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**INSTITUTE OF WATER AND ENERGY SCIENCES**
**(Including CLIMATE CHANGE)**

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Presented by

**Margaret Adobea ODURO**

## EVALUATING THE SUCCESS OF RENEWABLE ENERGY AND ENERGY EFFICIENCY POLICIES IN GHANA- MATCHING THE POLICY OBJECTIVES AGAINST POLICY INSTRUMENTS AND OUTCOMES

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# EVALUATING THE SUCCESS OF RENEWABLE ENERGY AND ENERGY EFFICIENCY POLICIES IN GHANA- MATCHING THE POLICY OBJECTIVES AGAINST POLICY INSTRUMENT AND OUTCOMES

By:

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**BSc. (Hons.) Meteorology and Climate Science**

A thesis submitted to the Pan African University Institute of Water and Energy Sciences and the University of Tlemcen, Algeria, in partial fulfilment of the requirements for the award of the degree of

***MASTERS OF SCIENCE, ENERGY POLICY TRACK***

JULY, 2018

## Declaration

I, **Margaret Adobea ODURO**, hereby declare that this research, 'Evaluating the success of renewable energy and energy efficiency policies in Ghana- Matching the policy objectives against policy instrument and Outcomes', is wholly of my work from the research conducted undertaken under supervision and that none of the part has been presented or published for another degree elsewhere, otherwise, with the exception of permission from references from other sources that have been entirely referenced.

| | | |
|---|---|---|
| Margaret Adobea Oduro |  | 01/08/2018 |
| (Student) | Signature | Date |

Certified by

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|---|---|---|
| Dr. Samuel Gyamfi |  | 01/08/2018 |
| (Supervisor) | Signature | Date |

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## List of Abbreviations

| | |
|---|---|
| AREA | Africa Renewable Energy and Access programme |
| CFLs | Compact Fluorescent Lambs |
| CSP | Concentrated Solar Power |
| ECG | Electricity Company of Ghana |
| ECOWAS | Economic Community of West African States |
| EE | Energy Efficiency |
| GDP | Gross Domestic Product |
| GEF | Global Environmental Facility |
| GoG | Government of Ghana |
| GRERC | Ghana Renewable Energy Risk Capital |
| GRIDCo | Ghana Grid Company |
| GW | Gigawatts |
| GWh | Gigawatts hour |
| FiT | Feed-in-Tariff |
| IPPs | Independent Power Producers |
| kWh | Kilowatts hour |
| kWp | Kilowatt peak |
| LEDs | Light Emitting Diodes |
| MASEN | Morocco Agency for Solar Energy |
| MW | Megawatt |
| N | North |
| NEDCo | Northern Electricity Distribution Company |
| NERSA | National Energy Regulator of South Africa |

| | |
|---|---|
| OECD | Organisation of Economic Cooperation and Development |
| ONEE | National Office for Electricity and Waste |
| PPA | Power Purchase Agreement |
| PURC | Public Utility Regulatory Commission |
| PV | Photovoltaic |
| RE | Renewable Energy |
| REIPPPP | Renewable Energy Independent Power Producers Procurement Programme |
| RETs | Renewable Energy Technologies |
| SE4All | Sustainable Energy for All |
| SMEs | Small and Medium Scale Enterprises |
| UNDP | United Nations Development Programme |
| US | United States |
| W | West |
| VRA | Volta River Authority |
| VRPP | Variable Renewable Power Plant |

## Abstract Translation (Résumé)

Cette étude résume les politiques d'étiquetage des énergies renouvelables et de l'efficacité énergétique au Ghana, en commençant par l'objectif politique à travers les instruments politiques et les institutions politiques. La politique énergétique est donc une stratégie pour s'attaquer aux problèmes liés à l'approvisionnement en énergie, à la demande, au développement de l'industrie et du commerce liés à l'énergie et aux conséquences des activités énergétiques. Il y avait une série de politiques élaborées au Ghana pour améliorer l'utilisation des énergies renouvelables pour la production d'électricité et pour assurer l'utilisation efficace de l'énergie électrique. Certains des objectifs spécifiques de la politique gouvernementale comprennent sécuriser les approvisionnements en combustible à long terme pour les centrales thermiques, réduire les pertes techniques et commerciales en électricité, soutenir la modernisation et l'expansion des infrastructures énergétiques pour répondre aux demandes croissantes et assurer la fiabilité et accélérer le développement. technologies d'énergie renouvelable et d'efficacité énergétique. Bien que certains des objectifs aient été atteints, certains doivent encore être réalisés. Une étude détaillée de la littérature disponible, des rapports scientifiques, des entretiens structurés et des questionnaires ont été réalisés pour différentes parties prenantes des énergies renouvelables provenant d'institutions gouvernementales sélectionnées, des conférences professionnelles d'universités sélectionnées et des producteurs d'énergie renouvelable à travers le Ghana. Il s'agissait de connaître la favorabilité des politiques, la mise en œuvre des politiques incitatives et les barrières de l'énergie renouvelable. En outre, une analyse comparative a été faite avec les secteurs de l'énergie renouvelable de l'Afrique du Sud et du Maroc sur les différentes stratégies adoptées pour leurs réalisations et sur ce que le Ghana peut apprendre. (continuer). Des indicateurs d'énergies renouvelables ont été utilisés pour analyser la comparaison faite, SPSS, visio et excel ont été les outils utilisés pour analyser les entretiens et les questionnaires menés pour les parties prenantes. L'étude a révélé deux problèmes principaux dans le développement des énergies renouvelables au Ghana. Ces questions concernent la mise en œuvre des politiques touchant les générateurs photovoltaïques solaires hors réseau et hors réseau et les obstacles au développement des énergies renouvelables. En conclusion, les incitations politiques telles que le système de facturation nette, le tarif de rachat et les fonds d'énergie renouvelable n'ont pas été mis en œuvre; par conséquent, les diverses politiques gouvernementales établies sont les principaux obstacles à l'énergie renouvelable pour son développement au Ghana.

Mots-clés: Générateurs de réseau et hors réseau, barrières à l'énergie renouvelable, incitations politiques, institutions politiques

## Abstract

This study outlined the policies targeting renewable energy and energy efficiency in Ghana, starting from the policy objective through the policy instruments and policy institutions. Energy policy is thus a strategy for tackling issues related to energy supply, demand, development of energy related industry and trade, and the consequences of energy activities. There have been numerous policies developed in Ghana to improve the uptake of renewable energy for electricity production and to ensure efficiency use of electrical energy. Some of the specific government policy objectives include secure long-term fuel supplies for the thermal power plants, reduce technical and commercial losses in power supply, support the modernization and expansion of energy infrastructure to meet growing demands and ensure reliability, accelerate the development and utilization of renewable energy and energy efficiency technologies. While some of the objectives have been met, some are yet to be realized. A detailed study of the available literature, scientific reports, structured interviews and questionnaires were conducted for different renewable energy stakeholders from selected government institutions, professional lectures from selected universities and renewable energy generators across Ghana. This was to know the favourability of the policies, the implementation of the policies incentives and the renewable energy barriers. Also, a comparative analysis was made with South Africa and Moroccan's renewable energy sectors on the various strategies adopted to their achievements and what Ghana can learn from. Renewable energy indicators were used to analyse the comparison made, SPSS, visio and spreadsheets were the tools used to analyse the interviews and questionnaires conducted for the stakeholders. The study found out two main issues affecting the renewable energy sector of Ghana. 1) policy implementation affecting grid and off-grid solar PV generators; and 2) barriers to renewable energy development in Ghana and concluded that, policy incentives such as the net metering scheme, the feed-in-tariff and the renewable energy funds are poorly implemented in the country.



**Keywords**: Grid and off-grid generators, renewable energy barriers, policy incentives, policy institutions

Table of Contents

## List of Figures

## List of Tables

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background

Energy demand and its associated services to meet both social and economic development is increasing (Edenhofer *et al*., 2011). Presently, about 80% of the global energy demand is met from fossil fuels (REN21, 2018). Excessive fossil fuels consumption does not only lead to decrease in the rate of fossil fuel reserves Farhad *et al*. (2008) but has an impact on the environment. Even though access to energy improves human development, according to Asumadu-Sarkodie and Owusu (2016), 1.3 billion people, which is equivalent to 10% of the world's population, lack access to modern energy, with 22% of these living in developing countries. Close to 97% of the population without access to modern energy live in sub-Saharan Africa and developing Asia (IEA, 2017). Renewable energy (RE) is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. These resources which include solar, hydro, wind, bioenergy, geothermal, tidal and waves, can be used to generate electricity and heat. Unlike conventional energies, energy from renewable sources are of unlimited supply.

The use of renewable energy technologies has provided electricity to regions that lack electricity access, which will help create 11 million jobs as well as increase in energy efficiency up to 30% by 2050 (IRENA, 2018)

In Asian countries like India and China where there is increased energy demand due to rapid population growth and economic development Shukla *et al*. (2017), there is the need to source for energy alternatives specifically renewable sources such as solar, wind, biomass to reduce the over dependency on fossil fuels as well as manage the growing demand for energy (Salem and Kinab, 2015).

In Ghana, there are available energy resources that have not yet been exploited but of a great potential. Resources such as wind, tidal waves have not been exploited. There are about 22 mini and small hydro power exploitation sites across the country with potential ranging from 15 kW to 100 kW (UNDP, 2012) with a total of 800 MW.

More energy companies are investing in various energy projects in Ghana but growth of renewable energy technologies is low. The percentage share of solar photovoltaic is 0.5% (23.5 MW) out of the total energy installed of 4674.85 MW (Energy Commission of Ghana, 2017b). Although there are domestic and international financial incentives, policy and regulatory barriers limits the possibility of utilizing renewable resources in both off grid and grid-connected applications (Gboney, 2009).

Barriers to renewable energy application in Ghana have been classified into technical, social, environmental, economic and policy related barriers (Gyamfi *et al*., 2015). Another area that would need require critical focus to ensure successful transition into renewable and sustainable energy is investments in energy efficiency. This has been given attention in Ghana in recent times. In 2007, the government of Ghana introduced the National Implementation of Incandescent Lamps Exchange programme where Compact Fluorescent Lamps (CFLs) were given out freely nationwide. This programme helped in cutting down peak load demand of about 300 MW. in 2012, the government of Ghana with supports from the United Nations Development Programme (UNDP) and Global Environmental Facility (GEF) launched the 'rebate and turn in' programme which encouraged consumers to trade in their old and inefficient refrigerators with new and more efficient ones for a top-up fee. The government later banned the importation of old and inefficient used refrigerators which has led to a drop of about 63% in their import (UNDP, 2012).

## 1.2 Problem Statement

Figure 1 shows the relationship between policy objectives, policy instruments and policy institutions. Policy objectives are the long-term goals of the government in terms of what it wants to achieve. The Ghana government has set up a goal to generate 10% of its electricity from renewable energy by the year 2020. Later in 2018 the goal to generate 10% of renewable energy in the national energy mix was extended to 2030. The Policy Instrument gives effects to the renewable energy legislations that could help in the realization of the policy objectives. In that case, policy instruments are used to achieve policy objectives.

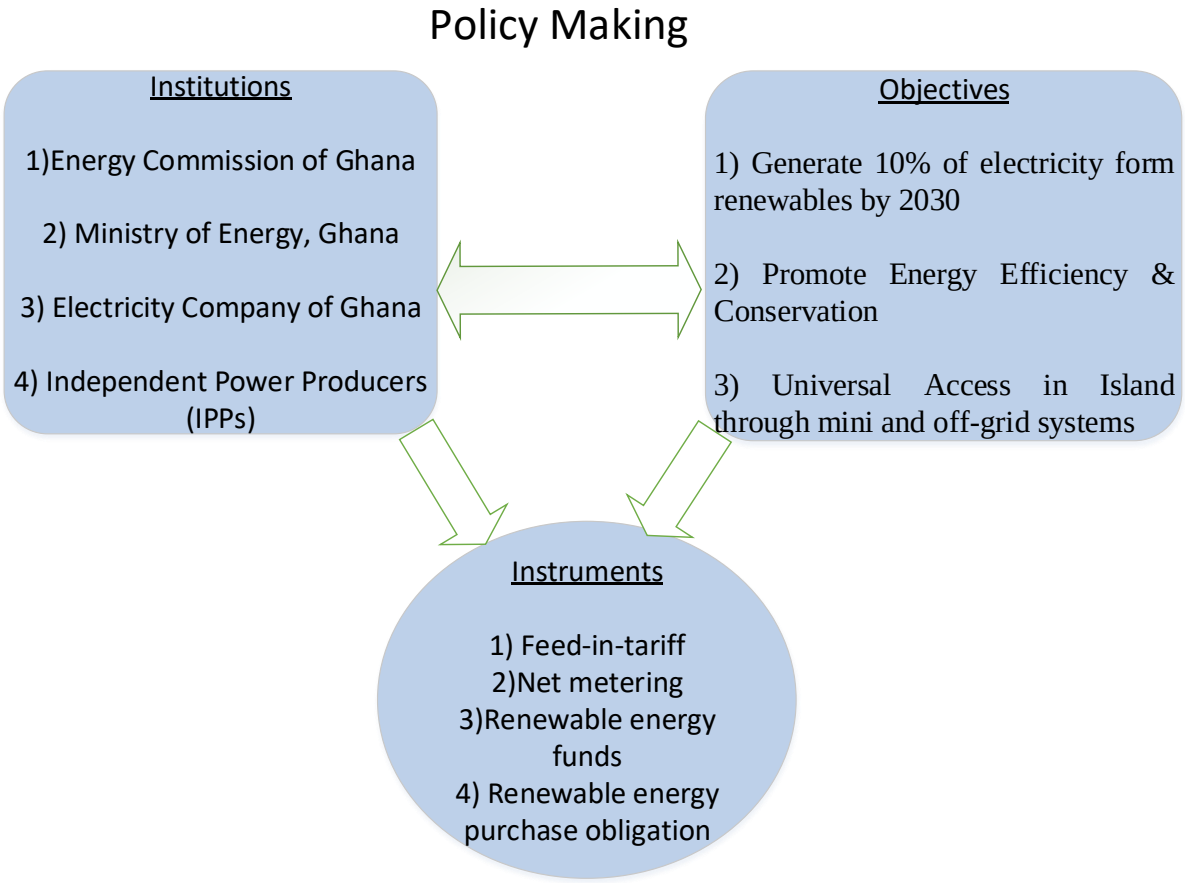


*Figure 1 Conceptual Framework showing the Policy Making Process in Renewable Energy Sector of Ghana*

**Source:** (Ministry of Energy, 2010)**;** (Energy Commission of Ghana, 2017b)

Although, there are interventions set thus the policy instruments to achieve the objectives however, the growth of renewable energies in Ghana is low. Currently, the percentage share of installed grid-connected renewable energy is 0.5% (22.6 MW of the current total installed capacity of 4674.85 MW) (Energy Commission of Ghana, 2017b), notwithstanding the potential. But there are challenges ahead with regards to the policy and regulatory environment.

### 1.3 General Objective

The main objective of the study is therefore to evaluate the success of renewable energy and energy efficiency policies in Ghana by matching the policy objectives against the policy outcomes.

#### 1.3.1 Specific Objectives

- To review the existing policies on renewable energy and energy efficiency in Ghana;
- To evaluate the success of the policies by matching the policy objectives against the policy outcomes; and
- To analyse challenges/barriers faced by energy institutions in the implementation of renewable energy and energy efficiency policies in Ghana.

#### 1.3.2 Research Questions

- What are the policies on renewable energy and energy efficiency in Ghana and what have been their outcomes?
- How well have the renewable energy policies been achieved?
- What are the barriers and challenges faced by Energy Institutions in the implementation of renewable energy and energy efficient policies in Ghana?

### 1.3.3 Hypothesis

- Flexible energy policies with right instruments and objectives enable easy implementation of renewable energy policies by institutions.
- Renewable Energy can be implemented cost effectively when efficient appliances are used.

## 1.4 Research Gap

Although, several studies have shown that network and technical such as system failure, economic and financial like high initial cost for start-ups, market for example high cost of renewables compared to that generated from fossil fuels as well as policy framework have contributed to the hindrance to achieve 10% of renewables by 2030

Most of these studies analysed these barriers on Ghana perspective. However, this study made a comparative analysis with Morocco and South Africa renewable energy policies.

## 1.5 Significance of the Study

The study would help to identify the loopholes in the renewable energy policies to other countries and strategies/measures to be put in place to attain the 10% of renewables in the national energy mix by 2030.

## 1.6 Thesis Outline

The first chapter introduces the concepts of energy technologies and elaborates on the topic to be studied. The chapter includes the main reasons of the choice of the topic, the goals to be achieved after the research and the importance of the research to society. The second chapter looks at the energy policies and implementation in Ghana. Contributions from literature on barriers to renewable energy development in Ghana and proposed mitigation

actions were made. In addition, a comparative analysis was made with Morocco and South Africa's success stories and the kind of strategies Ghana can adopt to help increase its renewable energy target. Chapter three is about the methods employed in achieving the objectives of the study. Chapter four presents the results, the findings and outcomes of the study conducted. The final chapter presents the conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

## 2.1 Introduction

Ghana as a country is divided into ten regions. The country is endowed with natural resources in the mining, agricultural and energy sectors. Most of the export commodities are from the agricultural and the mining sectors. Natural resource deposits such as gold, timber, diamond, rubber, bauxite, silver, limestone, salt and others whiles cash crops such as cereals, root and tuber crops are in abundance. The energy sector has petroleum deposit which was discovered in 2007 and exploitation began in 2011.

## 2.1. Overview of Ghana's Energy Sector

As shown in Table 1, Ghana's installed electricity capacity currently stands at 4673.8 MW (Energy Commission of Ghana, 2018) including large hydro, thermal and renewables of which 2334 MW are from Independent Power Producers (IPPs). Although the country has made a remarkable improvement in its energy sector, its target to reach 5000 MW of installed capacity by 2016, could not materialise.

*Table 1 Ghana's Total Energy Installed Capacity*

| **Type of Energy** | **Installed Capacity (MW)** |
|---|---|
| Hydro | 1580 |
| Thermal | 3071 |
| Renewables | 22.6 |
| **Total** | **4673.7** |

Source: (VRA, 2017); (Energy Commission of Ghana, 2018)

The table 2 shows Ghana's energy demand and supply projections whiles figure 2 shows energy consumption by customers.

*Table 2 Statistics on Energy Demand, Consumption and Supply in Ghana*

| **Energy Statistics** | **Year** | |
|---|---|---|
| | 2016 | 2017 |
| Total energy demand (MW) | 2,087 (13.8%) | 2,386 (14.2%) |
| Total energy consumption (GWh) | 13,700 (12.1%) | 15,615 (13.8%) |
| Total energy supplied (GWh) | 13,707 | 15,615 |
| Total solar consumption (GWh) | 36 | 36 |

Source:(Energy Commission of Ghana, 2017a); (Energy Commission of Ghana, 2018)

According to the Energy Commission of Ghana (2017a), peak electricity demand continues to increase at the rate of up to approximately 1 % and above.

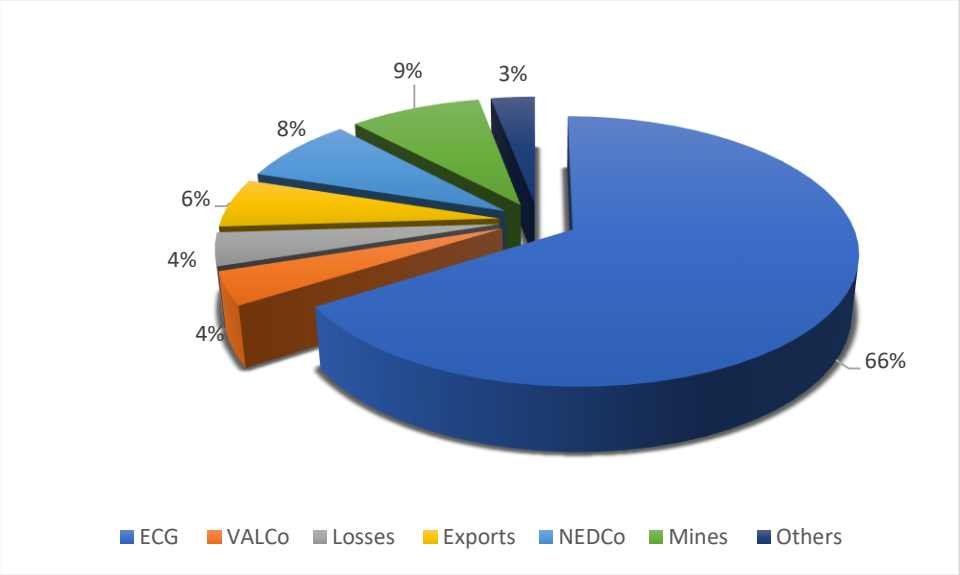


*Figure 2 2017 Projected Energy Consumption by Customers*

Source:(Energy Commission of Ghana, 2017a)

ECG is the largest bulk purchaser and distributor, 66% of electricity consumed in Ghana whiles NEDCo only purchase and distribute 8% of the total energy. The rest of energy is consumed by VALCo, an aluminium and steel company, mining companies, exports, sectors such as agriculture, health, transport contributes to other energy users.

In Ghana, the Volta River Authority (state-owned) and the Independent Power Producers (IPPs) are responsible for generating electricity in the country. Transmission of electricity generated is a sole responsibility of the state-owned Ghana Grid Company Limited (GRIDCo). However, distribution is done by two corporate bodies; the Electricity Company of Ghana which is responsible for distributing electricity to the six southern regions of Ghana whiles the Northern Distribution Company (NEDCo) is responsible for the four northern regions. Both distribution companies are state owned. Figure 2 shows the structure of the Ghana energy sector.

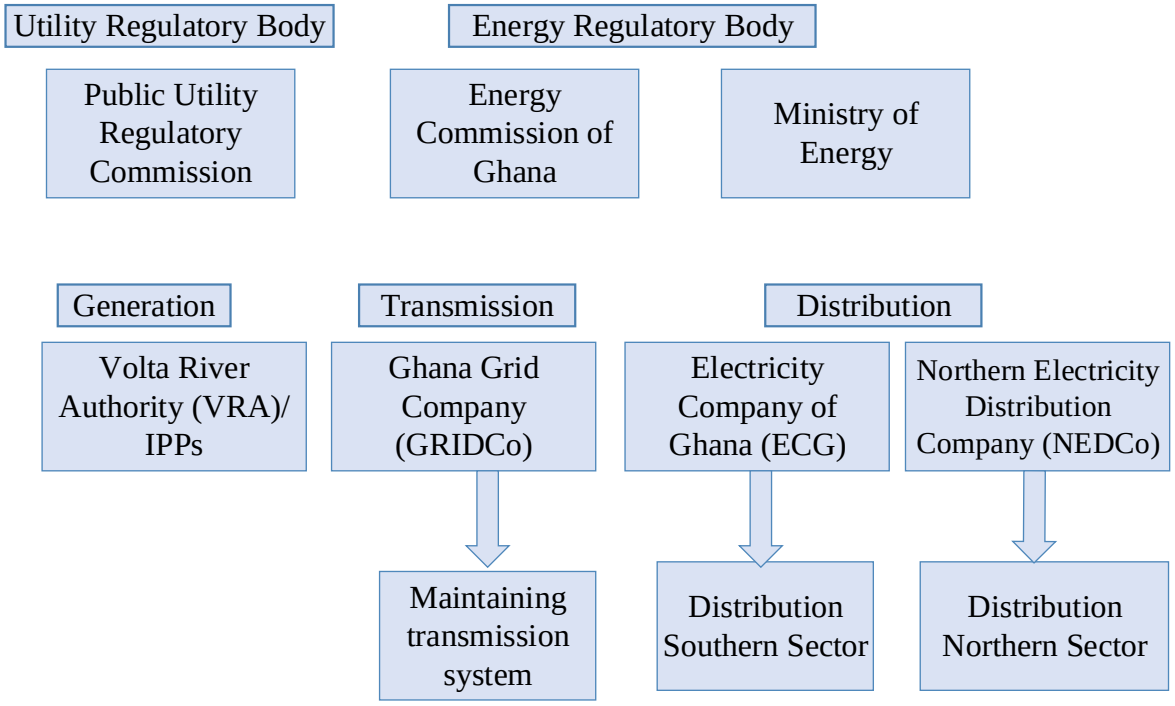


*Figure 3 Structure of Ghana's Energy Sector*

Source: (Energy Commission of Ghana, 2017b)

### 2.1.1 Renewable Energy Technologies in Ghana

Ghana has a renewable energy potential in wind, solar, biomass, small hydro, etc., that can be exploited for electricity generation in the country. A number of measures have been put in place to boost the renewable energy sector, but the sector has not made any noticeable

improvement for decades. Kwarteng (2017) reported that the country has an average solar irradiance of 5 kWh/$m^2$ of which 1 MW grid connected solar could be developed on every 4 acre of land, with an estimated total potential of 240 GW. However, only 23.8 MW of the 240 GW solar potential have been developed in the country (Energy Commission of Ghana, 2017). A wind potential of 2000 MW across the country is yet to be exploited. Estimated biomass potential of 2700 cubic metres which could generate 110 MW of power, according to research conducted by the Kwame Nkrumah University of Science and Technology, is yet to be exploited. Biomass resources such as firewood, energy crops, agricultural crop residues, forest products residues, urban wastes and animal waste are available. According to the Energy Commission of Ghana (2017), 16 potential hydro power sites have been assessed and work is expected to begin on them soon.

### 2.2 Review of Policies and Strategies on Renewable Energy Deployment in Ghana

Policies can help put in place the extent to which renewable energy is adopted in a country. Ghana has put in place several policies and measures to help promote the development of renewable energy technologies in the country, particularly, incentives that will attract investors into the renewable energy sector. Figure 3 shows the renewable energy policies in Ghana from 2006 to 2018.

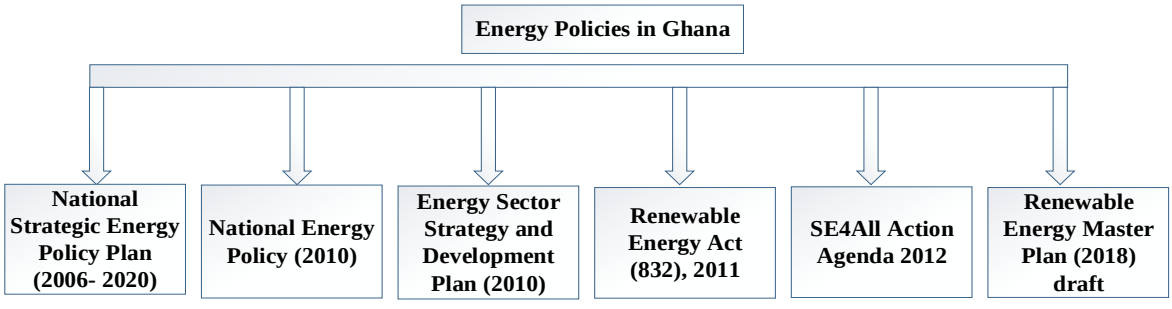


*Figure 4 Energy Policies in Ghana*

Source: (Energy Commission of Ghana, 2017b)

### 2.2.1 Strategic National Energy Plan, 2006- 2020

The Energy commission of Ghana has mandate to review all plans to ensure energy demands are met in a sustainable manner. The Commission developed the Strategic National Energy Plan for the period 2006 to 2020. The goal was to provide a sound energy market and to ensure the provision of sufficient energy services for Ghana. The target was to boost the renewable energy market. The renewable energy objective of this policy aimed at increasing the share of renewables up to 10% by 2020 whiles ensuring energy efficiency and conservation (Ministry of Energy, 2006) and to achieve universal access to electricity by the year 2020.

The policy seeks to develop the renewable energy technology regulations through the development of standards and codes to increase the growth of renewable energies in Ghana. Under Energy Efficiency and Conservation, the government continues to encourage the use of efficient appliances such as compact fluorescent bulbs (CFCs) and LED bulbs. Various measures have been put in place to ensure efficiency of energy consumption; to adopt energy demand side management, and to set up Energy Efficiency Revolving Fund to offer low interest facility of energy efficiency improvement in the country. However, the government is yet to release fund for its implementation (Ministry of Energy, 2006).

### 2.2.2 National Energy Policy, 2010

The vision for the National Energy Policy in 2010 was to develop an energy economy to ensure secure and reliable energy supply to all Ghanaians. Due to the high cost of solar and wind technologies which makes the renewables uncompetitive at the market level, the renewable energy sub-sector was introduced under the National Energy Policy 2010 to increase the proportion of renewable energy in the total national energy mix and also to focus on the fiscal incentives, awareness creation and regulations to promote energy efficiency and

conservation in the country. The policy also set the target to achieve 10% of renewables by the year 2020 and reduce wood fuels consumption from 66% to 30% by 2020; encouraging the use of clean cooking alternatives such as LPG, and efficient cook stoves (Ministry of Energy, 2010).

### 2.2.3 Energy Sector Strategy and Development, 2010

The Energy Sector Strategy and Development Plan was also introduced in 2010 alongside the National Energy Policy 2010 and it covers strategies, programmes and projects intended to support the national development agenda of Ghana in the following areas;

- Energy Sector Institutions
- Power sub-sector
- Petroleum sub-sector
- Renewable energy sub-sector

This policy sets the goal and strategies to be put in place to increase (1) the percentage of renewable in the total national energy mix and efficient use of stoves (Ministry of Energy, 2010) and (2) establish legislation to encourage the development of renewable energy technologies.

### 2.2.4 The Sustainable Energy for All Action Plan (SE4ALL), 2012

The Sustainable Energy for All (SE4All) Action Plan targets universal access to electricity to islands and riversides communities in Ghana through both on and off-grid systems and also provide universal access to clean cooking solutions. The UNDP in 2012 collaborated with some partner agencies to provide a universal access to sustainable energy by 2030. The current electricity access in Ghana is 84% (Energy Commission of Ghana, 2018).

Asumadu-Sarkodie and Owusu (2016) reviewed the national energy statistics and policy framework to create awareness on the national strategic plans to help in national decision-making for the efficient development and utilization of energy resources to know what have been done and what is the way forward. Review of the trends, policies, plans and programmes that would help to increase energy access in Ghana with a focus on electricity, cooking fuels and renewable energy, Kemausuor *et al*. (2011) argued that government for the past years have not delivered effective results to accelerate energy access specifically in rural and peri-urban areas where these services are badly needed and calls out to the government to set out strategies such as financing mechanisms to achieve the said targets. Proposing what constitutes energy access and energy access indicators, a study by Mensah *et al*. (2014) which reviewed the different types of indicators to measure the energy access in Ghana by using the energy access indicators employed in Ghana and concluded that Ghana has achieved a commendable access to modern energy compared to some other sub-Sahara African countries. The Renewable Energy Master Plan (draft) 2018, is yet to be launched (Energy Commission of Ghana, 2012b).

### 2.2.5 The Renewable Energy Act, 2011

In 2011, The Renewable Energy Act, 2011 (Act 832) was passed. The Act was enacted to provide for the development, management, utilization, sustainability and adequate supply of renewable energy for the generation of heat and power, and provide an enabling environment to attract investors in the renewable energy sources (Appiah, 2015). Under this Act, there are Licencing procedures, feed-in-tariff scheme, purchase obligation and rights to transmission and distribution systems for RE plants, net metering and renewable energy fund (Energy Commission of Ghana, 2015). The Feed-in-tariff scheme was established under the Renewable Energy Act 2011 of Ghana to guarantee the sales of electricity generated from RE sources. The Public Utility Regulatory Commission (PURC) is responsible to set feed-

in-tariff rates under the 2011 Act. The feed-in-tariff rates are guaranteed at a fixed rate to a registered producer for a maximum of 10 years and subject to renewal for every two years thereafter. PURC publish feed-in-tariff rates for energy generated from solar, wind, small hydro, waste-to-energy, biomass technology and takes into account the type of technology used, and the location of the generating facility.

### 2.3 Grid Integration of Renewable Energy

Renewable Energy transmission and distribution sub-codes were developed that proposes minimum technical connection conditions for a Variable Renewable Power Plant (VRPP) or Embedded Generator to the Distribution Network. The code is in line with National Electricity Distribution Code and international best practices and standards that constitutes the basic requirement that VRPP need to comply with to be able to connect to the network. Any variable renewable power plant (VRPP) that is to be connected to the distribution network with a nominal capacity greater than 1 kW are to comply with the National Distribution Code (Energy Commission of Ghana, 2015).

A report by the Ministry of Energy (2010**)** pointed out that distribution infrastructure is old, distributing electricity to only 66% of the population which has resulted in fluctuations in transmission.

Areas that receive significant amount of solar gives information to policy makers and individuals concerning solar grid connected system performance in the country (Quansah *et al*., 2017). Grid network systems are often characterized by insufficient power supply and interruptions Abdoulaye *et al*. (2012) as a result of this, solar PV generators are unable to profit from their installations and proposed battery storage as a solution to their problems. However, Adaramola *et al*. (2017) counter this statement that PV battery storage comes with a high cost which are hardly cost competitive with grid option serving as a storage facility

thus preventing the cost on battery storage. While variability of hybrid mini grid is a solution to rural electrification development in South Africa, Azimoh *et al*. (2016), the development of distributed technology in rural communities where there is adequate resource potential is a solution to help reduce the current energy outages in Ghana (Gyamfi *et al*., 2015). In Addition, Arranz-piera *et al*. (2018) indicated that planning the rural electrification projects in underdeveloped countries are facing great challenges by decision makers and practitioners, however, since there is a lot of biomass potential in remote areas standalone mini-grid electricity service using agricultural residue would be beneficial. Nevertheless, connecting renewable to the national grid or off grid systems are expensive Abdoulaye *et al*. (2012) government however need to absorb the cost on transmission and distribution as well as providing incentives and funding options for renewable energy producers. Moreover, the development of rural electrification project in underdeveloped countries is to bring about socioeconomic development to households (Azimoh *et al*., 2016). Furthermore, Kemausuor and Ackom (2017) argued that electricity generation in Ghana has not met demand and there should be the need for distributed generation systems, using community mini-grid and off-grid systems as alternatives which could help to explore within the framework to reach the unserved poor located in remote rural communities in the country. Besides, renewable energy does not necessarily require grid connection but can be developed on a much smaller scale (Krauber, 2014).

### 2.4 Renewable Energy Licensing Procedures

Under the Renewable Energy Act 2011, an applicant is required to obtain a license in order to operate in the renewable energy domain. However, there are some requirements that need to be followed to acquire a permit. To qualified, the license will only be granted to

- a citizen

- a body corporate registered under the Companies Act, 1963 or alternatively, registered under any other laws in the country and
- a Partnership to be registered under the Incorporated Private Partnership Act, 1962, (Act, 152).

Also, the applicant must apply directly to the Energy Commission of Ghana, a state body responsible for granting license to the energy sector in the country with a fee. The applicant will be granted a permit license by the Commission based on the fulfilment of the necessary requirements which is granted for a period of time and is subject to renewal. The license is applied for the following activities; production, transportation, storage, distribution, installation and maintenance, sales and marketing, exportation.

The procedures to acquire a license involve 3 stages. The first stage is the provisional acquisition of license. The second stage is siting permit for construction and finally, the company has to acquire an operational licence.

*Table 3 Stage one of the Licence Acquisition Process - Acquisition of Provisional Licence*

| **Required Submissions** | |
|---|---|
| Exhibit WS1 | Scope of operations (Summary description of project, including technical details |
| Exhibit WS2 | Company Registration Documents (include form 3) |
| Exhibit WS3 | Principal Officers, Director and Partners (include contact details) |
| Exhibit WS4 | Ownership and Corporate Structure |
| Exhibit WS5 | Cross-Ownership and Ring Fencing |
| Exhibit WS6 | Disclosure of Liabilities and Investigations |
| Exhibit WS7 | Financial Capability and Proposed Financial Plan |
| Exhibit WS8 | Statement of Assets |
| Exhibit WS9 | Feasibility Report |
| Exhibit WS10 | Business Plan |
| Exhibit WS11 | Company History and Existing Activities |

| | |
|---|---|
| Exhibit WS12 | Industry Participation |
| Exhibit WS13 | Operational Experience and Expertise |
| Exhibit WS14 | Specific License Conditions and Exemptions |
| Exhibit WS15 | Indicative Implementation Plan |
| Exhibit WS16 | Commercially Sensitive Information |
| Exhibit WS17 | Generating Plant Technology and Type of Renewable Energy Resource |

Source: (Energy Commission of Ghana, 2012a)

*Table 4 Stage two of the Licence Acquisition process- Land Permit*

| **Required Submissions** | |
|---|---|
| Exhibit WS18 | Site Analysis Report |
| Exhibit WS19 | Land Coverage Agreement |
| **Exhibit WS20** | Geological Survey |
| **Exhibit WS21** | Health, Safety and Environmental Plan |
| **Exhibit WS22** | Environmental Permit |
| **Exhibit WS23** | Site Layout and Right of Way |
| **Exhibit WS24** | Water Use Permit (applicable to only hydro generators) |
| **Exhibit WS25** | Implementation Agreement |
| **Exhibit WS26** | Detailed Implementation Schedule |
| **Exhibit WS27** | Plant and Machinery Specifications |
| **Exhibit WS28** | Construction Contract |
| **Exhibit WS29** | Gazetted Feed-in-Tariff by the Public Utility Regulatory Commission |
| **Exhibit WS30** | Power Purchase Agreement (with an off-taker) |

Source: (Energy Commission of Ghana, 2012a)

*Table 5 Stage 3: Acquisition of Operational License (Authorization to operate fully)*

| | **Required Submissions** |
|---|---|
| Exhibit WS31 | Supply Agreement (equipment, part**s)** |
| **Exhibit WS32** | Operations and Maintenance Plan |
| **Exhibit WS33** | Safety and Technical Management Plan (including Environmental Management Plan |
| **Exhibit WS34** | Commissioning Report |
| **Exhibit WS35** | Plant Drawing |
| **Exhibit WS36** | Receipt of Initial License Fee |

Source:(Energy Commission of Ghana, 2012a)

*Table 6 Schedule for License Fees in Ghana*

| **Type of Permit** | **Application Fee GH₵** | **Sitting Fee GH₵** | **Size of Plant** | **Initial Licence Fee GH₵** | **Annual Operational Fee (GH₵)** | |
|---|---|---|---|---|---|---|
| | | | | | Fixed | Variable |
| **Wholesale Electricity Supply** | 17,500.00 | 35,000.00 | ● Small scale 10kW ≤ 10MW | 7,000.00 | 7,000.00 | 1,750.00 per MW installed |
| | | | ●Medium scale 10MW ≤ 100MW | 28,000.00 | | |
| | | | ●Large scale ≥ 100MW | 52,500.00 | | |

The fees are reviewed annually. GH₵ 4.6~ 1 USD (June 2018 rates)

Source: (Energy Commission of Ghana, 2012a)

An applicant willing to operate in the renewable energy industry needs to undergo all the above procedures before acquiring a license to operate.

## 2.5 Comparative Analysis in Ghana, Morocco and South Africa Renewable Energy Policies

The Government of Morocco has put in place regulations and laws to promote utilization of renewable energy in the country, has established institutions to manage and promote renewable energy and has invested in their RE sector (Leidreiter and Boselli, 2015). In 2008, the National Renewable Energy and Energy Efficiency Plan was launched to achieve 42% of its energy from renewable sources by 2020 and more than a half (52%) by 2030 (Moulin, 2011). A report by World Energy Council (2016) pointed out that 34 % of the total installed electricity capacity in 2017 are from renewable energy sources and a further preparation is to be put in place to meet its target. Morocco has abundant wind energy potential estimated at 6000 MW with an average wind speed between 8 m/s and 11 m/s (World Energy council, 2016). The country has no fossil fuel reserves and is regarded as the largest importer of energy in North Africa (Morocco World News, 2018a). As a results of its high importation bill, the government has put various implementation measures to exploit all available energy potential to generate energy from renewables as well. Morocco has set a target to achieve 14% of energy from solar by 2030 Morocco World News (2018a). Approximately 14% (1200 MW) of energy from wind is targeted by 2020 (Morocco World News, 2018b) and an installed capacity of 2000 MW by 2030 (World Energy Council, 2016). Out of the 14%, 800 MW representing 9.4% have been achieved in 2015 (Energypedia, 2018) and a lot of provisions for RE projects are being put in place to boost its market. The policy also set a strategy to achieve 15% of energy efficiency by 2030 (Karmouni, 2016). Besides, the country is expected to add 18% within a period of 13 years to achieve the 52% target by 2030.

Furthermore, feed-in-tariff rates are not fixed but agreement of the rates is between the power producer and the government. An effort that shows that Moroccans have made a massive improvement in their renewable energy sector.

In South Africa, the Renewable Energy Policy, the White Paper was launched in 1998 and 2003 with the fifth objective addressing the need to generate energy from renewables which sets a target of 10,000 MWh by 2013 (Thabethe Hon E, 2010). Although the country has significant amount of solar and wind potential, its development has been slow (Edkins *et al*., 2010). Notwithstanding that, South Africa has the largest wind energy market with installed capacity of 1053 MW in Africa, followed by Egypt with 810 MW and Morocco with 800 MW (Oxford Business Group, 2016). Furthermore, more than a 90% of energy is generated from fossil fuel mainly coal (Nano Energy, 2008), making the country's renewable energy sector at a very low pace. In addition, the country has targeted a 97% of universal access by 2025, with 90% grid connection; although its current energy access is between 85% to 90% (RECP, 2018) an indication that its target will be achieved but mostly from energy generated from fossil fuels. As at 2016, a wind capacity of 1,460 MW, solar PV of 1,474 and a 200 MW of CSP are currently in operation and fed into the grid (Bischof-niemz, 2017). Currently, renewable energy contributes to 3% of the total energy (Power Africa, 2017), with a target of 17.8 GW (9%) by 2030 (Fisher and Downes, 2014).

In Ghana, the National Energy Plan 2010 targeted a 10% share of renewables and a universal access by 2030. Currently the percentage of renewables is less than 1% whiles fossil fuels contribute more than 60% (VRA, 2018). The various policies implemented have not been able to help increase the generation and consumption of renewables in the country. It is therefore proposed that Ghana can learn from the success stories of these two country to bring out the loopholes in the various policies in achieving their target. Hence comparison is made in line with the two countries' renewable energy sector. More of the success stories will be analysed in the discussion session of chapter four.

### 2.5.1 Renewable Energy Policies Incentives in Ghana, Morocco and South Africa

To make renewable energies attractive, policy incentives are implemented to allow renewable energy generators to benefit financially.

#### 2.5.1.1 Feed-in-Tariff (FiT)

Unlike Ghana and South Africa, Morocco do not have legally fixed FiT but the Moroccan Agency for Solar Energy (MASEN) see to all funding needs for individual projects and governmental programs. Feed-in-tariff in Morocco is signed according to the Power Purchase Agreement (PPA) between the producer and the government. The Feed-in-tariff rates are very high for South Africa RE generators than Ghana's rates. There is likelihood of change (increase or decrease) in the feed in tariffs rate which does not affect the guaranteed period issued to the producer (Government of Ghana, 2011). Tables 7 and 8 shows the feed-in-tariff rates in Ghana and South Africa respectively.

*Table 7 Feed-in-Tariff Rates in Ghana*

| **Electricity generated from Renewable Energy Technology/source** | **FIT (UScent/kWh) Effective October 01, 2016** |
|---|---|
| Wind with Grid Stability Systems | 14.0 |
| Solar | 12.6 |
| Hydro <= 10MW | 11.0 |
| Hydro >10 MW, <=100 MW | 11.87 |
| Tidal wave (ocean wave) | 11.1 |
| Run off river | 11.1 |
| Biomass | 14.49 |
| Biomass (Ethanol Technology) | 15.12 |
| Biomass (Plantation as feed stock) | 16.38 |
| Landfill Gas | 14.51 |
| Sewage Gas | 14.51 |
| Geothermal | 9.8 |

Source:(PURC, 2016)

*Table 8 Feed-in-Tariff Rates in South Africa*

| Renewable Energy Technology | FIT rates in Eurocent/kWh |
|---|---|
| Solar Photovoltaic | 26 |
| Wind | 15.6 |
| Concentrated Solar Power | 46 |

Source: (Anton & Kaberger, 2016)

### 2.5.2 Net Metering Scheme

This allows electricity producer to export excess power to the national grid and use the exported electricity to balance out deficit which allows them to meet their demand with their own power generated. The Net Metering solar PV technology provides back up storage that makes it possible for power producers to self-generate power and continue usage during power failure (Nawathe *et al.*, 1982). There exists a customer-generator relationship between the utility and the producer. The net metering sub-code was embedded in the Renewable Energy Act 2011 of Ghana. A report indicated that the government has not been able to implement the Net Metering system since it was passed in 2012. However, the Energy Commission in collaboration with the Electricity Company of Ghana has piloted 35 net metering systems in 2017 but the Commission is waiting for the tariff structure from the PURC of Ghana. Net metering is yet to be introduced in South Africa. The country is currently experiencing some challenges in the grid connection of some projects making it difficult to implement this scheme. Also, preparations are in place to implement the net metering in Morocco, but generators are allowed to sell out the exported power no more than 20% of their annual production (Yaneva, 2016).

### 2.5.3 Renewable Energy Funds

The provision of funds to support the RE sector is included in the Renewable Energy Act 2011. The provision is to offer financial support to promote the development and utilization of renewable energy in the country. Funds in the form of financial incentives, feed-in-tariff, capital subsidies, importation levy, production-based subsidies, etc., are mentioned. The Renewable Energy Fund has not funded any project yet. The Ghana Renewable Energy Risk Capital (GRERC) funds which is intended to find innovative financial solutions to the renewable energy lacks the needed support. In 2012, The World Bank established the Africa Renewable and Access program (AFREA) in some areas in Africa with special energy needs (World Bank Group, 2015). The project contributed $28 million to fund the AFREA which was reported to be successful because it was linked to shaping, leveraging and has also empowered development and proper implementation measures to the International Development Association portfolio.

Morocco is massively investing its renewable energy sources to meet its target. In addition to the numerous efforts made, an amount of $40 billion has been invested into their renewable energy market to achieve its goal by 2030 (Morocco World News, 2018b) South Africa's Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) established in 2009 allows for competitive bidding through the setting up of this programme and has been able to call out for various investment into the renewable energy sector of the country.

### 2.5.4 Renewable Energy Purchase Obligation

This allow an amount of renewable to be purchased from the generator. In Ghana, it is mandatory for bulk distributing companies to purchase some quantity of power from the generator, although this amount is not stated. According to the NERSA Consultation Paper,

(2009) in South Africa, the Renewable Energy Purchasing Agency is obliged and mandatory to purchase power from renewables. The case of Morocco appears to be an introduction of rates to renewable energy generators connected to the grid and National Office for Electricity and Waste (ONEE) purchases excess power produced (Africa Energy Forum, 2015).

## 2.6 Barriers to Renewable Energy Development

The barriers to renewable energy development are identified below.

### 2.6.1 Economic and Financial

Financial and economic barriers are identified as a barrier to renewable energy development in the country. Financial constraints include high start-up cost, high interest rate, high government taxes and unstable currency (Bensah *et al*., 2015) transaction costs, economic status (Kariuki, 2018).

Lack of financial management has limited business community from setting up businesses successfully Dauda (2011) and government need to provide support in a form of capital to overcome capital barriers. Battaglini *et al*. (2012) pointed out that recent studies suggested CSP could reduce the carbon emission from electricity generated but capital is a challenge to the North African countries to encourage high foreign investment from the private sector. To increasing potential on energy efficiency in developing countries stated by Painuly *et al*. (2003) is financial constraints and the paper outlined that, service companies face market, finance and poor energy policy pricing which are required to promote energy service companies with measures to increase renewables. In addition, there is monopoly of electricity generation, transmission and distribution by some governmental agencies in most developing countries Attachie and Amuzuvi (2013) that has resulted in little or no access to electricity in rural communities where larger proportion of the population resides and further

discussed factors that have prevented the growth of solar photovoltaic in the market as environment and lack of financing being the main source of limitation

### 2.6.2 Stakeholders Disengagement

Although stakeholders are involved in decision making, some generators have raised concern regarding insufficient involvement and compliance to their needs in the country. Due to bureaucracy, concerns raised by them are sometimes not taken into action. An instance is where these generators are seeking for free import duty on solar panels, the government of Ghana has rather increased taxes on these panels; although it is stated in the Energy Sector Strategy and Development, 2010 to provide incentives for imported devices on renewable energies to increase it generation in the national energy mix. Some concerns raised are though still on hold.

Stevenson and Wales (2010) suggested that development of renewables has become a challenge for some years and recommended new policy and framework for policy delivery on renewables such as involvement of stakeholders in policy formulation for sustainable development policies. Gottwald (2012) indicated that the involvement of stakeholders and policy analysts will help boost the level of technology and development of renewable energy market.

### 2.6.3 Socio-cultural Beliefs

While it is policies that hinders renewable energy development in some countries Pasqualetti (2011) identified social barriers to renewable energy development being environmental, political and environment and need to be dealt with more of social than technical. Households are unwillingness to adopt to the use of renewable energy due to the fear of unreliability (Kariuki, 2018).

Ghana is depended on biomass consumption due to the abundance of biomass resources. In 2013, biomass consumption contributed to 39%, electricity 15% and 46% from petroleum sector (Energy Commission of Ghana, 2014). These consumption is mostly in rural areas. The renewable energy technologies are seen to be new since they have been using biomass for cooking and lighting for so many years. Some even belief that, the modern technologies are threats to the society. Also, due to some failed piloted projects encountered previously has prevented most of the people to use the technology.

Wu *et al*. (2007) added that, one main renewable energy technology barrier of not achieving its target set by various government is social acceptance which is further categorised as community, market and socio-political. The paper further proposed that there is the need for proper research from scholars to deal with the problem

### 2.6.4 Inadequate Awareness on the use of Renewable Energy Technology

Information required are not properly clarified to the people. Information such as the financial benefits on renewable which comes as a long term benefits are not well clarified.

One main barrier found by Mitchell and Connor (2004) in UK renewable energy sector is lack of clarity of goals to policy implementation and explained that government must comprehend from previous mistakes, challenges and difficulties to focussing on engaging mentors to give adequate motive for the support of renewables.

### 2.6.5 Technical and Network

This include inadequate technology and infrastructure necessary to support the renewable energy technologies. Inadequate human skills on manufacturing and installations, immature technological knowledge, difficulty in obtaining spare parts, problems in maintaining devices, transmission and distribution constraints. To implement effective and well planned policy in order to encourage more investment Klessmann *et al*. (2011) suggested that there

is the need to do system upgrade on grid connection infrastructure to increase energy efficiency effort in less developed country to meet their energy demand. Although there are available incentives to encourage renewable energies in the UK, system failure in technology innovation has been identified by Foxon *et al*. (2005) as the main barriers and proposed new innovative solution as getting information on technology feedback between stages of development. Measures to reduce carbon emission in European countries involves a large scale and decentralized renewable sources Battaglini *et al*. (2012) which requires improvement on grid system and the effort to enlarge it has become a problem of inappropriate regulatory framework and public acceptance to use renewable energies. Unruh (2007) also identified institutional factors, techno economic of technology components, system-level infrastructure all contributes to RETs development which they propose financial institutions and local acceptance to deal with the problem. The views of Hammons (2008) in his paper assessed challenges on current grid and future smart grid and the findings proposed that these challenges can be in a form of distributed generation and the use of renewable energy sources. Hagan (2015) on the other hand, identified these barriers as inadequate indegenious capacity building; and lack of skilled technical human resources to oversee renewable energy projects and also inexperienced institutions

### 2.6.6 Policy and Regulatory Framework

Lack of enforcement in regulatory framework and codes, political willingness, non-implementation of incentives and bureaucracy due to frequent changing of government in Ghana.

Ã *et al*. (2010) compared implementation of policies on electricity generation from renewables with other countries and argued that the long term policy goals on energy security, its mitigation actions and policy instrument are lagging in providing incentives on

new technologies. South Africa which is a carbon intensive energy consumer has taken steps to promote energy efficiency and increase generation from renewables Pegels (2010) yet, have failed to show large scale efforts. The paper further explained that feed-in-tariff to increase renewables would rather be effective for small scale quantity generated. Also, to know whether quantity-driven such as Tradable Green Certificate based on quotas (quantity) or quality driven in a form of feed-in-tariff instruments are strategies to increase the share of renewables in the country Haas *et al*. (2011) stated that renewable energy success in the European countries is rather as a result of the quality driven implementation and not quantity driven. Menanteau *et al*. (2010) also outlined the different incentives scheme on energy efficiency for renewable energy development in the European states by comparing price-driven and quantity-driven approaches and concluded that price-driven approach such as feed-in-tariff are more effective and efficient than bidding systems. For problems associated with penetration of renewable energy supply systems in Europe, Meyer (2003) argued that there is too much emphasis laid on free trade at the rate of long range planning for sustainable development. Jäger-Waldau (2007) pointed out that there was massive growth in photovoltaic and other renewables in Europe during the increase in oil prices in 2005 hence the need to increase prices on fossil fuel leading to an exceptional re-evaluation by political and financial organization. Also, Renewable energy barriers have been limited to institutional framework and policies, high initial cost, lack of man power, inadequate information Karekezi and Kithyoma (2002) government needs to provide financial mechanism in a form of micro credits institutions, corporate loans and organising long term policy programmes. Edjekumhene (2017) stated that renewable energy policy formulation lacks private sector involvement, hence the policies are unfavourable for the private institutions to go into renewable energies. Apeaning and Thollander (2013), in their study which was aimed at enhancing the knowledge of industrial energy efficiency and

management strategies in Ghana investigated the various barriers to and the driving forces for implementing in Ghana's largest industries and concluded that energy is poorly managed and these gap is as a result of low implementation measures, while Gboney (2012) suggested that these barriers requires both government's commitment towards a comprehensive strategy and support from different stakeholders to search for solutions which can be supported from international support for capacity building, technical assistance and finance.

### 2.6.7 Market Barrier

In Ghana, generation and consumption of renewable energies is currently very low. Although market exist, the size is small. Generators finds it difficult to compete with fossil fuel market due to the unusual efforts made to convince their existing and new customers to use renewables.

Martinot (1999) stated that market level energy prices, privatization and Independent Power Producers (IPPs) favour investment in renewable energy development but the investment are linked to transaction barriers such as capital and institutional incentives. Weisser (2004) argued that the only way to promote renewable energy market is to reduce cost on electricity generated from renewables however, it will require both policies and structure of electricity planning. Owen (2006) studied the externally impact of market constraints to renewable energy development and showed that externality cost borne on fossil fuel in a form of damages could be used to construct numerous renewable energy technology development which is far beneficial to a country. Gyamfi *et al*. (2015) presented the barriers of renewable energy utilization as a result of higher electricity cost on renewables compared to the electricity costs generated from fossil fuel sources. Amewu (2011) proposed that if market is not producing renewables, then market see no need for renewables.

### 3.6.8 Over Dependency on Fossil Fuel Resources

Carbon intensive resources have locked up the promotion of renewables and has limited strategies to carbon reduction Lehmann *et al*. (2012) suggested in their studies that carried out assessment on the performance on existing policies and proposed a feed-in-tariff payment as a solution. Kousksou *et al*. (2015) outlined the barriers that has hindered the promotion of renewables in Morocco as the bulk intensive fossil fuel utilization; the paper however concluded that incentives, tax reduction should be given out to related bodies to help promote RETs. Dittmar (2009) suggested that for developing and developed countries to switch to the use of renewable resources, they must gain independency from oil and fossil fuel whiles it was further stated by Bailey (2008) that oil imports are a major contributor to Ghana's debt as 10% of its GDP are spent to import oil for use Renewable energy sources will still support developing countries to gain independency from fossil fuel.

### 3.6.9 Over Dependency on Centralized Grid

Deichmann *et al*. (2011) in their study identified and concluded that over dependency of centralized grid is a barrier to rural energy development however, renewable energy can be alternative means to providing energy access through decentralized system, by so doing, it will encourage the consumption of renewables in the country.

### 3.6.10 Cross-Cutting Barriers

Some literature also identified more than one barrier on renewable energy development. These barriers have been grouped under the cross-cutting barriers. These includes the interconnection of renewable energy barriers of financial, network, market, awareness, stakeholders' disengagement, socio-cultural beliefs, policy regulatory framework, over dependency on fossil fuel resources.

Verbruggen *et al*. (2010) in their study investigated the interconnection of factors affecting renewable energy supplies which pointed out that cost and prices of energy goods and services provided have effects on its development and proposed a potential unified taxonomy regarding policy driven as a whole. Mezher *et al*. (2012) pointed out that not only climate change and fossil fuel consumption are the main drivers to renewable energy resource exploitation but high cost on technology, economic and political interference were also identified to be the barriers to renewable power generation and suggested that there should be mixed implementation on feed-in-tariff and quota systems for the United Arab Emirates to meet its target set.

Bensah *et al.* (2015) demonstrated that financial and market barriers could be removed through provision of grants, soft loans, flexible financial scheme as well as organizing awareness and training programs. Notwithstanding the barriers such as market, technical, regulatory, social and environmental contribute to its development Painuly (2001) and these could be removed by consulting various institutions, policies should be implemented, tax exemption, credit facilities and incentive-based mechanism should all be adopted. Although Ghana is endowed with renewable energy sources, exploitation of these renewables for electricity generation is currently low Gyamfi *et al*. (2015) further highlighted five main barriers to renewable energy utilization as: (1) technical which includes trained personnel, voltage fluctuations (2) social (3) environmental (4) economics and (5) Policy and Kemausuor *et al*. (2011) identified eight main barriers adding up (6) inadequate access to modern energy services, (7) inadequate information and awareness; fear on the part that the project might fail and (8) Stakeholders' involvement.

The Energy Commission of Ghana (2015) also conducted a survey that presented the various findings of Ghana's Renewable Energy Policies in conjunction with the China Renewable energy policy and the factors that constrain the development and the deployment of the

various stakeholders; concluded that poor financing of renewable energy investments; lack of affordability of renewable energy systems; cumbersome licensing processes; challenges with enabling instruments for RE investment; unbalanced emphasis on on-grid RE systems. Bensah *et al*. (2015), in their paper stated that, one of the driving forces of renewable energy technology access is the inadequate modern energy services; although with the high rate of electricity access, there are still a huge number of off-grid communities in the country as well as the high dependency on charcoal and wood fuels, renewable energy market size, the high interest rate to finance the project, among others are the main causes of renewable technology transfer in the country. Even so, renewable energy sources do not only provide energy to the society but also help to reduce the massive indoor pollution from biomass resources, Pegels (2010) hence a contribution to health improvement. Therefore, solution to barriers on renewable energy should be a country's priority. In Addition, barriers to industrial energy efficiency improvements in some developing countries are more noticeable due to factors such as weak energy policy frameworks, financial constraints, weak information systems and many more.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 Introduction

In this chapter, methods used have been identified and justified explaining the motive why it is suitable for the objectives of this research. Discussions will be focused on scope of the study, data collections procedure, the various stakeholders involved, comparative analysis with other countries, data collection methods and processing tools in analysing the results and outcomes.

## 3.2 Scope of the Study

The research was conducted in Ghana. Ghana is a West African country on the latitude $5^{o}$ W and Longitude $0^{o}$ N which is bordered by Togo to the east, Cote D'Ivoire to the west, Burkina Faso to the north, and the Gulf of Guinea to the south. It has an area of 227,535 square kilometres (World Atlas, 2018) and a population estimated at 29.6 million (GRA, 2018).

Interviews were conducted among renewable energy researchers, policy makers, private companies, and renewable energy users.

## 3.3 Sampling Design and Survey Instrument

The purposive sampling technique was used to select key scientific publications and experts that have key knowledge in the field of this study. A purposive sample, also referred to as a judgmental or expert sample, is a type of nonprobability sample. The main objective of a purposive sample is to produce a sample that can be logically assumed to be representative of the population (Lavrakas, 2008).

### 3.4 Data Collection and Analysis Approach

Both secondary and primary data was used to address the objectives of the study. The data was obtained from published articles and non-published papers, reports that includes relevant renewable energy policy documents, interview guide, questionnaires and opinions from stakeholders.

#### 3.4.1 Review of Literature

Documentation on the renewable energy and energy efficiency policy implementation were evaluated. Also, various literature on renewable energy barriers were identified and analysed. The various documentation was helpful in determining the level of renewable energy penetration in the country.

#### 3.4.2 Comparative Analysis

Country wise analysis were made from South Africa and Morocco on their renewable energy sectors and the various policies guiding them. South Africa is a country located at the southern part of Africa on latitude -25.74 and longitude 28.19 with a population of 48.8 million as at 2012 (Santander, 2018). It is bordered by Namibia, Lesotho, Mozambique, Swaziland, Zimbabwe and Botswana. Although the country depends heavily on coal for electricity, it has the largest wind energy market in Africa with installed capacity of 1053 MW. Morocco is a North African with longitude 31.79$^{o}$ N and latitude 7.09$^{o}$ W (World Atlas, 2015). It is geographically located to the east of Algeria, south of Mauritania, west of the Atlantic Ocean and has a population estimated at 34 million (Marokko info, 2018). Currently it has the largest solar thermal plant in the world (Parke and Giles, 2018). The country, which is noted for their over reliance on imported resources to generate power Acquah (2018) has been able to generate 34% of energy from renewables (Export.gov, 2017)

to reduce carbon emissions. Morocco has the third largest capacity of installed wind power in Africa, with 800 MW (Morocco Energy, 2018).

#### 3.4.2.1 Renewable Energy Indicators

For business purposes, one needs to take into account the interest rate of the country, inflation rate, exchange rate and government taxes as well. These indicators help to make a clear indication as to whether the business environment is favourable or not. For the case of a RE generator, some policies have been set for them to make the market attractive and these include incentives such as, net metering, RE funding and feed-in-tariff scheme.

Moroccans interest rate currently stands at 2.25%, inflation is at 1.6%, annual business taxes are slightly 10% and 15% (Santander, 2018). South Africa on the other hand has a steady interest rate of 6.5% (Tradingeconomics, 2018), inflation rate of 4.4% but higher government taxes of 21% to 28% (Pwc, 2018) whiles Ghana has a very high interest rate which currently stands at an average of 30% (Acquah, 2018) with inflation rate of 15.3% (Government of Ghana, 2018). There is a tax rate of 25% per annum (GRA, 2018) of profits made. In terms of the business aspect, Morocco and South Africa have favourable environment for RE generation as a result of policies being implemented in the country. Reference were made with respect to these two countries with achievement level to know the numerous efforts made in their renewable energy sectors and what Ghana can learn from them to be able to achieve its targets.

### 3.4.3 Stakeholders Engagement

The government of Ghana has set institutional bodies to be in charge of the energy sector. These bodies set policies, rules, regulations and legislations to govern the energy sector. These institutions were consulted during data collection. The institutional bodies were the Energy Commission of Ghana and the Ministry of Energy which are state-owned. To complement information obtained from the public institutions, renewable energy private

companies were also interviewed. These companies spelt out the challenges/barriers to RE development and suggested solutions. In addition, researchers from the country's universities were also interviewed. Owners of solar rooftop installations were also interviewed to know their views on solar PV efficiency, challenges they encounter after installing solar panels and the various incentives available for them.

### 3.5 Methods and Calculations

Number interviewed = 47

1) To analyse information on the implementation of RE policies

$$\frac{n}{N} * 100\% \text{ ---------- equation 1}$$

Where $n$ = number who agreed policies are not implemented

$N$ = total number of sample size

Which has been express as a percentage

### 3.6 Summary of Methodology

Figure 5 shows the summary of the methodology for the study

### 3.7 Analysis

SPSS was used to calculate and analyse the information for individual solar PV users. Excel spreadsheets and visio were used to plot the graphs, charts and diagrams.

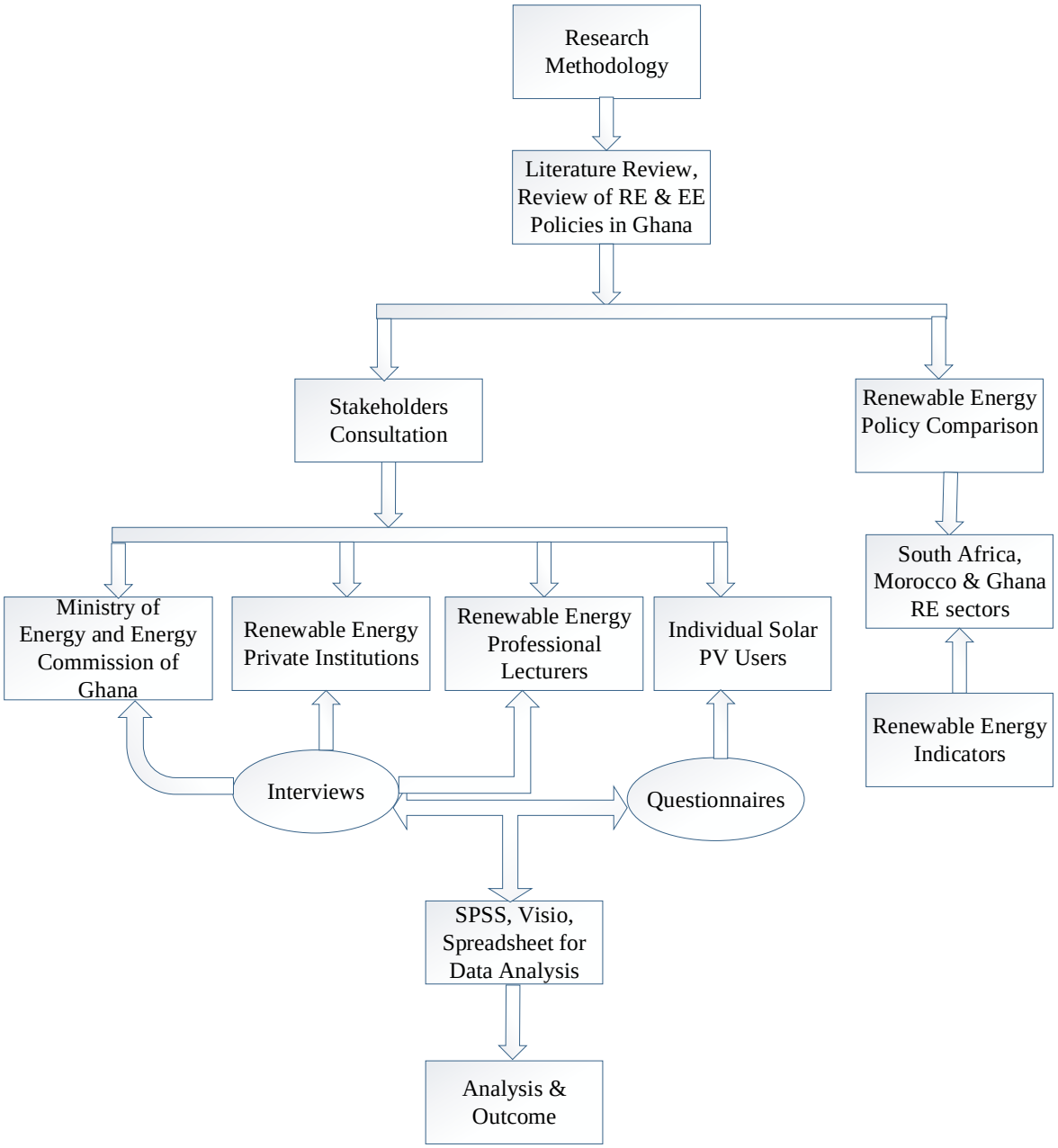


*Figure 5 Summary of Research Methodology*

# CHAPTER FOUR

# RESULTS AND DISCUSSIONS

## 4.1 Introduction

The results of the study are discussed based on the research objectives: (1) Review the existing policies on renewable energy and energy efficiency in Ghana (2) To evaluate the success of the policies by matching the policy objectives against their instruments (3) To identify and analyse challenges/barriers faced by Energy Policy Institutions in the implementation of renewable energy and energy efficiency policies in Ghana

The results of the study identified two major issues encountered in the Renewable Energy sector of Ghana. These problems have been identified as

1. Policy Implementation affecting Grid and Off-grid solar PV Generators in Ghana and
2. Barriers to Renewable Energy Development in Ghana

These two problems have been analysed in this chapter.

## 4.2 Outcome of Stakeholders' Consultation

### 4.2.1 Response from the State, Private Institutions and RE Lectures

The responses are based on the policy implementation issues in Ghana

#### 4.2.1.1 Feed-in-Tariff (FiT)

The Feed-In Tariff rates which were gazetted by the PURC in 2016 serve as a cap for the amount at which electricity from RE sources can be purchased. An Independent Power Producer (IPP) looking to sell power must sign a PPA with the off-taker (distribution utility or bulk customer) and the rate must not exceed that of the gazetted FiT rate. According to the private institutes, the FiT serves as a form of motivation but no one has benefitted from

it both those connected to the grid and individual PV users in the country policy is not working for the individual solar PV users but works for those connected to the grid (but not being paid). In addition, the current government of Ghana is ready to sign any agreement to pay FiT of 10 Cent/kWh or below, but not to sign above 10 Cent/kWh. This is a new recommendation to generators to sign a PPA and invest in various RE (2016 FiT rate are more than 10 Cent/kWh for RE technologies in Ghana). Investors are however not convinced with the change of the FiT rates being one of the motivation available to RE generators

#### 4.2.1.2 Net Metering Scheme

According to the state, net metering scheme was piloted by the Commission in 2015 with 33 being installed. The scheme was gazetted by the PURC with ECG and NEDCo being implementing agencies. However, in 2017, the piloted project failed due to technical and financial challenges faced by the utility but the private institutes identified this problem as financial and not technical. The stakeholder agencies are working to find solutions to fully implement the scheme. However, RE lecturer argued that, some energy institutions see no need to reward renewable energy generators hence, failure to implement the scheme.

#### 4.2.1.3 Renewable Energy Funds

In the past and currently, various funding options have been employed to finance RE projects in Ghana. It includes loan financing, on-lending financing which will be used to create market including RE and EE interventions. The government has established the GRERC as a financial instrument which seeks to assure project financiers and investor community to invest in RE with focus on SMEs and domestic green projects. However, no RE community has benefited under the GRERC. Also, government of Ghana for the past years has encountered failed projects such as the Ape Bank Project, with support from the World Bank which is to install solar mini grids in rural communities but the communities failed to pay back.

#### 4.2.1.4 The Renewable Energy Purchase Obligations

Guidelines for the Renewable Energy Purchase Obligation (REPO) which mandates bulk customers to purchase its electricity from RE sources, has not yet been finalized. Per the RE Act, electricity can be sold ONLY to either distribution utilities or bulk customers. In Ghana, there are 2 distribution utilities namely ECG (Southern Sector) and NEDCo (Northern Sector). Currently, the percentage of electricity being generated by RE sources and fed into the grid are from the 20 MW solar PV plant developed by BXC Company Limited, 100 kW waste-to-energy plant by Safi Sana Ghana Ltd and 2.5 MW solar PV plant developed by VRA. BXC and Safi Sana have Power Purchase Agreements (PPAs) with ECG and the power generated by the 2.5 MW solar plant is being supplied to NEDCo. According to the private institutions, the percentage of renewables sold are however not known to them. They argue that since the production is in small quantity, the percentage might be small.

#### 4.2.1.5 Acquisition of License in Ghana

Though it is stated in the RE Act 2011 that acquiring license takes a maximum of 60 days, it is not always so. Private companies have raised a concern on the procedures as being cumbersome and lengthy. It took some a maximum of more than a year, some 2 years and so on. But the approval depends on how fast the applicants go about acquiring the permit. Some of them end up paying more than expected, and since the RE technology is not common and the market is not so good, most of these companies end up moving to the conventional market in order to make profit.

### 4.2.2 Response from the Individual Solar PV Users/Off-grid Generators

The tables 9-16 represent the response from renewable energy individual users.

#### 4.2.2.1 Frequency Table

Table 9 shows that all the individual solar PV generators are aware of the solar rooftop programme in Ghana.

*Table 9 Individuals Aware of the Solar Rooftop Programme in Ghana*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 25 | 100.0 | 100.0 | 100.0 |

In table 10, more than $^{2}/3$ of the generators bore the costs of solar panels and its installation whiles only $^{1}/10$ had their installation and equipment subsidized.

*Table 10 Individuals whose Solar Panels were Subsidized*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 3 | 12.0 | 12.0 | 12.0 |
| No | 22 | 88.0 | 88.0 | 100.0 |
| Total | 25 | 100.0 | 100.0 | |

However, 72% consume exactly what they produce while 28 % generates excess power.

*Table 11 Individuals who Generate Excess Power*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 7 | 28.0 | 28.0 | 28.0 |
| No | 18 | 72.0 | 72.0 | 100.0 |
| Total | 25 | 100.0 | 100.0 | |

With the excess power being generated, table 12 clearly shows that 16% feed the excess power into the grid, 80 % do not produce excess so they do not feed anything into the grid but 4% excess go wasted (is not being fed into the grid).

*Table 12 Excess Power User*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Fed into the grid | 4 | 16.0 | 16.0 | 16.0 |
| Not Applicable | 20 | 80.0 | 80.0 | 96.0 |
| Other purpose | 1 | 4.0 | 4.0 | 100.0 |
| Total | 25 | 100.0 | 100.0 | |

Also, out of the number who export power into the grid, 8% get the power back without being paid for while 12% has to paid for power that has been fed into the grid. But 80% neither generate excess power nor feed power into the grid.

*Table 13 Number of People who Get Exported Power Back*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 2 | 8.0 | 8.0 | 8.0 |
| Not Applicable | 20 | 80.0 | 80.0 | 88.0 |
| Exported power is being paid for | 3 | 12.0 | 12.0 | 100.0 |
| Total | 25 | 100.0 | 100.0 | |

Table 14 indicates that, 100 % would love to generate more and benefit from the incentives when fully implemented.

*Table 14 Individuals who would like to Produce Excess when the Incentives are Implemented*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 25 | 100.0 | 100.0 | 100.0 |

Table 15 shows that more than a half interviewed face challenges after installing the panels whiles 36% do not face challenge.

*Table 15 Individuals facing Challenges after installing the Solar Panels*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Yes | 16 | 64.0 | 64.0 | 64.0 |
| No | 9 | 36.0 | 36.0 | 100.0 |
| Total | 25 | 100.0 | 100.0 | |

Table 16 rated the use of solar energy in terms of efficiency. More than 50 % rated its use as excellent, almost $^{1}/3$ rated it as good while 12 % rated it as average.

*Table 16 Rating Solar PV Efficiency in Ghana*

| Valid | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|
| Excellent | 14 | 56.0 | 56.0 | 56.0 |
| Good | 8 | 32.0 | 32.0 | 88.0 |
| Average | 3 | 12.0 | 12.0 | 100.0 |
| Total | 25 | 100.0 | 100.0 | |

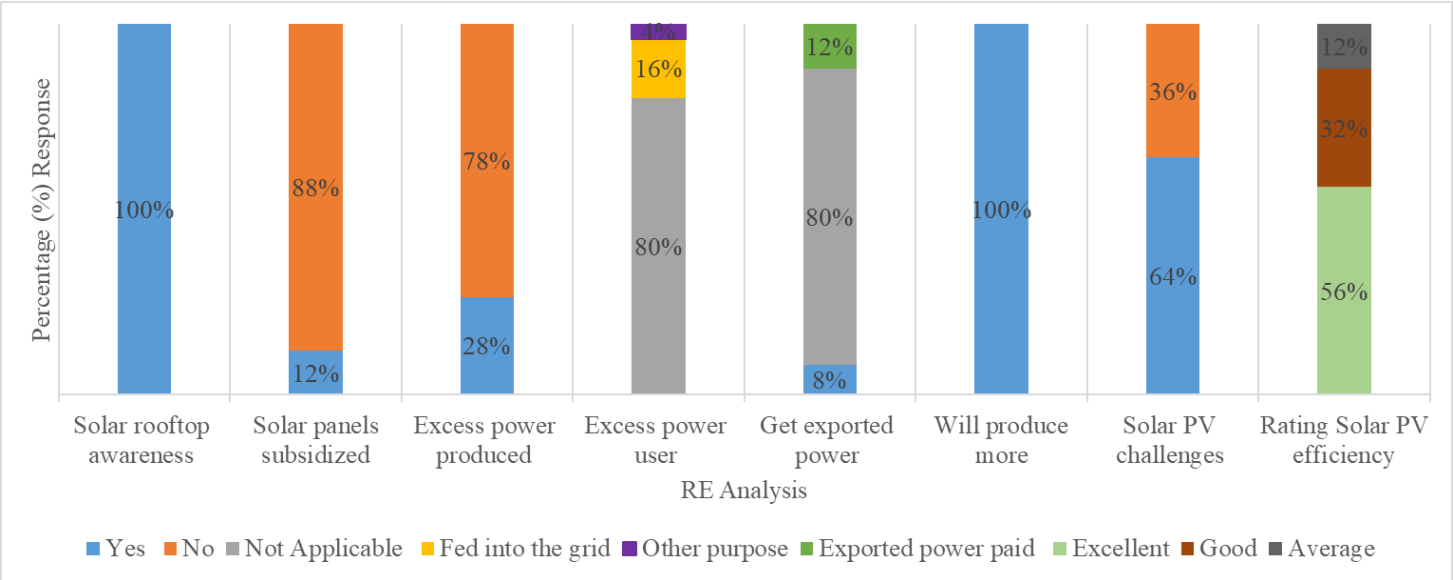


*Figure 6 Summary Response from Individual Solar PV Generators*

The individual solar PV generators were interviewed to know their ideas about the use of solar PV and their associate problems. The survey was carried out in Kumasi, Accra, Sunyani and Tamale.

From figure 10, all the individuals know about the solar rooftop programme which was implemented early 2016. Quite a number of them started operation before the programme was implemented so they did not get to benefit from the programme. However, a number of them applied to the commission to be given the panels but for almost 2 years, they are unable to get a feedback from commission in charge of the distribution of the panels. 88% of their panels were not subsidized by the government. While only 12 % of them had theirs subsidized.

When ask if they generate excess power, 28% being government institutions and individuals generate excess power. 78% do not produce excess power because the cost of panels and installations are very expensive and they generated exactly what they could consume. They also pointed out that the government on its part has failed to implement the various incentives

that makes RE attractive so they generated what they could use to avoid any challenges. Nevertheless, 28% who thought they could enjoy some financial benefits from the utility generate excess power. 16% of them feed excess power into the grid for free while 4% of them use the excess power either for irrigation during the dry season in the Northern part of the country or go wasted during the rainy season. More than 80% chose not to generate excess. Out of the number who feed power into the grid, 12% have to pay for the exported power even though it has been fed into the grid. This is because, there is no net meter for the feed-in-tariff rates and 8% of them get exported power back without paying for it. These are mainly government institutions who have installed solar PVs.

Even though, with more than 60% facing challenges like cost of storage and no financial benefits from the government of Ghana, they would love to produce more upon a condition that the RE incentives will be fully implemented. In conclusion, almost one third rated the efficiency of solar PV as good, 12% as average and more than a half rated the efficiency as excellent. RE energy consumption in Ghana is very low due to the quantity being generated. In my opinion, if government should fully implement the various incentives, it would encourage more of the people into the RE market thereby increasing its share of the energy mix.

### 4.2.3 Summary of the Policy Implementation Issues Identified by the Stakeholders

The table19 shows the views from stakeholders regarding RE development and policy implementation issues in Ghana

*Table 17 Stakeholders response on policy instruments*

| | **Policy implementation instruments** | | | |
|---|---|---|---|---|
| **Stakeholders** | **Net metering** | **Feed-in-tariff** | **RE Funding** | **RE Purchase Obligation** |
| Lecturers | × | × | × | Quantity unknown |

| | | | | |
|---|---|---|---|---|
| RE Private Companies | × | × | × | Quantity unknown |
| State | × | ✓ | × | Small amount |
| Individual PV Users | × | × | × | Not aware |

×~ not implemented, ✓~ implemented

The views of the state are different from the views from the people. These views shows that there are discrepancies between these two entities. These could be either from political influence or bias. Instances where the state has made is clear that the feed-in-tariff is working but the other side pointed out not to be working could mean that it is working but is being enjoyed by only a few people and not all or the FiT has been published for the sake of making it look good and attractive. In that case, the state has become biased and has violated the policy. Although the name RE funds exist, no private entity has benefited from it. These individuals and companies still purchase RE devices at higher cost, import at a higher tax rate very high interest rate for start-ups, while others see no need for RE.

### 4.3 Policies on Renewable Energy Incentives in Ghana

The ECG is in charge of net metering implementation in Ghana and the payment of FiT for the Southern sector. The Volta River Authority is in charge of paying feed-in-tariff for the northern Sector. The GoG is the main body responsible for the implementation of RE funds. With the exception of the PURC, the rest of the Institutional Bodies have failed to fully implement the incentives for RE generators.

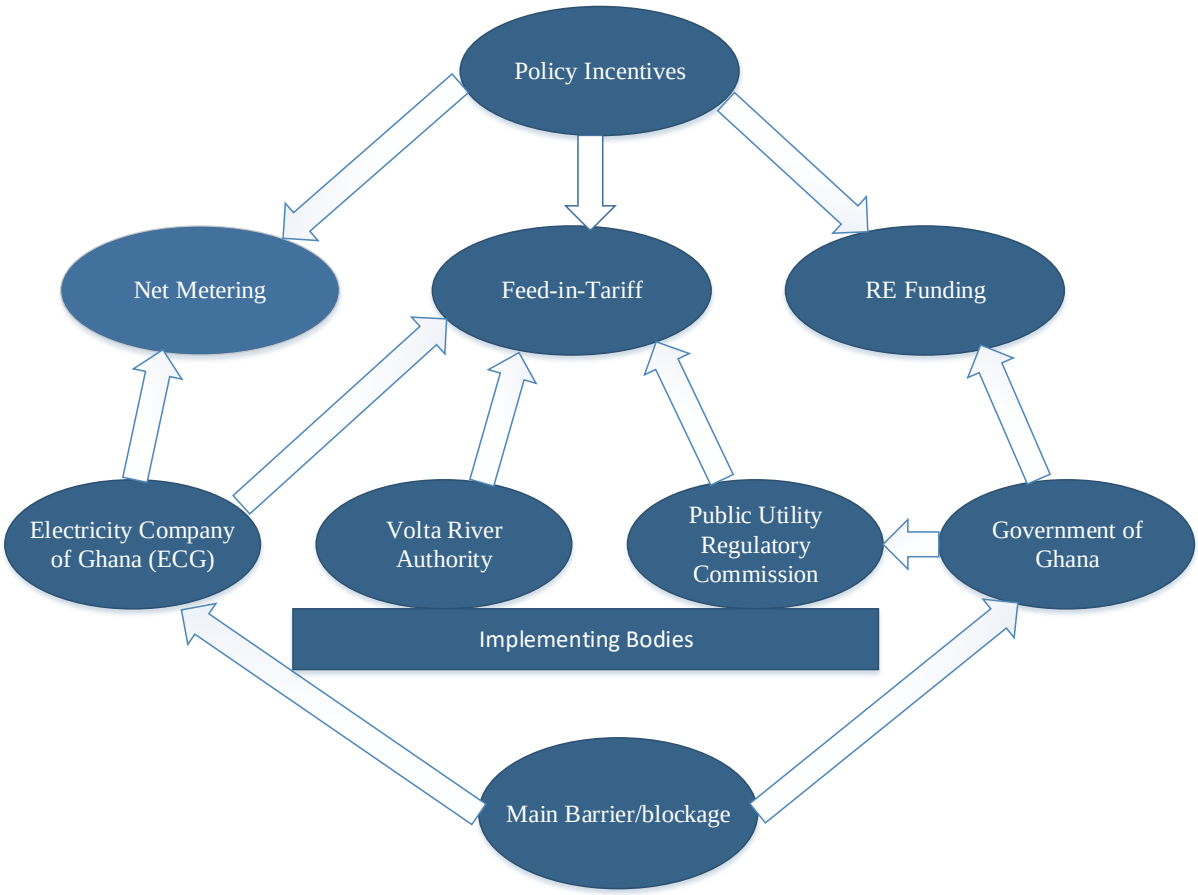


*Figure 7 Ghana's Renewable Energy Policy Incentives*

ECG is the main blockage for net meter scheme implementation whiles the GoG is the main blockage for RE funds in supporting RE projects. Since there is no meter for calculating excess power fed into the grid and that to be paid out for RE customers. As a result of this, the feed-in-tariff is currently not in operation and none of the RE generators has benefitted although the rates are being published by the PURC every two years.

The figure 10 shows the outcome of implementing net metering scheme in Ghana. The case when net metering is fully implemented in the country.

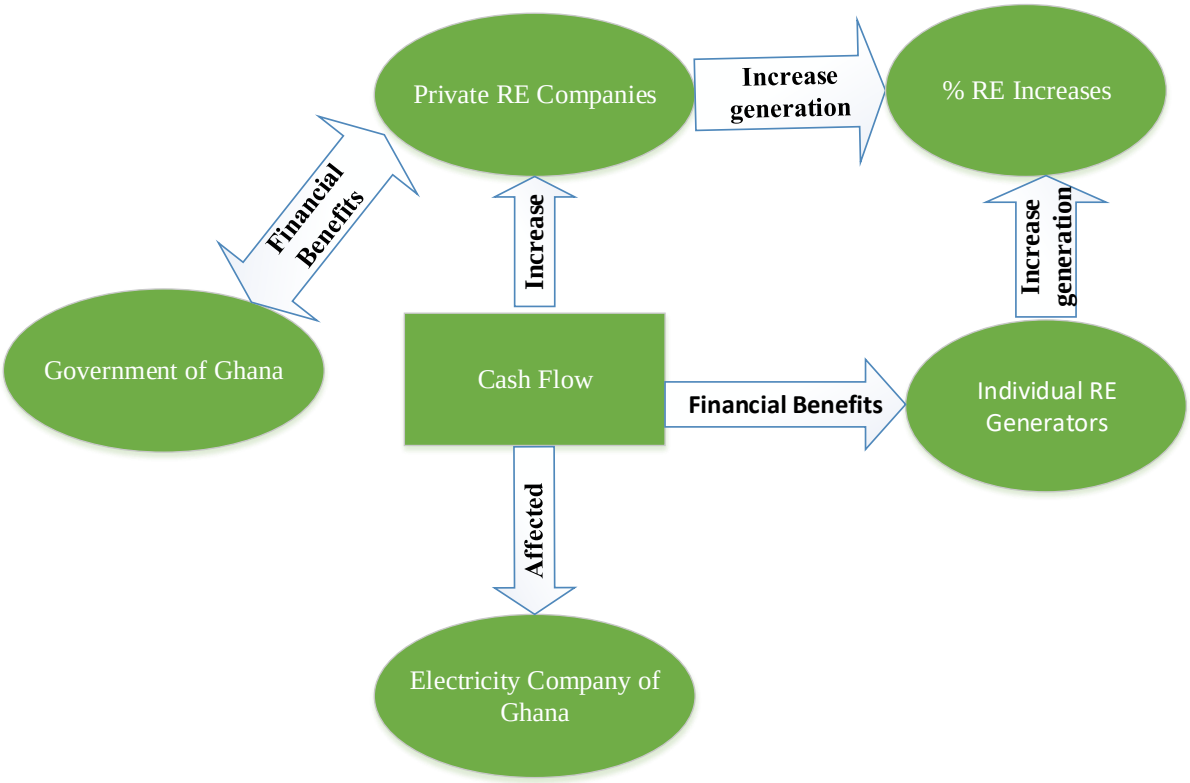


*Figure 8 Net Metering Scheme Implementation Outcome*

From the figure, it is obvious that revenue/cash flow is involved when there is a net metering scheme operation in the country. The ECG being the largest power purchaser and distributor in the country and as such, has a good revenue flow. If the net metering scheme is implemented, more RE generators will dominate the RE market however large customers will be lost to these generators and the ECG cash flow will decrease. The private companies would be seen as competitors to the ECG. Cash flow for private companies will increase and individual RE generators too will benefit financially from the government incentives. In the course of this, the percentage of RE increases because more people will be attracted to the sector. In a long run, the government get financial benefits from the private generators through the signing of PPA in the country. From observation, ECG see this as a treat to its sector and has then failed to abide by the RE policies in the country.

### 4.4 Summary on Barriers and Policy Issues faced by Renewable Energy Generators

Promoting renewable energy technologies in Ghana as a whole has some drawbacks. An attempt to increase its quantity and consumption in the country still at a slow pace. Table 20 outlined some barriers identified by literature whiles Figure 11 are barriers identified by the stakeholders involved in this study.

*Table 18 Renewable Energy Barriers identified by Literature*

| | **Renewable Energy Barriers** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Authors | Stakeholder's involvement | Socio-cultural beliefs | Economic & Financial | Dependency on centralized grid | License procedure | Technical Barriers | Access to modern energy services | Information & Awareness | Legal framework | Market/Cost of electricity from RE | Dependency on fossil fuels |
| Dittmar (2008) | | | | | | | | | | | 1 |
| Bjorn (2014) | | | | 1 | | | | | | | 1 |
| Gboney (2009) | 1 | 1 | 1 | | | 1 | | | 1 | | |
| Benson *et al*. (2015) | 1 | 1 | 1 | | | 1 | 1 | 1 | 1 | | 1 |
| Gyamfi *et al*. (2014 | | 1 | 1 | | | 1 | | | 1 | 1 | |
| Sakah *et al*. (2017) | | | 1 | | | | | | | 1 | |
| Energy Commission of Ghana (2015) | | | 1 | | 1 | 1 | | | | | |
| Atsu *et al*. (2016) | | 1 | 1 | | | 1 | | 1 | | 1 | |
| Hagan (2015) | | | | | | 1 | | 1 | | | |
| Amewu (2011) | | | | | | | | | | 1 | |
| Edjekumhene *et al*. (2001) | | | 1 | | | | | 1 | 1 | | |
| Apeaning and Thollander (2013) | | | 1 | | | | | 1 | 1 | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Attachie and Amuzuvi (2013) | | | 1 | | | | | | | | |
| Deichman *et al*. (2011) | | | | 1 | | | | | | | |
| Essel (2015) | | | 1 | | 1 | | | 1 | | | |

Note: 1 signifies barrier identified

The table 20 shows barriers identified by literatures. Most of these issues are the unavailability of funds and awareness on the part of the people. In spite of that, this study came out with new findings as

1) the main policy implementation issue affecting renewable energy development in Ghana is the non-implementation of Net Metering Scheme whereas
2) the main barrier identified is attributed to the RE policies in Ghana and not necessarily financial and economic or awareness.

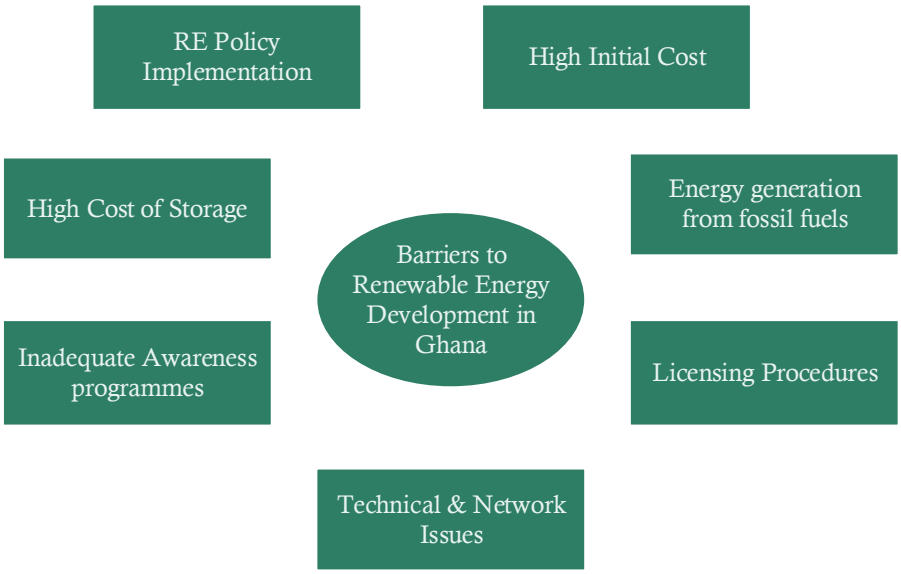


*Figure 9 Renewable Energy Barriers identified by the Stakeholders*

And the table below is rated in percentage in terms of the implementation issues to RE development.

*Table 19 Implementation Issues affecting Grid and Off-grid Renewable Energy Generators*

| ***RE Policy Implementation Issues in Ghana*** | **Net metering** | **Feed-in-tariffs** | **RE Funding** | ***Barriers to RE in Development Ghana*** | **RE Policies** | **High Initial Cost** | **Existence of Fossil Fuel Energy Resources** | **Licensing Procedure** | **High Cost of Storage** | **Technical & Network** | **Inadequate Awareness** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stakeholders' Response (%)** | 100 | 85 | 42 | | 80 | 53 | 21 | 25 | 42 | 15 | 25 |

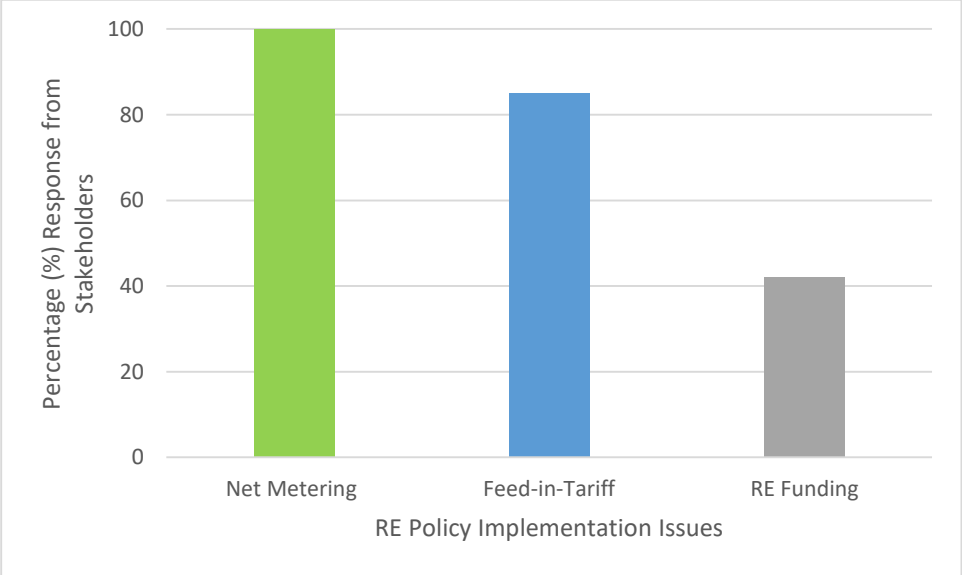


*Figure 10 Graph representing non-Implementation level of Renewable Energy Policy Incentives in Ghana*

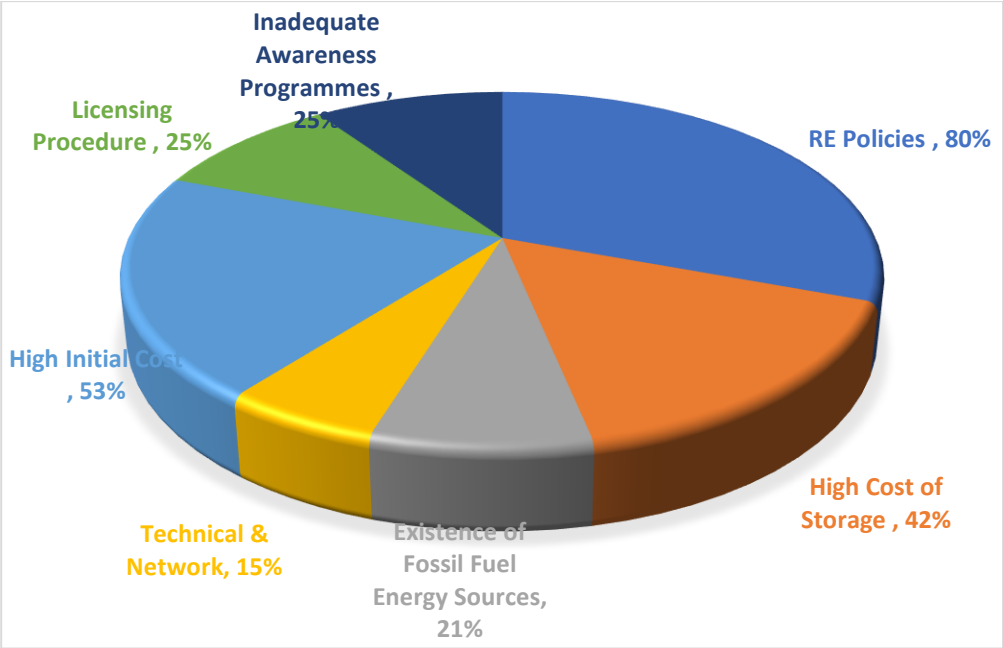


*Figure 11 Graph representing percentage level of Renewable Energy Barriers in Ghana*

The RE policies are not attractive to people who generate excess power and inject into the national grid, e.g. there is no cash reward for injecting excess power into the grid. The power go waste for the generator but the government get to benefit from this since power is fed free of charge into the grid. Implementation of net metering scheme has been in a stand still since it was passed in 2012. In that case, connecting to the national grid has become a big problem since there are no incentives for onsite power generators and the slow rate of passing legislation to back the initiative. When this happens, grid connected system developers find it difficult to bring their projects to a financial close.

Another big challenge to the deployment of RE projects in Ghana is the permitting requirements (i.e. licensing), particularly from the Energy Commission and EPA. Many investors are not able to successfully complete/provide all the requirements whiles it takes others period of two years or more to granted the permit. Other RE institutions are not able to start operation though they have all the necessary requirement to start operations, this may be financial constraints.

Formally selling power to the ECG was. Currently, signing a PPA has become very difficult in the country. The government has now made it a competitive bidding, where the state will advertise for a bidding and whoever is interested will sign the bidding. RE generators want a feed-in-tariff rate of more than 10 cents/kWh for any of the technology. Besides, the current GoG has opted not to sign any PPA with a feed-in-tariff rate of more than 10 cent/kWh generated. Yet investors are not convinced with this rates.

Information gathered indicated that RE developers are not been able to get funds to operate even when they have been issued with a license. High cost to start up a business generally translate from high interest rate, high inflation rate, high import duties on panels which translate to high cost for grid system owners and household systems. Unlike the grid which serves as a storage, the non-implementation of the various incentives would mean household systems owners must add batteries to their systems further escalating cost on the system.

Adding to all system costs incurred, the feed-in-tariff which serves as a motivation is not working for the individual power generators. They seem not getting any financial benefits from installing solar PV or generate electricity from renewables. Instances where none of the incentives are working out for them, they see no benefits to install solar PV and will opt to use conventional energy sources. Fossil fuel energy sources are easier to generate and require much less hurdles and permitting processes. But, my view is that, reliance on fossil fuels is not the way to go – it's not sustainable and in the long run, it is more expensive

Technical and Network systems are another area to RE development especially grid-tied system owners due to the unstable nature of the grid. The RE generator is seen as a competitor. And, even if they were able to produce enough, the grid as it is now being not well positioned to receive a large amount of RE power. The conclusion appears to be that the current grid infrastructure becomes unstable if so not much power is able to be connected to the utility and the available power transmitted and distributed, much of it is being lost at

21% by the state estimated at $ 250 million per annum (Ministry of Energy, 2010). The infrastructure requires retrofitting. However, the Energy Commission is aware of this fact and has limited the amount of power every investor can generate and feed into the grid.

In addition, maintenance culture is a big problem to Ghanaians. Cost of cleaning the panels are higher than that in Europe. It is however a huge task to maintain the panels. In that case, RE generators are advised to operate in an off-grid system in order to experience this challenge. Off-grid generation systems would help distribute power to communities and islands that are further from the utility and promoting decentralised distribution systems across the country.

Awareness on the use of renewable energies are not adequate enough to help promote its use. RE is much less expensive than fossil fuels, but affordability is known per the lifetime project. However, the people are not well informed on the financial benefits involved. Also, failed projects have created the impression that solar does not work so it becomes very difficult to convince someone who have had a bad experience.

### 4.5 Evaluation on Renewable Energy and Energy Efficiency Policies in Ghana

In recent years, the country has been battling with energy crisis due to the over reliance on hydro generation, which has failed the nation recently due to low rainfalls. Measures were also put in place such as energy management that took place across the country. The country generates very little power from renewable energy sources, currently about 0.5%. Renewable energy and energy efficiency policies have been in existence for a decade, purposely to help increase the percentage share in the national energy mix as well as incorporate with energy efficiency measures. Table 9 shows the areas Ghana's renewable energy policies cover. The country has set policy instrument to match with the policy objectives. In addition to the policy instrument, measures and activities have been put in place to achieve the goals of the

policy to increase the development of renewable energies in the country. The various policies include laws and regulations that governs the sector.

*Table 20 An Overview of Renewable Energy and Energy Efficiency Policy in Ghana*

| Energy Policies | RE Policy Objectives | Regulations | Activities |
|---|---|---|---|
| **Strategic National Energy Plan, (2006- 2020)** | Increase the share of RE up to 10% and a universal access by 2020 (later changed to 10% by 2030) | Energy Efficiency Standards and Labelling | Standards and labelling programmes, e.g. enforcing standards for Room Air Conditioners and CFLs, |
| | Promotes Energy Efficiency and Conservation | Energy management scheme | Ensuring energy management practices, building codes, energy audits, load management programmes |
| | | | **Activities** |
| **National Energy Policy, 2010** | Increase the proportion of renewable energy in the total national energy mix by 10 % by 2020 (later changed to 10% by 2030) | | Encourage the use of clean cooking alternatives such as efficient cook stoves |
| | Promote energy efficiency and conservation in the country | | Use of efficient appliances such as refrigerators, CFLs, LEDs, |

| | | |
|---|---|---|
| | | **Activities** |
| **Energy Sector Strategy and Development Plan, 2010** | Increase the percentage of renewable in the total national energy mix and its efficient use | To encourage the development of renewable energy technologies<br><br>Provision of tax incentives on importation of RE devices |
| **Sustainable Energy for All (SE4All), 2012** | Universal access to electricity to islands and riversides communities in Ghana | Promote off grid and mini grids electrification projects<br>Solar street lightings,<br>Solar Lantern Project,<br>Clean cooking solutions, |
| **Renewable Energy Act, 2011** | Ensure the development, management, utilization, sustainability and adequate supply of renewable energy for the generation of heat and power | **Policy Instruments**<br>Net Metering<br>Feed-in-tariff<br>RE funding<br>Purchase Obligations |

**Sources:** (Ministry of Energy, 2006); (Energy Commission of Ghana, 2017b)

### 4.5.1 Evaluation: Renewable Energy Policies in Ghana

*Table 21 Evaluation on Renewable Energy Achievements in Ghana*

| EVALUATION OF RENEWABLE ENERGY POLICIES | | | |
|---|---|---|---|
| **Energy Policies** | **Targets** | **Achievements** | **Analysis** |
| **Strategic National Energy Plan (2006 – 2020)** | 10% of power generated from renewables by 2030 in the national energy mix | 0 % renewable energy as of 2010 | No incentives for RE promotion, no projects to accelerate the RE development |
| | | | Heavily depended on hydro dam 54.4 % (2013) |
| **National Energy Policy 2010** | 10% of power generated from renewables by 2030 in the national energy mix | 0 % renewable energy as of 2010 | Heavily depended on source of hydro dam and thermal |
| **Energy Sector Strategy and Development Plan 2010** | Provision of tax incentives on importation of RE devices | The tax incentive was removed | Due to wrong importation of devices |
| | 10% of power generated from renewables by 2030 in the national energy mix | 0 % renewable | |
| **Renewable Energy Act 2011, Act (832)** | 10% of power generated from renewables by 2030 in the national energy mix | 0 % of renewables as of 2012 | Non implementation of RE incentives |

| | | | |
|---|---|---|---|
| | Implementation of RE policy instrument | | Unfavourable RE environment to generators |
| **Sustainable Energy for All Action Plan 2012** | off grid and mini grids electrification projects<br><br>10% of power generated from renewables by 2030 in the national energy mix | 6 mini grid monitored,<br>3 mini grid was constructed in 2015<br><br>16 wind and<br>23 mini hydro assessed as at 2015<br><br>2.5 MW solar accounting to a 0.11 % of renewables as of 2013 and 22.6 MW (0.5%) as of 2015 | No renewables till 2012<br>No wind power till date<br>No mini hydro power constructed<br>Unavailability of funding options<br><br>Only < 1 % renewables achieved after a 9-year period of RE polices (2006- 2015)<br>Policies unattractive to some energy Institutions<br>Unfavourable policies to generators |

Sources: (Buskirk *et al.*, 2007); (Energy Commission, 2009a; 2009b; 2017b); Ministry of Energy (2010**)**

### 4.5.2 Evaluation: Energy Efficiency Policies in Ghana

*Table 22 Evaluation on Energy Efficiency Achievements in Ghana*

| EVALUATION OF ENERGY EFFICIENCY POLICIES IN GHANA | | | |
|---|---|---|---|
| **Energy Policies** | **Target** | **Achievements** | **Analysis** |
| **Strategic National Energy Plan (2006 – 2020)** | Reduce wood intensity of charcoal production from 6-5: 1 to 4:1 in forest zone and 4:1 to 3:1 in savannah zone by 2015<br><br>Reduction in traditional biomass from 60% (2006) to 50% by 2015 | Charcoal consumption<br>917 ktoe (2007)- 1210 ktoe (2015)<br>24.2 % increment within 8 years<br><br>69% of biomass consumed as of 2016 | Target not met<br><br>Increase in population growth<br><br>Increase LPG especially 2011 (30,000,000 MMBtu)<br>(free distribution of gas cylinders, subsidizing of LPG to wood fuel)<br><br>Impacts: Demand for LPG increased; increase import)<br>Effects: A switch to biomass |
| **National Energy Plan 2010** | Use of efficient appliances such as refrigerators, CFLs, LEDs | CFLs and LEDs 20% in 2007, 79% in 2009<br>Incandescent:<br>68% in 2007<br>3% in 2009<br><br>Some population still uses inefficient refrigerator | Target met<br>Almost all households in Ghana uses these efficient lamps<br><br>A reduction in peak power electricity demand of 200- 220 MW (2009) |

| | | | |
|---|---|---|---|
| | | although (32,257 recycled) (UNDP, 2018) | Target still in progress |
| **Energy Sector Strategy and Development Plan 2010** | Ensure the efficient use of woodfuels to reduce deforestation | There has been an increase in biomass consumption | Target not met |
| **Renewable Energy Act 2011, Act (832)** | | | |
| **Sustainable Energy for All Action Plan 2012** | Install solar street lightings, | A number of street solar lantern has been installed in the cities | Target in terms of (% cannot be determined). More of the street lightning project needs to be expanded to towns and villages |
| | Solar Lantern Project | 200 each solar lantern distributed as of 2013 and 2017 | Will help reduce subsidise on kerosene. Projects ongoing |
| | Other efficiency project | 1,006 units of solar panels distributed since it implementation | Target has not yet been met |
| | Solar Rooftop Programme 20,000 solar panels to households | | Problem from the service provider (Energy Commission) / from the government of Ghana |

Sources: (Buskirk *et al.*, 2007); (Energy Commission, 2009a; 2009b; 2017b); (Ministry of Energy, 2010)

With RE targets, and the different activities and measures carried out, only 22.6 MW of grid-connected RE plants have been constructed in Ghana. Although there is very good wind, solar, and mini hydro resource potentials, these resources have not been utilized to expectation. In addition, all efforts made to boost the RE market have not yielded much effort. The Government of Ghana on the other hand has not been able to fully fund RE projects although it has carried out energy efficiency projects in the country. It has in 2018, laid aside a $ 230 million to be given to private companies for the development of off-grid and mini grids across the country but the funds are yet to be released (Graphic.com.gh, 2018).

### 4.5.3 The Renewable Energy Instruments

The Renewable energy implementation are based on the following incentives and instruments. These instruments were passed in 2012 which was included in the Renewable Energy Act 2011 purposely to make the generation of renewable energy technologies attractive in the country. Figure 6 shows these instruments.

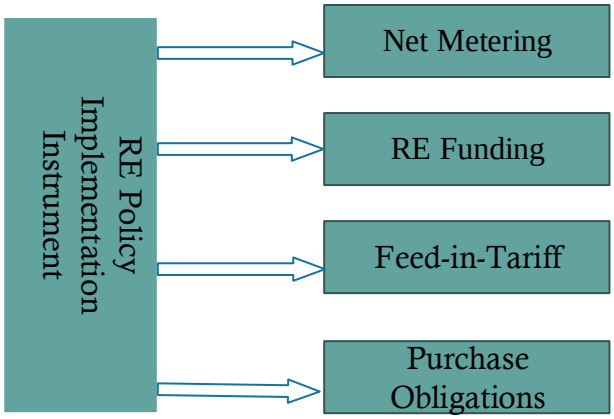


*Figure 12 Renewable Energy Policy Instrument in Ghana*

Net metering system in Ghana was proposed by the German Corporation in collaboration with the Electricity Company of Ghana and the NEDCo; being the responsible bodies to implement and manage with systems in Ghana. The scheme piloted some households in

Accra but the project has not been able to operate fully. The idea behind this project is that, the meter, which is a smart one will help calculate excess power being fed to the grid from renewable energy sources and the amount calculated based on the excess power generated.

The feed-in-tariff is now what one gets paid for by generating and feeding the excess power into the grid. Generators who feed excess power into the grid are either allowed to export the same amount to be used during deficient hours or get paid for the actual power. This could only be done by the smart meter system. In Ghana, the law does not allow one to sell excess power generated directly to neighbours except through Power Purchase Agreement. the feed-in-tariff are published every two years.

The renewable energy funds are to be available to help fund RE projects whiles generating renewable energies in the country. The funds are not to be used to support private renewable energy generators in the country.

However, it is an obligatory as stated in the Renewable Energy Act 2011 to purchase an amount of RE by the distributing companies thus the ECG, and Volta River Authority-Northern Distribution Company (VRA-NEDCo) but the amount of RE is unknown and quantity of generation is small.

### 4.6 Comparative analysis: Renewable Energy Policies

As stated in the methodology, Ghana's RE policies and their targets were compared with Moroccans and South Africans RE policies and targets. The two countries have been able to increase their capacities in their renewable energy sectors. The study would have sought to find out what these two countries have done that have increased their RE market and what Ghana can learn from their achievement. The results after thorough research shows the following outcomes

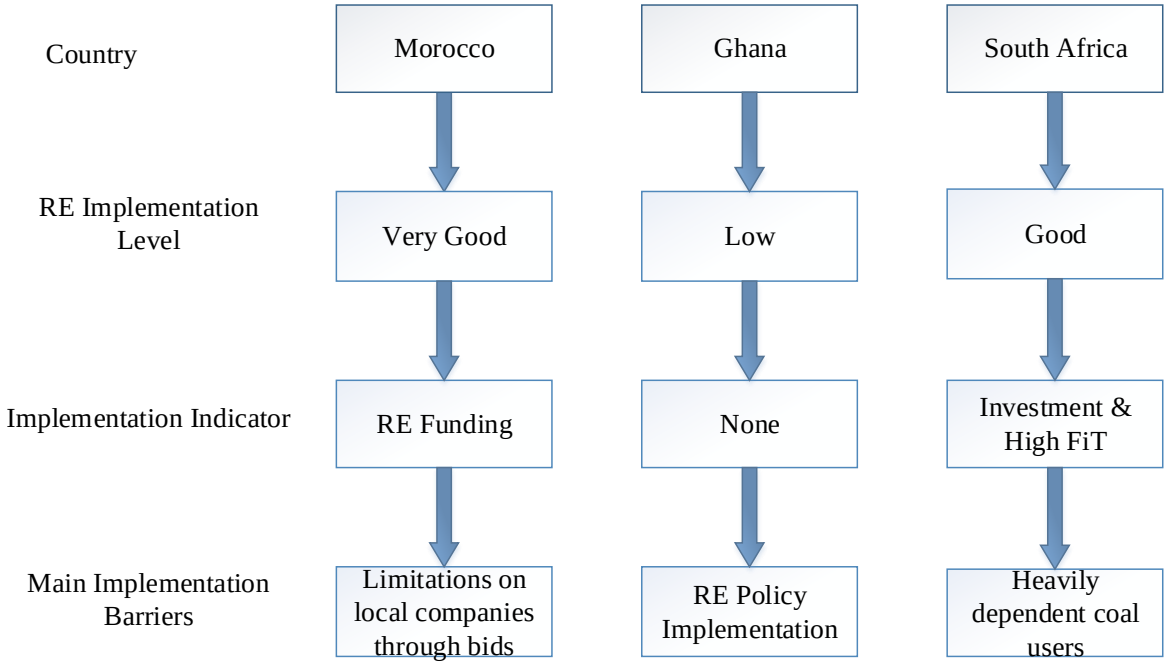


*Figure 13 Comparative Analysis of RE in Ghana with Morocco and South Africa*

Achievement level explains the RE targets set by the three countries.

To promote renewable energies in Morocco, the country set a competitive bidding in 2006 to issue certificates to renewable energy generators which allowed them to construct from 10 MW plant and above mainly from wind and other sources of renewables Haas *et al*. (2011). However, renewable energy contributed to only 4% of the national energy mix in 2009, out of the target set to achieve 20% by 2012 (Šimelytė *et al.*, 2016). The 10 MW bid was then increased to 50 MW in 2009; thus investors are allowed to construct RE plants of 50MW above. This led to some financial constraints on the part of the local renewable energy companies to fund projects of 50 MW.

In addition to the above, Moroccans have set a target to achieve a 42% of electricity to be generated from renewable energy technologies by 2020 and a 52% by 2030. Currently, the country generates 34% (2017) Abdelbari (2018) of their electricity from renewables. The Morocco government has allocated $42 billion to help reach the RE target set by the country. FiT rates depend on agreement signed between the generator and the government but these

rates are less than 8 eurocents/kWh of RE generated. All provisions to help implement net metering scheme is being put in place but the Moroccan government has allowed up to 20% payment of FiT for any excess power produced at the end of the year.

In South Africa, the Integrated Resource Plan (2010) set a target to generate 17.8 GW (9%) of electricity from renewables by 2030 (Fisher and Downes, 2014), which has 5.2 GW of renewables as of 2017 contributing 3% of installed electricity capacity (Power Africa, 2017). An additional of 12.6 GW is needed to achieve the target, which means in the next 12 years, the country needs more than doubled the current capacity which was attained over the past 15 years. A competitive bidding was issued out to investors and a private body was set to see to this bidding process for procurement into the RE sector, an effort attributed to the REIPPPP launched in 2011. Investments of $100 million in 2011, $5.7 billion in 2012, $4.5 billion in 2013 (Baker, 2015) with a capacity of 3922 MW of renewable energy constructed and an investment totalling $14 billion in 2014 Eberhard *et al.* (2014) were invested in the various renewable energy technologies in the country, making South Africa one of the countries with a clean energy investment growth (Suryapratim *et al*., 2010). To add up to the investment plans made, the country has set a very high FiT rates of 26, 15.6, and 46 Eurocent/kWh for Solar, wind and CSP technologies respectively that are favourable to RE generators and to encourage more into generation. There has also been a drastic subsidy for their renewable energy users. Net metering in South Africa works for customers connected to Eskom medium-voltage and large power (Eskom, 2016).

Significantly, Ghana expects an increase of 10% of renewable in the energy mix by 2030 which is to construct mini hydro, wind, solar PV and biomass electricity plants. Less than 1% of the target has been achieved so far. Comparing the target to that for Morocco and South Africa, performance and implementation level is very poor, Ghana is observed to be lagging in its effort to make renewable energies attractive for generators.

In spite of their efforts, the various incentives instituted for renewable energy generator has not been in implementation except that the feed-in-tariff which is under implementation for RE connected to the grid, but have encountered some challenges in the payment of the fee. Thus, the policies are present but the implementation is poor.

In addition to the efforts made, the government of Ghana has made plans for competitive bidding for renewable energy generators. The bidding will have to reward to the renewable energy generator. Currently, the country has held two bids and the plants are yet to be constructed.

Comparing Ghana with Morocco and South Africa, the rate at which the Moroccans have increased their generation of electricity from renewables is higher than that of South Africa. Although the percentage increased from 4% in 2009 to 34% in 2017; a massive 30% increment within a period of 8 years was attained. This indicates that, Morocco will hit its remaining target of 20% by 2030 if the same pace of RE development is followed.

For the case of South Africa though, generation of RE has been slower than Morocco over the last ten years, though their performance would be marked as good with respect to the three countries.

In conclusion, would have to fund their renewable energy sector and set a private body to supervise the bidding process as well as increase the FiT rate as the case of Morocco and South Africa respectively.

### 4.6.1 Summary on Comparison Analysis in South Africa, Morocco and Ghana

*Table 23 Summary on Comparison Analysis in South Africa, Morocco and Ghana*

| | Country | | |
|---|---|---|---|
| **Instruments** | **South Africa** | **Morocco** | **Ghana** |
| **Feed-in-tariffs** | Present | Agreement between generator and the government | Present (poorly implemented) |
| **Net Metering Scheme** | Present (grid) For customers connected on Eskom medium voltage & power | Absent Generators allowed up to 20% annually | Absent |
| **Renewable Energy Funds** | In a form of Investment through bidding | Present Government funds and Competitive bidding | Competitive bidding |
| **Renewable Energy Purchase Obligation (REPO)** | Present | Present Excess purchased by ONE | Present Purchase by distributor and /transmitter |

Sources: (Baker, 2015); (Eskom, 2016); Haas *et al*. (2011); (Šimelytė *et al.*, 2016)

### 4.7 Comparative Analysis: Energy Efficiency Policies in Ghana, Morocco and South Africa

Comparative analysis for energy efficiencies for the three countries were not taken into consideration. This is because, energy efficiency policies, targets and projects in Ghana divers from that of Morocco and that for South Africa.

For instance, in Ghana, emphasis is based on increasing the percentage of renewables by 2030 as well as its consumption but there have been quite energy efficiency projects that have been carried out. Although there have been energy efficiency conservation measures put in place, the main factors of encouraging energy efficiencies in the Ghana are 1) to reduce peak power demand as indicated in the evaluation table 22 such as the use of energy saving appliances, which has a great potential of reducing peak power demand while incorporating with renewable energies. 2) to reduce the rate of deforestation in the country. Most of the

population are dependent on woodfuels and charcoal as the source of energy for cooking. Refer also table 22.

Morocco is noted for being one of the largest importer of fossil fuel in Africa (RCREEE, 2018). The National Energy Policy was set in 2008 with the aim to promote energy efficiencies in the country by reducing energy dependency on fossil fuel while preserving the environment.

According to Sebitosi, (2008) South Africa is noted for being the 7$^{th}$ highest GHG emitter in the world and the country's primary energy consumption per capita is almost halved that of the average primary energy consumed by the OECD countries (2.15 against 4.78). However, The White Paper Policy (1998) set a target to improve upon energy efficiency up to 12% by 2015 to reduce emission rate in the country. Table 24 shows the summary on energy efficiency policies in Morocco, South Africa and Ghana

*Table 24 Summary on main target for Energy Efficiencies in Morocco, South Africa and Ghana*

| | **Country** | | |
|---|---|---|---|
| | **Morocco** | **Ghana** | **South Africa** |
| Energy Efficiency Main Target | Reduction in the cost on over dependency on fossil fuel consumption | Reduction in peak power & reduction in deforestation | Reduction in GHG emissions |

# CHAPTER FIVE

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

Renewable energy resources such as wind, hydro, solar, biomass, already abound in Ghana, but the issue is harnessing these resources into productive uses. Policies on these resources were set to be able to develop it into productive uses. In addition, policy interventions, energy efficiency measures, activities were also put across to achieve the objectives of increasing power generated from renewable sources by 10% in 2030. In spite of the numerous attempts, the interventions have failed to be implemented. The principal cause is attributed to the fact that some energy institutional bodies responsible for implementing the policies see it as unattractive and will loss revenue to the RE generators. The study identified two major problems as implementation issues affecting grid and off-grid renewable energy generators and barriers to renewable energy development in Ghana.

Major challenge facing RE development in Ghana is financing. A lot of companies have expressed interest in establishing RE power plants which would ensure that the policy target would be met. However, most of these entities are seeking Sovereign Guarantees from the government and these guarantees are very difficult to acquire. The Government of Ghana (GoG) is looking to solve this problem through Competitive Tendering and would provide guarantees to the winner of the tender and if this is implemented, the percentage of electricity from renewables would increase.

To add up to the policy issues, the barriers to RE development identified have been a great burden to the sector. High initial cost in start-up businesses, licensing procedures which are cumbersome, technical and network, high cost of storage, inadequate information on RE benefits to the people. Individual solar PV users however size their system to fit into what to be consumed in order not to waste excess power. It is becoming difficult to sign a PPA

with the off-taker. They prefer to sign agreement with the fossil fuel generators than the renewable energy generators because generation is lower than expected. Also, generators are interested in constructing their plants in the southern part of Ghana. This has been disadvantageous, in that acquisition of land which is another problem. In as much as the northern part of Ghana receives more solar insolation than the southern part, acquiring land is easier and a sparsely distributed region. They prefer to operate in larger scales than smaller scales; as smaller scale would be difficult in bringing their finances to a close.

Drastic action need to be taken to encourage more renewable energy in the country, to reduce the cost on renewables to increase supply to enlarge the market. Pushing for solar PV alone would not help increase the percentage share, however, the government must also incorporate energies like wind, biogas, tidal and waves by supporting private companies through partnership to seek for funds and to make sure agreements are in favour of the renewable energy generators as well.

## 5.2 Recommendations

- ✓ It is recommended that the government should make it compulsory for all new building that are coming up to install solar PV for it's promotion. In the near future, this practice would become accepted by most of the population in the country and will upgrade to the level of combining RE and fossil usage in the same building.
- ✓ Secondly, acquiring a license could be made simply if a hub is set up. Instead of moving from the bodies such as EPA, Ministry of Energy, Energy Commission, ECG etc. Setting up a hub could be a one stop for the applicants to get everything done. This will save time and reduce the period of years they are to go through to acquire the necessary documentation.

- ✓ Sensitization of people on the RE technology practically not theoretical, we can start from the SHS, once solar is installed in these schools, they can also recommend them for their parents and other people. Doing this will help create awareness on the new technology.
- ✓ The 10 years feed-in-tariff guarantee period should be extended to suit the lifetime project if it implemented.
- ✓ Although off-grid systems are expensive, government should release funds for the private companies to construct plants at rural areas which will promote decentralised system in Ghana thereby increasing RE consumption in the country.
- ✓ There should be motivation from International Corporate Bodies who are pushing for renewable energies to fund RE projects in the country.
- ✓ A private body should be set aside for competitive bidding processors in Ghana like the case of South Africa.
- ✓ ECG should have their own renewable energy company as well. They should invest in RE and not let all the private companies to take up the RE market, else it will get to a point they would lose more of their revenue/cash flow.

REFERENCES

Ã, L. G., Eskeland, G. S., & Kolshus, H. H. (2010). Green electricity market development : Lessons from Europe and the US, *35*(2007), 144–155. https://doi.org/10.1016/j.enpol.2005.10.008

Abdelbari, R. (2018). *Business opportunities report for Morocco ' s renewable energy sector*.

Abdoulaye, D., Koalaga, Z., & Zougmore, F. (2012). Grid-connected photovoltaic ( PV ) systems with batteries storage as solution to electrical grid outages in Burkina Faso, *29*, 1–16. https://doi.org/10.1088/1757-899X/29/1/012015

Acquah, N. (2018). BoG worried over high lending rates. Retrieved from http://citifmonline.com/2016/09/19/bog-worried-over-high-lending-rates/

Adaramola, M. S., Quansah, D. A., Agelin-Chaab, M., & Paul, S. S. (2017). Multipurpose renewable energy resources based hybrid energy system for remote community in Northern Ghana. *Sustainable Energy Technologies and Assessments*, *22*, 161–170. https://doi.org/10.1016/j.seta.2017.02.011

Africa Energy Forum. (2015). Electrical infrastructures and renewables energies to meet Moroccan electricity demand growth ONEE ( Electricity branch ) IN FIGURES 2014.

Amewu, P.-J. The case of the feed in tariff: issues, challenges and the way forward (2011).

Anton, E., & Kaberger, T. Renewable energy auctions in South Africa off shine feed-in-tariffs (2016). Retrieved from http://unctad.org/en/docs/ditcted20108_en.pdf

Apeaning, R. W., & Thollander, P. (2013). Barriers to and driving forces for industrial energy efficiency improvements in African industries - A case study of Ghana's largest industrial area. *Journal of Cleaner Production*, *53*, 204–213. https://doi.org/10.1016/j.jclepro.2013.04.003

Appiah, F. K. (2015). Background to the renewable energy act.

Arranz-piera, P., Kemausuor, F., Darkwah, L., & Edjekumhene, I. (2018). Mini-grid electricity service based on local agricultural residues: Feasibility study in rural Ghana. *Energy*. https://doi.org/10.1016/j.energy.2018.04.058

Asumadu-Sarkodie, S., & Owusu, P. A. (2016). A review of Ghana's energy sector

national energy statistics and policy framework. *Cogent Engineering*, *3*(1). https://doi.org/10.1080/23311916.2016.1155274

Attachie, J., & Amuzuvi, C. K. (2013). Renewable energy technologies in Ghana : Opportunities and threats. *Research Journal of Applied Sciences, Engineering and Technology*, *6*, *5*, *776-782.*, (June). https://doi.org/10.19026/rjaset.6.4118

Azimoh, C.L., Klintenberg, P., Wallin, F., Karlsson, B., Mbohwa, C. (2016). Electricity for development: Mini-grid solution for rural electrification in South Africa. Energy conversion and management, 110: 268-277.

Bailey, I. (2008). Climate policy implementation : geographical perspectives, *39*(4), 415–417.

Baker, L. (2015). The evolving role of finance in South Africa ' s renewable energy sector. *Geoforum*, *64*, 146–156. https://doi.org/10.1016/j.geoforum.2015.06.017

Battaglini, A., Komendantova, N., Brtnik, P., & Patt, A. (2012). Perception of barriers for expansion of electricity grids in the European Union. *Energy Policy*, *47*, 254–259. https://doi.org/10.1016/j.enpol.2012.04.065

Ben Hagan, E. (2015). Renewable energy policy review, identification of gaps and solutions in Ghana, 1–89. Retrieved from http://www.energycom.gov.gh/files/Renewable Energy Policy and Regulatory Gap Analysis Final(2015).pdf

Bensah, E., Kemausuor, F., Antwi, E., & Ahiekpor, J. (2015). China-Ghana South-South Cooperation on renewable energy technology transfer: Identification of barriers to renewable energy technology transfer to Ghana. Retrieved from http://www.energycom.gov.gh/files/Barriers to Renewable Energy Technology Transfer in Ghana(2015).pdf

Bischof-niemz, T. (2017). Statistics of utility-scale solar PV , wind and CSP in South Africa in 2016 CSIR Energy Centre South Africa ' s Renewable Energy Independent Power Producer Procurement Programme ( REIPPPP ) started in 2011, (April).

Dauda, A. (2011). Technology transfer for renewable, 4800–4804.

Deichmann, U., Meisner, C., Murray, S., & Wheeler, D. (2011). The economics of renewable energy expansion in rural Sub-Saharan Africa. *Energy Policy*, *39*(1), 215–

227. https://doi.org/10.1016/j.enpol.2010.09.034

Dittmar, C. (2009). Barriers and drivers for the deployment of renewable energy technology in developing countries.

Dorcas Kariuki. (2018). Barriers to renewable energy technologies development. https://doi.org/dx.doi.org/10.1515/energytoday-2018-2302

Eberhard, A., Kolker, J., & Leigland, J. (2014). South Africa's Renewable Energy IPP Procurement Program: Success factors and lessons. *PPIAF, Washington DC, USA*, (May), 1–56. Retrieved from http://www.ee.co.za/article/south-africas-reippp-programme-success-factors-lessons.html

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Kadner, S., Zwickel, T., & Von, C. S. (2011). Renewable energy sources and climate change mitigation. Cambridge: Cambridge University Press.

Edkins, M. A. X., Marquard, A., & Winkler, H. (2010). South Africa ' s renewable energy policy roadmaps, (June).

Energy Commission. (2009). Final Report - CFL exchange programme impact assessment, (January), 37.

Energy Commission of Ghana. (2012a). Energy Commission service providers in the renewable energy industry.

Energy Commission of Ghana. (2012b). Sustainable energy for all action plan - Ghana. *Ghana Sustainable Energy for All Action Plan*, 25–26. Retrieved from http://energycom.gov.gh/files/SE4ALL-GHANA ACTION PLAN.pdf

Energy Commission of Ghana. (2014). 2014 Energy (supply and demand outlook for Ghana). *Final Report*, 1–63.

Energy Commission of Ghana. (2015). National energy statistics 2005 - 2014, (April), 1–29. Retrieved from http://energycom.gov.gh/files/Energy Statistics_2015Final_1.pdf

Energy Commission of Ghana. (2017a). 2017 Electricity supply plan for Ghana.

Energy Commission of Ghana. (2017b). 2017 Energy supply and demand outlook for Ghana, (April), 1–51. Retrieved from http://www.energycom.gov.gh/files/Energy Commission - 2015Energy Outlook for Ghana_final.pdf

Energy Commission of Ghana. (2018). 2018 Energy supply and demand outlook for Ghana, (April), 1–51. Retrieved from http://www.energycom.gov.gh/files/Energy Commission - 2015Energy Outlook for Ghana_final.pdf

Energypedia. (2018). Morocco energy situation. Retrieved from https://energypedia.info/wiki/Morocco_Energy_Situation

Eskom. (2016). Connection of small-scale renewable generation to Eskom's network background (Customer Small-Scale Renewable Generation).

Export.gov. (2017). Morocco energy. Retrieved from https://www.export.gov/article?id=Morocco-Energy

Farhad, S., Saffar-Avval, M., & Y.-S. (2008). Efficient design of feedwater heaters network in steam power plants sing pinch technology and exergy analysis. International Journal of Energy Research 2008.

Fisher, N., & Downes, G. (2014). South Africa, (March).

Foxon, T. J., Gross, R., Chase, A., Howes, J., Arnall, A., & Anderson, D. (2005). UK innovation systems for new and renewable energy technologies : drivers , barriers and systems failures, *33*, 2123–2137. https://doi.org/10.1016/j.enpol.2004.04.011

Gboney, W. (2009). Policy and regulatory framework for renewable energy and energy efficiency development in Ghana. *Climate Policy*, *9*(5), 508–516. https://doi.org/10.3763/cpol.2009.0636

Gboney, W. K. (2012). Es2012-91419 Promoting the sevelopment of concentrating solar power in the Middle East and North Africa regions: Policy and regulatory implications, 1–8.

Gottwald, J. (2012). Understanding the role of universities in technology transfer in the renewable energy sector in Bolivia. https://doi.org/10.1108/14777831211217495

Government of Ghana. (2011). Renewable Energy Act 2011: Act 832. Retrieved from http://energycom.gov.gh/files/RENEWABLE ENERGY ACT 2011 (ACT 832).pdf

Government of Ghana. (2018). GSS releases inflation rate for July. Retrieved from http://www.ghana.gov.gh/index.php/media-center/news/912-gss-releases-inflation-rate-for-july

GRA. (2018, March). Income tax. Retrieved from http://www.gra.gov.gh/index.php/tax-information/income-tax

Graphic.com.gh. (2018). Govt earmarks $230m for renewable energy project -. BusinessGhana. Retrieved from https://www.businessghana.com/site/news/general/162735/Govt-earmarks-230m-for-renewable-energy-project

Gyamfi, S., Modjinou, M., & Djordjevic, S. (2015). Improving electricity supply security in Ghana - The potential of renewable energy. *Renewable and Sustainable Energy Reviews*, *43*, 1035–1045. https://doi.org/10.1016/j.rser.2014.11.102

Haas, R., Resch, G., Panzer, C., Busch, S., Ragwitz, M., & Held, A. (2011). Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources- Lessons from EU countries. *Energy*, *36*(4), 2186–2193. https://doi.org/10.1016/j.energy.2010.06.028

Hammons, T. J. (2008). Electrical power and energy systems integrating renewable energy sources into European grids q, *30*, 462–475. https://doi.org/10.1016/j.ijepes.2008.04.010

IEA. (2017). *Energy access outlook 2017*. Retrieved from https://www.iea.org/access2017/

IRENA. (2018). *Renewable energy capacity 2018*.

Jäger-Waldau, A. (2007). Photovoltaics and renewable energies in Europe. *Renewable and Sustainable Energy Reviews*, *11*(7), 1414–1437. https://doi.org/10.1016/j.rser.2005.11.001

Karekezi, S., & Kithyoma, W. (2002). Renewable energy strategies for rural Africa : is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa ?, *30*, 1071–1086.

Karmouni, G. W. El. (2016). Morocco energy policy: From one dependent to another. Retrieved from https://lb.boell.org/en/2016/12/12/perspectives-9-moroccan-energy-policy-one-dependence-another

Kemausuor, F., & Ackom, E. (2017). Toward universal electrification in Ghana. *Wiley Interdisciplinary Reviews: Energy and Environment*, *6*(1). https://doi.org/10.1002/wene.225

Kemausuor, F., Obeng, G. Y., Brew-Hammond, A., & Duker, A. (2011). A review of trends, policies and plans for increasing energy access in Ghana. *Renewable and Sustainable Energy Reviews*, *15*(9), 5143–5154. https://doi.org/10.1016/j.rser.2011.07.041

Klessmann, C., Held, A., Rathmann, M., & Ragwitz, M. (2011). Status and perspectives of renewable energy policy and deployment in the European Union — What is needed to reach the 2020 targets ? *Energy Policy*, *39*(12), 7637–7657. https://doi.org/10.1016/j.enpol.2011.08.038

Kousksou, T., Allouhi, A., Belattar, M., Jamil, A., Rha, T. El, Arid, A., & Zeraouli, Y. (2015). Renewable energy potential and national policy directions for sustainable development in Morocco, *47*, 46–57. https://doi.org/10.1016/j.rser.2015.02.056

Krauber, B. (2014). Drivers for the transition to renewable energy in developing countries.

Kwarteng, M. (2017). The sad story of Ghana's untapped 240,000MW solar power potential. Retrieved from https://www.myjoyonline.com/opinion/2017/March-16th/the-sad-story-of-ghanas-untapped-240000mw-solar-power-potential.php

Lavrakas, J. (2008). Where is South Africa? Retrieved from http://dx.doi/10.4135/978141296347.n419

Lehmann, P., Creutzig, F., Ehlers, M., Friedrichsen, N., Heuson, C., Hirth, L., & Pietzcker, R. (2012). Carbon lock-out: Advancing renewable energy policy in Europe, 323–354. https://doi.org/10.3390/en5020323

Leidreiter, A., & Boselli, F. (2015). *100 % Renewable energy: Boosting development*.

Marokko info. (2018). Moroccan population. Retrieved from https://www.marokko-info.nl/moroccan-population/

Martinot, E. (1999). Renewable energy in Russia : Markets , development and technology transfer, *3*, 49–75.

Menanteau, P., Finon, D., & Lamy, M. (2010). Prices versus quantities : Choosing policies for promoting the development of renewable energy, *31*(2003), 799–812.

Meyer, D. (2003). European scheme for promoting renewables in liberalised market (pp. 665–678).

Mezher, T., Dawelbait, G., & Abbas, Z. (2012). Renewable energy policy options for Abu Dhabi : Drivers and barriers. *Energy Policy*, *42*, 315–328. https://doi.org/10.1016/j.enpol.2011.11.089

Ministry of Energy. (2006). Stretegic National Energy Plan, Main report (2006- 2020).

Ministry of Energy. (2010). National Energy Plan, 2010- Final report, (February).

Mitchell, C., & Connor, P. (2004). Renewable energy policy in the UK 1990 – 2003, *32*, 1935–1947. https://doi.org/10.1016/j.enpol.2004.03.016

Morocco Energy. (2018). *Major projects put Morocco on the map for wind energy*. Retrieved from https://oxfordbusinessgroup.com/analysis/wind-rising-major-projects-have-put-morocco-map-wind-energy

Morocco World News. (2018a). Morocco on track for 2020 renewable energy goals. Retrieved from https://www.moroccoworldnews.com/2018/01/239531/renewable-energy-morocco-masen/

Morocco World News. (2018b). Morocco to invest USD 40 billion in energy sector by 2030. Retrieved from https://www.moroccoworldnews.com/2018/02/240667/morocco-to-invest-usd-40-billion-in-energy-sector-by-2030/

Moulin, S. (2011). Renewable energy in Morocco. *The Road to Rio+20: For a Development-Led Green Economy*, 83–87. Retrieved from http://unctad.org/en/docs/ditcted20108_en.pdf

Nano Energy. (2008). *Business case for a special funding application to NERSA* (Vol. 27).

Nawathe, Paden, J., & Confl, R. (1982). Net metering definition. *Pielegniarka i Polozna*. Retrieved from file:///C:/Users/home/Downloads/come abck to this literatures/Net Metering _ Suka Solar Ghana – Efficient Energy System.html

Owen, A. D. (2006). Renewable energy : Externality costs as market barriers, *34*, 632–642. https://doi.org/10.1016/j.enpol.2005.11.017

Oxford Business Group. (2016). South Africa energy sector. Retrieved from https://oxfordbusinessgroup.com/analysis/wind-rising-major-projects-have-put-morocco-map-wind-energy

Painuly, J. P. (2001). Barriers to renewable energy penetration ; A framework for analysis, *24*, 73–89.

Painuly, J. P., Park, H., Lee, M., & Noh, J. (2003). Promoting energy efficiency financing and ESCOs in developing countries : Mechanisms and barriers, *11*, 659–665. https://doi.org/10.1016/S0959-6526(02)00111-7

Parke, P., & Giles Chris. (2018). Morocco's megawatt solar plant powers up. Retrieved from https://www.africa-eu-renewables.org/market-information/south-africa/energy-sector/

Pasqualetti, M. J. (2011). Social barriers to renewable energy landscapes.

Pegels, A. (2010). Renewable energy in South Africa : Potentials , barriers and options for support. *Energy Policy*, *38*(9), 4945–4954. https://doi.org/10.1016/j.enpol.2010.03.077

Power Africa. (2017). South Africa.

PURC. (2016). *Feed-in-tariff, 2016.*

Pwc. (2018). South Africa corporate - Taxes on corporate income. Retrieved from http://taxsummaries.pwc.com/ID/South-Africa-Corporate-Taxes-on-corporate-income

Quansah, D. A., Adaramola, M. S., & Anto, E. K. (2017). Cost - competitiveness of distributed grid - connected solar photovoltaics in Ghana : Case study of a 4 kWp polycrystalline system. *Clean Technologies and Environmental Policy*. https://doi.org/10.1007/s10098-017-1432-z

RCREEE. (2018). Morocco. Retrieved from http://www.rcreee.org/content/morocco

RECP. (2018). *South Africa energy sector.* Retrieved from https://www.africa-eu-renewables.org/market-information/south-africa/energy-sector/

REN21. (2018). *Renewables 2018 Global status report*. https://doi.org/978-3-9818911-3-3

Salem, T., & Kinab, E. (2015). Analysis of building-integrated photovoltaic Systems : A Case study of commercial buildings under mediterranean climate, *118*, 538–545. https://doi.org/10.1016/j.proeng.2015.08.473

Santander. (2018). Morocco: Tax system. Retrieved from https://en.portal.santandertrade.com/establish-overseas/morocco/tax-system

Sebitosi, A. B. (2008). Energy efficiency, security of supply and the environment in South Africa: Moving beyond the strategy documents. *Energy*, *33*(11), 1591–1596. https://doi.org/10.1016/j.energy.2008.08.003

Serwaa Mensah, G., Kemausuor, F., & Brew-Hammond, A. (2014). Energy access indicators and trends in Ghana. *Renewable and Sustainable Energy Reviews*, *30*(2014), 317–323. https://doi.org/10.1016/j.rser.2013.10.032

Shukla, A. K., Sudhakar, K., & Baredar, P. (2017). Renewable energy resources in South Asian countries : Challenges , policy and recommendations. *Resource-Efficient Technologies*, 0–4. https://doi.org/10.1016/j.reffit.2016.12.003

Šimelytė, A., Ševčenko, G., El, N., El, A., & Monni, S. (2016). Promotion of renewable energy in Morocco, *4*(August). https://doi.org/10.9770/jesi.2016.3.4(2)CITATIONS

Suryapratim, R., Tsidiso, D., & Kiratu, S. (2010). Clean energy investment in developing countries : Domestic barriers and opportunities in South Africa, (June).

Thabethe Hon E. (2010). A Conference paper on renewable energy policies in South Africa.

Tradingeconomics. (2018). South Africa interst rate. Retrieved from https://tradingeconomics.com/south-africa/interest-rate

UNDP. (2012). *In Ghana, a victory in energy efficiency*. Retrieved from http://www.gh.undp.org/content/ghana/en/home/operations/projects/environment_and_energy/Susdevclusterprojects.html

Unruh, G. (2007). Overcoming the lock-out of renewable energy technologies in Spain : The cases of wind and solar electricity, *11*, 1498–1513. https://doi.org/10.1016/j.rser.2005.12.003

Van Buskirk, R., Ben Hagan, E., Ofosu Ahenkorah, A., & McNeil, M. A. (2007). Refrigerator efficiency in Ghana: Tailoring an appliance market transformation program design for Africa. *Energy Policy*, *35*(4), 2401–2411. https://doi.org/10.1016/j.enpol.2006.08.017

Verbruggen, A., Fischedick, M., Moomaw, W., Weir, T., Nadaı, A., Nilsson, L. J., … Sathaye, J. (2010). Renewable energy costs, potentials, barriers: Conceptual issues, *38*, 850–861. https://doi.org/10.1016/j.enpol.2009.10.036

VRA. (2017). Power generation: Fact & figures. Retrieved from http://www.vra.com/resources/facts.php

VRA. (2018). Power generation: Facts & figures. Retrieved from http://www.vra.com/resources/facts.php

Weisser, D. (2004). *On the economics of electricity consumption in small island developing states: a role for renewable energy technologies?*

World Atlas. (2015). Where is Morocco? Retrieved from https://www.worldatlas.com/af/ma/where-is-morocco.html

World Atlas. (2018). Location of Ghana. Retrieved from https://www.worldatlas.com/webimage/countrys/africa/ghana/ghlatlog.htm

World Bank Group. (2015). Achievements and lessons from the Africa Renewable Energy and Access Program (AFREA) phase I.

World Energy council. (2016). Major projects put Morocco on the map for wind energy. Retrieved from https://www.worldenergy.org/data/resources/country/morocco/wind/

World Energy Council. (2016). Major projects put Morocco on the map for wind energy. Retrieved from https://www.worldenergy.org/data/resources/country/morocco/wind/

Wu, R., Wolsink, M., & Bu, M. J. (2007). Social acceptance of renewable energy innovation : An introduction to the concept, *35*, 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Yaneva, M. (2016). Morocco amends renewable energy law. Retrieved from https://renewablesnow.com/news/morocco-amends-renewable-energy-law-507698/Morocco amends renewable energy law

APPENDICES

## Appendix 1

## Interview Guide

### 1.1 Part 1 (For RE Lecturers)

This survey is conducted by the student from Pan African University Institute of Water and Energy Sciences Including Climate Change, Algeria as part of her master thesis. Therefore, your responses are highly welcomed.

1. Do you have any idea why the net metering scheme has still not been implemented?

2. What do you think are the major factors that affect the net metering implementation in Ghana?

3. Does the feed-in-tariff rates serve as a form of motivation to draw investors into the renewable energy sector?

4. Could you tell us some of the barriers accounting for low growth in the RE sector?

5. I would like to know some challenges faced when acquiring a license to operate in the renewable energy domain, your opinion is needed.

6. What challenges limit the private institutions from connecting to the national grid?

7. Energy institutions with construction permit go into more fossil fuels to generate electricity than renewables, what is your opinion on this?

8. Does bulk distributor like ECG and NEDCo purchase part of its electricity from renewable energy sources?
9. What are some impact of connecting solar PV to the grid? (your ideas are welcomed)

### 1.2 Part 2 (For Private RE Institutions)

This survey is conducted by the student from Pan African University Institute of Water and Energy Sciences Including Climate Change, Algeria as part of her master thesis.

Therefore, your responses are highly welcomed.

10. Do bulk suppliers like ECG and NEDCo, purchase of its electricity from renewable energy sources?

11. Does the feed-in-tariff rates serve as a form of motivation to draw investors into the renewable energy sector?
12. Are you aware of the RE Fund in Ghana? if yes, then

13. Have your Institute benefited from the RE fund since its operation?

14. Do you have any idea why the net metering scheme has still not been implemented?

15. Would you love to join if the net metering scheme is implemented?

16. What do you think are the major factors that affect the net metering implementation in Ghana?

17. Could you tell me some of the barriers accounting for low growth in the RE sector?

18. I would like to know some challenges faced when acquiring a license to operate in the renewable energy domain

19. What challenges limit the private companies from connecting to the national grid?

20. Have you Company been involved in decision making in the renewable energy sector in Ghana?

### 1.3 Part 3 (For the State)

This survey is conducted by the student from Pan African University Institute of Water and Energy Sciences Including Climate Change, Algeria as part of her master thesis. Therefore, your responses are highly welcomed.

21. Do you have any idea why the net metering scheme has not been implemented in the country?

22. Does bulk customer like ECG and NEDCo purchase part of its electricity from renewable energy sources as mandated by the RE Act 2011?

23. How many institutions have benefited from the Ghana Renewable Energy Risk Capital (GRERC)?

24. Could you tell us what have been done with the various funding options for renewable energy domain?

25. Could you tell me how the of the feed-in-tariff rate in Ghana?

26. Do you involve the private sector in energy policy formulation? If yes, what contribution have they made to the sector. If no, give reasons why they are not being involved?

27. The current percentage of renewables in the country is less than 1%, what do you think can be done to achieve the 10 % share of renewables by 2030?

**Appendix 2**

**Questionnaires**

**1.4 Part 4 Individual Solar PV Users**

This survey is conducted by the student from Pan African University Institute of Water and Energy Sciences Including Climate Change, Algeria as part of her master thesis. Therefore, your responses are highly welcomed.

*Table 1 Questions for individual renewable energy generators*

| **Questions** | | **Responses** | | | |
|---|---|---|---|---|---|
| | | **No** | **Yes** | **Others** | |
| 1 | Have you heard about the solar rooftop programme? | | | | |
| 2 | Was the panels subsidized? | | | | |
| 3 | Do you produce excess? | | | | |
| 4 | What do you do with excess power | | | | |
| 5 | Do you get paid for feeding power to the grid? | | | | |
| 6 | Would you love to produce more if feed-in-tariff and net metering scheme are implemented? | | | | |
| 7 | Do you face any challenge after installing the panels? | | | | |
| | | | | | |
| | | **On a scale of i to iv** | | | |
| 9 | How will you rate the use of renewable energies in Ghana (efficiency) | i (Excellent) | ii (Good) | iii (Average) | iv (Poor) |

## Appendix 3

## Activities

*Table 2 Shows the activities of the study*

| **Activity** | **Date** | **Duration** |
|---|---|---|
| Proposal writing | | 1 month |
| Submission of research proposal | 11th January | 1 week |
| Start of research/Data collection | April- May 2018 | 2 months |
| Data analysis and interpretation | June 2018 | 1 month |
| Thesis write up | July 2018 | 3 weeks |
| First draft submission | July 2018 | 1 week |
| Defense and final thesis submission | August 2018 | 1 months |

**Appendix 4**

**Gantt Chart**

*Table 3 Shows the detailed activities and milestone of the study*

| **TASK TO BE PERFORMED** | **YEAR 1** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** |
| Research Proposal for submission | √√ | | | | | | | | |
| Ethical Clearance and permission to carry out the work | | √√ | | | | | | | |
| Contacts and consultation and orientation | | | √√ | | | | | | |
| Data collection | | | | √ | √√ | | | | |
| Data processing | | | | | √√ | | | | |
| Data analysis | | | | | √ | √√ | | | |
| Project writing (first draft) | | | | | | √ | | | |
| First project presentation to Supervisor | | | | | | | √ | | |
| Project writing (final draft) | | | | | | | | √ | |
| Final thesis defense | | | | | | | | √√ | |
| Submission of final report | | | | | | | | | √ |
| Feedback to scholarship sponsors | | | | | | | | | √ |

**Appendix 5**

**Master Thesis Expenditure**

GHC 4 ~ 1 dollar

| **Item Description** | **Quantity** | **Unit Price (DZD & GHC)** | **Total Price (DZD & GHC)** | **Amount in Dollar ($)equivalent** |
|---|---|---|---|---|
| Flight ticket (Algiers- Accra) return | Return | 137800 | 137800 | 1,300 |
| *Local transport (Tlemcen- Algiers) | return | 7000 | 7000 | 66.0 |
| Printing of questionnaires | 160 sheets | 1 | 160 | 40 |
| Stationary | - | - | 105 | 30 |
| Hotel accommodation for data collection | 4 nights (Tamale)<br>5 nights (Kumasi) | 165*4<br>185*5 | 1585 | 396.2 |
| Airtime for data bundles and communication | 6 | 330 | 1980 | 495 |
| Internal travels for weekly update on thesis report and;<br>Transportation for data collection | 1 | - | 1540 | 385.0 |
| Huawei router E5172 | 1 | 590 | 590 | 147.5 |
| Ethernet cable | 1 | 80 | 80 | 20.0 |
| Report printing for panel | 98 pages*5 | 98 | 490 | 122.5 |
| Comb binding of the reports | 5 | 3 | 15 | 3.7 |
| Final printing and binding | - | - | - | - |
| TOTAL | | | | **3005.9** |
| **Amount given** | | | | **3000.00** |