and during the Paris Conference, countries submitted comprehensive national climate actions plans .These are not yet enough to keep global warming below 2^{o}C,but the agreement traces the way to achieving this target.

Transparency and Global stock take- Governments agreed to:

- Come together every 5 years to set more ambitious targets as required by science;
- Report to each other and the public on how well they are doing to implement their targets
- Track progress towards the long-term goal through robust transparency and accountability system.

Adaptation- Governments agreed to:

- Strengthen societies' ability to deal with the impacts of climate change;
- Provide continued and enhanced international support for adaptation to developing countries.

Loss and damage- the Agreement also:

- Recognizes the importance of averting , minimizing and addressing loss and damage associated with the adverse effects of climate change;

- Acknowledges the need to cooperate and enhance the understanding, action and support in different areas such as early warning systems, emergency preparedness and risks insurance.
- Recognizes the role of non-party stakeholders in addressing climate change, other sub national authorities, civil society, the private sector and others.

Ghana has realized the impact of these new emerging challenges and has put in place several mechanisms both at both the local and national levels to address these challenges.

At the National Level

Establishment at Cabinet level, The Environment and Natural Resource Advisory Council chaired by the Vice-president of the Republic of Ghana

- A National Climate Change committee has been put in place charged with developing policies and programs to address all issues of climate change, both negative and positive
- Draft national climate change policy framework has been designed
- Climate Change has been mainstreamed into the GSGDA
- National Climate Change Adaptation and Mitigation Strategies have been developed and specific programs are being implemented at all levels e.g. African Adaptation Program, REDD+, FIP, FPP, NAMAs and Low Carbon Growth programs.

At the Local level:

- NGOs are engaging with local people and creating awareness
- GSGDA is been mainstreamed into District development plans
- Specific projects to address climate change are being implemented at all levels e.g. African Adaptation Program, REDD, FIP, FPP.

7. DISCUSSION AND RECOMMENDATIONS

This chapter looks at the presentation, discussion and analysis of data collected from the field. Research findings constitute very important stages of the research exercise. It is an integral part of the survey and it is affected by its overall quality. The findings are normally reported with respect to furnishing evidence for each research questions asked to guide the study. This study presents the results of the study and the findings.

This study developed a conceptual framework for RE investment assessment with renewable policies, technology and economic approach.

Using a conceptual framework and qualitative analysis, this study sought to shed light on an under-researched aspect of how RE investment is affected by renewable policies. The conceptual framework analysis also allowed me to draw a clearer picture of the relationship between investment and policies.

A comparison of the support schemes for the market based deployment of RE in Sweden demonstrate that RE policy instruments reduce the risks for investors and result in larger deployment mechanisms. Therefore, policy instruments have been effective in stimulating renewable investments. However, the effectiveness of renewable policy instruments depends on its impact on perception, understanding policy implications, regulatory burdens, investors ‘experience, and so on. Policy makers need a better understanding how RE investors make their decisions when considering RE investment. Furthermore, by taking a holistic perspective into understanding the obstacles that hindered successful policy interventions, this research was intended to come up with practical solutions that could maximize the potential of renewable investment. In the energy literature, there is lack of empirical studies about renewable investment from the investor perspective. This paper discusses this important consideration with both conceptual and qualitative analysis.

Both qualitative and conceptual analyses show that many factors including policies, technology, economic viability, and investors’ behaviors play an important role in stimulating renewable investment.

Furthermore, with the experiences gathered in the case study, Sweden appears to have a cost problem, specifically infrastructure/preliminary cost for investment. A key demand of those who want to invest in RE sources is the implementation of long-term stable policies that minimize uncertainty. Therefore, it is expected that policymakers should fix their policies, which should be synchronized with evolving RE markets.

Furthermore, interviewees reconfirm my choice of requirements regarding government interventions (such as policies, technological push, investor's experience, environment, energy security, and so on) in case countries.

Based on the specific needs of the country the following green economic policies would be rated as the most effective:

1. Policies of energy efficiency such as opting for renewable choices, retrofitting existing buildings and other infrastructure. This is due to the fact that improving energy efficiency will reduce wastage and all things being equal reduce production cost of firm, household expenditure on energy, reduce use of biomass for fuel and importation of petroleum products.

2. Policies that provide targeted support for research and development on environmentally friendly technologies. In agriculture, emphasis can be in the area of improved varieties that can with stand climate change and agricultural modernization. Clear policies on the dissemination and use of research findings are also very imperative. This is due to the fact that research and technology play a major role in the transition to green economy.

3. Policies that ensure substantial public investments in the restoration, maintenance and enhancement of natural capital, especially forest, lands, water bodies, etc.. This is due to the fact that the economy of Ghana depends mainly of natural resources and therefore the maintenance of these resources is very important for sustainable development.

4. Policies that ensure mass transportation use, example the Bus Rapid Transit System and the provision of bicycle lanes and pedestrian walkways in urban areas. Policies that introduce progressive tax regimes for transportation fuels is also very imperative. This

will reduce the current situation where every household strives to own a vehicle and consequently the reduction of emissions.

The Government, through the Ministry of Energy should formulate a comprehensive RE measures and policies that is committed to:

- Developing the country's renewable energy resources over the medium to long term (KITE, 2002);
- exploring and provide appropriate financial mechanisms for the development of RET projects;
- Creating the enabling fiscal and regulatory environment that would stimulate the effective participation and injection of private capital into the renewable energy sector (RDREG, 2002).
- Promoting inter-institutional involvement in the design and implementation of government funded renewable energy projects.
- Providing support to institutions that are involved in RE research and dissemination.

7.1 Creation of Regulatory frameworks that are RE friendly

In general, renewable energy based power supply, whether from power companies or individuals, should have priority dispatch status into the national interconnected electricity grid system.

For small, decentralized RETs a system of certification and standardization needs to be developed in order to ensure high quality installation and performance (Karekezi&Karottki, 1989; Karekezi&Kimani, 2002; Ward *et. al.* 1984). The Energy Commission should establish and enforce certification and licensing of small RETs dealers and also keep a register of these licensees (RDREG, 2002). The granting of licenses should be based on pre-determined requirements such as:

- Evidence of competence of technical staff
- Track record
- Evidence of certification from principals
- Evidence of capacity to provide after sale service
- Evidence of financial capacity to offer services.

It may be recommendable that for PV applications, standards developed by GHASES, ERG and GSB should be adopted as national standards (MME, 2000).

7.2 Promotion of innovative market delivery models to offset the high initial costs of RETs

The high upfront cost of RETs has been the single major barrier to their widespread deployment. The key problem that any innovative market delivery models has to deal with is the high initial cost of RETs and the additional sum cost needed for operation and maintenance as well as for repairing broken down components. This can be achieved through micro-credit schemes.

Remote rural communities not connected to the grid should be supported in meeting the high installation cost associated with commissioning of RE projects. The Ministry of Energy should, for instance, promote marketing models that will enhance the sustenance of RE projects by directly tying the generated electricity to commercially viable activities. Emphasis should be placed on management and marketing models that employ the active participation of the benefiting community, local institutions and entrepreneurs all geared towards helping to achieve sustainable development.

7.3 Establishment of favorable pricing policies for RETs

The single most important policy intervention that will accelerate the development and utilization of RE for electricity generation is the establishment of a friendly tariff regime (Akuffo, 1998) where guaranteed prices for generated electricity from REs are instituted by the Public Utilities Regulatory Commission (PURC) similar to the German experience (German Renewable Energy Act, 2000).

7.4 Rationalization of the fiscal regime for RETs

Considerable effort has been previously made by the government of Ghana to promote the development of RETs through liberal fiscal policies. Significant to this include the Ghana Investment Promotion Centre (GIPC) Act 478 (the investment code) (RDREG, 2002). This investment code for example, makes provision for tax exemptions for RETs manufacture and installation. In addition, wind powered and solar energy generating sets, plant, machinery equipment or parts for the establishment of PV manufacturing facility are exempted from import duty, VAT and excise duties, which together could account for up to 22.5% tax on these equipment (KITE, 2002).

There are however two major drawbacks in the existing fiscal regime for renewable energy technologies; first, when PV systems are imported as complete systems (i.e. including modules, regulators, batteries, lamps, inverters) they are exempted from VAT of 12.5% (Akuffo, 2008). On the other hand, where they are not imported as complete systems, only panels are exempted from import duty and VAT while the Balance of System (BOS) components such as batteries, regulators and lamps attract import duty. Secondly, other RETs such as solar water heaters, solar cookers, solar ovens, biogas equipment, and biomass-based generating sets, among others are not exempted from VAT. The current regime for RETs should be further expanded to include import duty and VAT exemption for the following:

- Solar water heater
- Solar cookers
- Solar ovens
- Biogas utilization equipment, appliances and system components
- Biomass-based generating sets

Appropriate policy recommendation will be to provide a working mechanism where importers of BOS can reclaim the import duty and VAT on their BOS upon showing prove that the BOS has been utilized in a RE project. BOS used in other conventional activities forfeit their import duty and VAT. The import duty and VAT refund procedure for the BOS can be achieved via a reverse supply chain activity where the RE project implementer/investor (after commissioning his/her RE project) can claim the refund from the retail shop where the BOS was purchased and the retailer subsequently reclaiming the money from the importer who then get his BOS import duty and VAT directly from the government or port authorities (or whoever is responsible). In order to avoid unforeseen bottlenecks along the reverse supply chain it will be prudent to make it possible for any of the stakeholders along the supply chain to be able to obtain his/her refund directly from the government.

7.5 Creation of awareness on the benefits of RETs

In order to build a viable market of RETs, there is the need to create awareness of RETs as an alternative to conventional energy technologies. In doing so the potential benefits of RETs regarding their strategic nature, environmental benefit, self-sufficiency and reliability have to be emphasized and projected. A recent survey (KITE, 2002) to determine awareness of SWH in hotels came out that most of the hoteliers interviewed were not aware of SWHs let alone to understand the immense benefits of SWHs towards energy saving retrofitting.

In the past, the MME has promoted RETs through demonstration projects in both the rural and urban communities and most of these projects collapsed with the withdrawal of external support because project sustainability issues were not incorporated at the initial stage of implementation. In the future information dissemination and awareness creation on the benefits and market potential of RETs should be the main focus.

8. CONCLUSION

The study has attempted to answer five research questions: 1) What are the sources of renewable energy in Ghana?; 2) What capacity does of Ghana have in the production and consumption of renewable energy?; 3) What are the strategies for the implementation of renewable energy in Ghana?; 4) How are these strategies implemented in the perspective of the UN SDGs and the Paris Climate Agreement?; 5) What are the constraints to investment in renewable energy generation?

8.1 FINDINGS

Climate change is still a more internationally driven agenda in Ghana. Across government there is only narrow understanding amongst a few of the impacts climate change will have on Ghana‘s development. Engagement to date has focused too narrowly within a select group of technical experts. There is an urgent need to build climate change leadership across a broad range of senior political leaders and to increase climate change awareness across government, civil society and the private sector. Capacity deficits are significantly restricting the response.

Access to available global funding has been limited to date in spite of the Government’s awareness of the possibilities for future climate change financing, particularly for mainstreaming adaptation. Although Ghana has incorporated climate change into it GSGDA, the lack of a finalized climate framework, and access to global funds, is hindering progress beyond a more fragmented and piecemeal progress, with the notable exception of NREG. Donors should consider further coordinating and unifying their commitment to climate change in Ghana including supporting the finalization a national climate framework with action plans. Gains on harmonization will only be fully realized once donors are able to align behind a strong nationally led agenda. The current national response will need to be scaled up dramatically if Ghana is to adequately address current and future climate change risks. Ghana is at an economic/energy transition point with oil and gas lock-in decisions on energy, together with transport and other infrastructure being made now. Government needs to align these with a strong adaptation and low carbon growth response as soon as possible, before a chasm opens up between the rhetoric and reality, and north and south of the country. The climate framework needs to be finalized urgently with mechanisms for delivery, supported from the international community via scaled up financing to meet Ghana‘s priorities and needs. A systemic response to the adaptation challenge and low growth opportunity is required now.

Additionally, while technology and science are advancing more and more over time, the step for making use of them in favor of our earth should be as important. The existing potential for a clean consumption and resource extraction is given by nature and neither harms humans and animals, nor would it ever end up compared to fossil fuels. Developed countries are already taking the initiative for renewable energy sources, and are creating different tools which cost millions billions of Euros just to aid the earth, environment and climate against toxic gases.

Ghana has shown commitment to renewable energy and has to evaluate which energy resources are cost-effective and the best with regards to the circumstances of the country. One of the hindrances of using more renewable energy resources in future could be the finances to install these technologies.

The four main sources discussed are solar, wind, water and biomass energies and the necessary technology for each category. The main part highlights the different advantages and disadvantages discussed lately on renewable energy sources, and what impact they have on nature compared to the use of fossil fuels. The paragraph after that, mentions the renewable energy resources with regard to Ghana and the options on how to slightly start using renewable energy resources.

This study provides further valuable insights into how to reach the significant RE investment levels. First, the implications for policy makers are clear and indicate how to design more effective renewable policies to encourage RE investment. Secondly, this study supports these implications with qualitative data provided by the investors themselves. Finally, this study improves the emerging of the field of renewable investment and extends the validity of previous findings.

8.2 FUTURE WORK

The fact that electricity demand has been forecasted empirically, little empirical studies is known on the intensity of energy consumption in the country, energy conservation and willingness to pay for better energy services. Thus for policy purposes, other areas like intensity of energy use, conservation behavior and willingness to pay for energy services need to be researched into.

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List of interviewees:

KWABENA A. OUT-DANQUAH. Head, Renewable Energy Division, Energy Commission of Ghana. Interviewed on June 29, 2015 in Accra.

DOROTHY A.Y. ADJEI. Program Officer, Bioenergy, Energy Commission of Ghana. Interviewed on July 10, 2015 in Accra.

KENNEDY AMANKWAH. Chief Program Officer, Energy Efficiency and Climate Change. Interviewed on April 8, 2016 in Trondheim via Skype.

ALBERT BOATENG. USAID-Power Africa Transaction Advisor. Interviewed on April 12, 2016 in Trondheim via Telephone and Skype.

DAVID ATO QUANSAH. PhD Candidate, Norwegian University of Life Sciences (NMBU), Norway and Lecturer at the Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology, Ghana. Interviewed on April 18 and 19, 2016 in Trondheim via Skype and Email respectively.

RICHARD ARTHUR. PhD Candidate, Faculty of Life Sciences, Department of Biotechnology Research on Anaerobic Digestion, Hamburg University of Applied Sciences, Germany and Lecturer at the Department of Energy Systems Engineering, Koforidua Polytechnic, Ghana. Interviewed on March 13 and 15, 2016 in Trondheim via Skype and Email respectively.

APPENDIX: INTERVIEW GUIDE:

Part 1: Introductory Questions

1. Could you please start by telling about your background, your role and your work?

2. How are you involved in the renewable energy sector?

Part 2: Renewable Energy Situation

1. Ghana's 10% of electricity from renewable energy sources by 2020. What do you think about this target? And, do you think this is realistic for Ghana? Why or why not? Why does Ghana use much more energy than……?

2. Which type of renewable energy source is the most realistic and efficient for Ghana?

3. The RE market is competitive in Ghana. What strategies does your company use to survive in the renewable energy market in Ghana? Are they effective? Are there other strategies that could be effective?

4. What is your market share in this renewable energy sector? Why are you still involved in this sector? What can be done to increase your market share?

5. Do you think new renewable technologies are promoted by this renewable energy sector? Is there new investment for new technologies? Can you give me detail about this?

6. Considering the high cost of renewable energy technologies, how long does an investment take to show profitability in Ghana?

Part 3: Renewable Energy Policies

1. The four main renewable policy instruments are feed-in tariffs, quotas, tender, and tax credits. Which of these four do you think are effective for Ghana? Why?

2. Do you think implementations of renewable energy policies encourage or discourage the use of renewable energy technologies? Could you give me an example in your company? In general, what would you say is the opinion within your company about government renewable energy policies?

3. What do you think about the government incentives: Are they enough? What else can government do? Should government do anything at all?

4. How does the Ghana government encourage investors to invest in the renewable energy sector?

5. Are these efforts effective, in your opinion? Is the government right to try to influence what investors are doing with their money?

6. Energy security, economy, and climate change are the main challenges. Do you think these are serious challenges? How do you think these challenges influence development of renewable energy? Are there other ways to help meet these challenges outside of the renewable energy development?

8. How do you see renewable energy market in the next ten years to twenty years?

Part 4: Closing Questions

1. Is there anything else you think I should know about your experiences in the renewable energy sector?

2. As I talk to other interviewees, I may realize that there is something important I neglected to ask you. Can I contact you again if I want your opinion on something else? What is the best way to get in touch with you again phone, email, letter, or appointment?