Chapter

Evaluating the Success of Renewable Energy and Energy Efficiency Policies in Ghana: Matching the Policy Objectives against Policy Instruments and Outcomes

Margaret Adobea Oduro, Samuel Gyamfi, Samuel Asumadu Sarkodie and Francis Kemausuor

Abstract

Advancement in energy policies has stimulated the adoption of instruments used in the renewable energy sector and climate change mitigation. Renewable energy policies play a crucial role in the abatement of greenhouse gas emissions, by providing access to modern energy and energy security by diversifying energy supply. There have been numerous policies developed in Ghana to improve the uptake of renewable energy for electricity production and to ensure efficient use of electrical energy. Some of the specific government policy objectives include reducing technical and commercial losses in power supply, support the modernization and expansion of the energy infrastructure to meet the growing demands, ensure reliability and accelerate the development and utilisation of renewable energy and energy-efficient technologies. These policies have defined targets and period to be implemented. This chapter outlined the renewable energy and energy efficiency policies in Ghana by matching the policy objectives against policy instruments and outcomes to measure what has been achieved. A comparative analysis was made with South Africa and Morocco's renewable energy sectorial policies on the basis of various strategies adopted to their achievements and what Ghana can learn from.

Keywords: renewable energy policies, energy efficiency, independent power producers

1. Introduction

Environmental policies have aided the adoption of superlative policy instruments profoundly used in climate change mitigation, adaptation option and renewable energy-related planning and implementation. Renewable energy policies play a crucial to abate greenhouse gas emissions, provide access to modern energy, and bring about energy security by diversifying energy supply as energy demand and its

associated services to meet both social and economic development keep increasing [1]. International Renewable Energy Agency (IRENA) describes four categories of policy instruments used to promote renewable electricity generation, namely fiscal incentives; public finance, regulations; and access policies [2].

The use of renewable energy technologies has provided electricity to regions that lack electricity access, which will help create jobs as well as an increase in energy efficiency up to 30% by 2050 [3]. Also, Klein et al. [4] categorised instruments supporting renewable electricity (RES-E) generation based on whether they affect demand or supply of renewable electricity or whether they support power generation. First, policies may regulate renewable electricity price or the quantity produced and second, policies may support investment in renewable energy generation or direct subsidised generation [4]. On the other hand, categorised environmental policies instruments as regulative instruments, market-based instruments, procedural instruments, co-operative instruments and persuasive instruments [5].

Regulative instruments such as command-and-control aim at controlling the actions of firms and include mandatory regulations where the government directly intervenes in the activities of individual firms by prescribing or forbidding certain activities [6]. Market-based instruments (MBIs) are regulations that aim at providing actors or polluters with incentives to adopt low-emission technologies and encourage behaviour change through market signals and economic incentives [6, 7]. Procedural instruments aim at assessing the environmental impact of certain production processes and determine alternative arrangements that are environmentally friendly, examples are environmental impact assessment [8]. Persuasive instruments such as information provision tools work best where there is information gap-such that the missing information becomes a hindrance to behavioural change in reducing environmental impacts [9]. Co-operative instruments such as voluntary agreements and energy efficiency measure work best where there are existing incentives to behavioural change integrated with prevailing laws [8, 10].

Consistent with this, Ghana has a number of renewable energy and energy efficiency policies and initiatives to ensure the security and diversification of energy supply. **Figure 1** shows the Renewable Energy Policy Framework in Ghana that outlines the relationship between policy objectives, policy instruments, and policy institutions, while **Figure 2** shows the general energy policies. Although there are domestic and international financial incentives, policy and regulatory barriers limit the possibility of utilising renewable resources in both off-grid and grid-connected applications [13]. For instance, the percentage share of solar photovoltaic is 0.5%

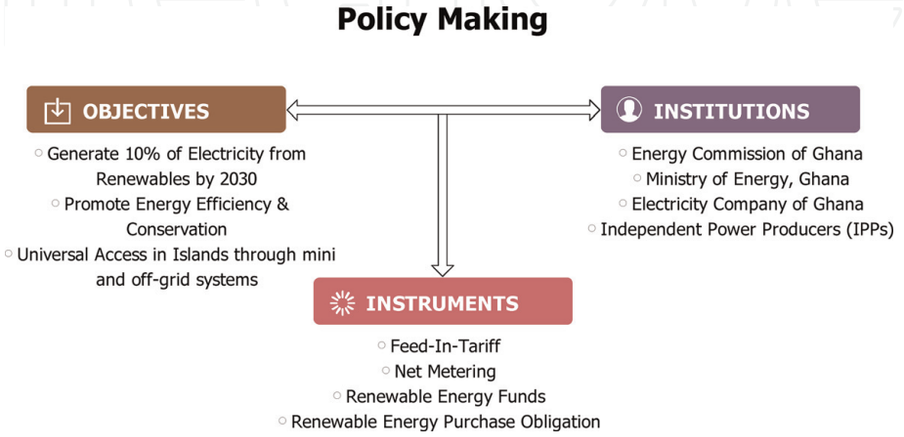

Figure 1.
Conceptual framework showing the policy making process in renewable energy sector of Ghana (source: [11, 12]).

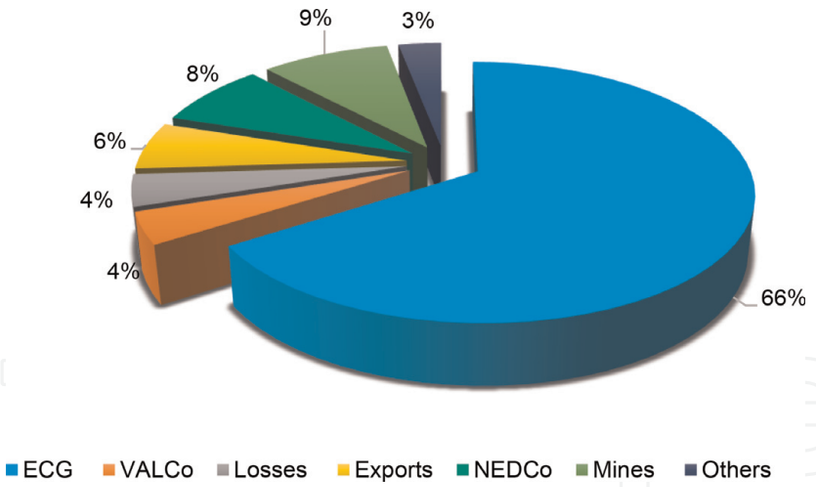

Figure 2.
2017 projected energy consumption by customers (source: [11]).

(22.6 MW) out of the 4674.85 MW of total installed energy [14]. Barriers to renewable energy application in Ghana have been classified into technical, social, environmental, economic, and policy-related [15]. 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. Likewise, there are numerous interventions instituted (i.e. the policy instruments) to achieve the objectives, however, the growth of renewable energy in Ghana is low. The percentage share of installed grid-connected renewable energy is a mere 22.6 MW (0.5%)—notwithstanding its potential [11]. Although, several studies have shown that network and technical barriers such as system failure and financial barriers (i.e. like the high upfront cost of renewables compared to that generated from fossil fuels) [15] have hindered the achievement of the 10% renewable energy penetration by 2020.

Another area that requires critical focus to ensure a successful transition into renewable and sustainable energy is an investment 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 freely given out nationwide. The effect of the programme resulted in cutting down the peak load demand of about 300 MW [12]. In 2012, the government of Ghana with support 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 [12].

Against the background, it is essential to evaluate the success of renewable energy and energy efficiency policies in Ghana by matching the policy objectives against policy instruments and outcomes. Almost all the studies in the scope analysed the system failure and financial barriers using Ghana as a case study. However, this chapter includes a comparative analysis of Morocco and South Africa's renewable energy policies. The significance of this chapter revealed and identified the gaps in renewable energy policies as well as strategies or measures required to achieve the 10% renewable energy penetration in the national energy mix by 2030.

The remainder of this chapter includes background, methodology, results and discussion, and conclusion.

2. Background

2.1 Overview of Ghana's energy sector

As shown in **Table 1**, Ghana's installed electricity capacity currently stands at 4673.8 MW [14, 17] including large hydro, thermal and renewables of which 2334 MW is from independent power producers (IPPs).

Electricity Company of Ghana is the largest bulk purchaser and distributor, 66% of electricity consumed in Ghana while the Northern Electricity Distribution Company (NEDCo) only purchase and distribute 8% of the total energy. The rest of the energy is consumed by the Volta Aluminium Company (VALCo)—an aluminium and steel company, mining companies, exports, and sectors such as agriculture, health, and transport contributes to other energy users. **Figure 3** shows the structure of Ghana energy sector.

Type of energy	Installed capacity (MW)
Hydro	1580
Thermal	3071
Renewables	22.6
Total	4673.7

Source: [16].

Table 1.
Ghana's total energy installed capacity.

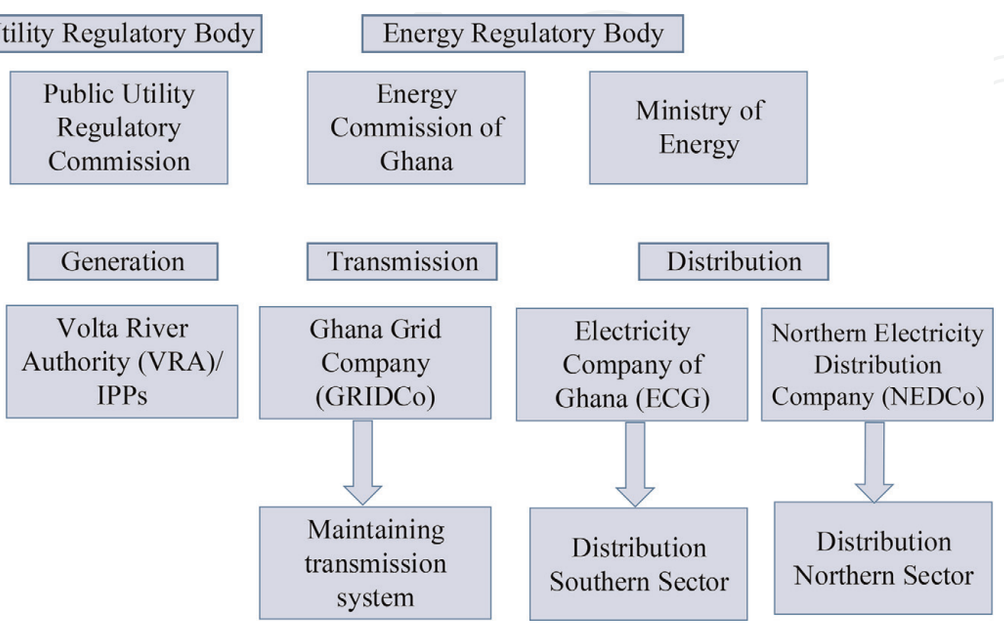

Figure 3.
Structure of Ghana's energy sector (source: [14]).

2.2 Review of policies and strategies on renewable energy deployment in Ghana

Policies facilitate the extent to which renewable energy technologies are adopted in a country. Ghana has instituted several policies and measures to help promote the development of renewable energy technologies, particularly, incentives that will attract renewable energy sector investors. **Figure 4** shows the renewable energy policies in Ghana from 2006 to 2018.

2.2.1 Strategic national energy plan, 2006–2020

The Energy Commission of Ghana has the mandate to review all investment plans to ensure energy needs are met in a sustainable manner. The commission developed the Strategic National Energy Plan for the period 2006–2020. The goal was to provide a sound energy market and to ensure the provision of sufficient energy services for Ghana. In contrast, the target of the Strategic National Energy Plan 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 while ensuring energy efficiency and conservation and achieving universal access to electricity by the year 2020 [18].

The policy sought to develop renewable energy technology regulations through the development of standards and codes. 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 instituted to ensure efficient energy consumption, adopt energy demand-side management, and set-up energy efficiency revolving fund to offer a low-interest facility for energy efficiency improvements in the country. However, the government is yet to release funds for its implementation [19].

2.2.2 National energy policy, 2010

The vision of the National Energy Policy was to develop an energy economy to ensure secure and reliable energy supply to all Ghanaians. The 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 to focus on the fiscal incentives, awareness creation and regulations to promote energy efficiency and conservation practices. The policy also set the target to achieve 10% of renewables by the year 2020, reduce the consumption of woodfuels from 66 to 30% by 2020 and encourage the use of clean cooking alternatives such as LPG, and efficient cookstoves [19].

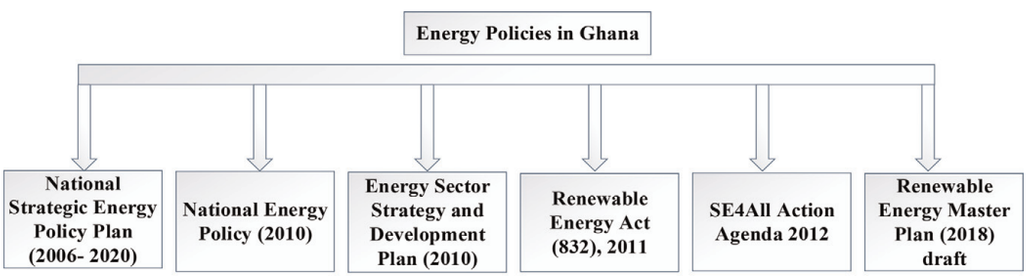

Figure 4: Energy Policies in Ghana

Figure 4.
Energy policies in Ghana (source: [11, 14]).

2.2.3 Energy sector strategy and development, 2010

The Energy Sector Strategy and Development Plan was introduced in 2010 alongside the National Energy Policy 2010. It covered 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, and renewable energy sub-sector. This policy sets the goal and strategies to increase (i) the percentage of renewable in the total national energy mix and efficient use of stoves and (ii) establish legislation to encourage the development of renewable energy technologies [19].

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 island and riverside communities in Ghana through both on- and off-grid systems and providing universal access to clean cooking solutions. The UNDP has collaborated with some partner agencies to achieve universal access to energy by 2030. The current electricity access in Ghana is approximately 84% [17].

2.2.5 The renewable energy act, 2011

The renewable energy act (832) was passed and enacted to provide for the development, management, utilisation, sustainability and adequate supply of renewable energy for the generation of heat and power, and provide an enabling environment to attract renewable energy sector investors [20]. Under this act, there are Licencing procedures, feed-in-tariff scheme, purchase obligation and rights to transmission and distribution systems for renewable energy (RE) plants, net metering and renewable energy fund [21]. 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 into the national grid. The Public Utility Regulatory Commission (PURC) is responsible for setting 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 2 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.

2.2.5.1 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 photovoltaic (PV) users in the country. The policy does not work to the advantage of individual solar PV users but for those connected to the grid (but not being paid). In addition, the government of Ghana is ready to sign an agreement to pay FiT of 10 cents/kWh or below, but not above 10 cents/kWh—this is a new recommendation to generators to sign a PPA and invest in various RE (2016 FiT rate are more than 10 cents/kWh for RE technologies in Ghana). Investors are however not convinced with the change of the FiT rates—which has being one of the motivations of RE generators.

2.2.5.2 Net metering scheme

The net metering scheme was piloted by the energy commission in 2015 with 33 being installed. The scheme was gazetted by the PURC with the Electricity Company of Ghana (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 the problem as financial but not technical. The stakeholder agencies are working to find solutions to fully implement the scheme. However, RE school of thought argued that some energy institutions see no need to reward renewable energy generators, hence, failure to implement the scheme.

2.2.5.3 Renewable energy funds

In the past and present, 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 energy efficiency interventions. The government has established the Ghana Renewable Energy Risk Capita (GRERC) as a financial instrument which seeks to assure project financiers and investor community to invest in RE with focus on small and medium-sized enterprises (SMEs) and domestic green projects. However, no RE community has benefited under the GRERC. Similarly, the government of Ghana for the past years has encountered failed projects such as the Ape Bank Project with support from the World Bank which was to install solar mini-grids in rural communities but the communities failed to pay back.

2.2.5.4 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 finalised. 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 is 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 are 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.

2.3 Barriers to renewable energy development

Barriers to renewable energy developments have been identified as, inter alia, economic and financial, market, technical and network, policy regulatory framework, over-dependency on a centralised grid, and dependency on fossil fuel resources.

2.3.1 Cross-cutting barriers

Existing literature also identified more than one barrier to renewable energy development [1]. These barriers have been grouped under cross-cutting barriers. These include 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. [22] 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. They proposed a potentially unified taxonomy regarding policy driven as a whole. Mezher et al. [23] pointed out that not only climate change and fossil fuel consumption are the main drivers to renewable energy resource exploitation but the high cost of RE technology. Economic and political interference were also identified as barriers to renewable power generation and suggested that there should be a mixed implementation of feed-in-tariff and quota systems for the United Arab Emirates to meet its set target [23].

Bensah et al. [24] demonstrated that financial and market barriers could be removed through the provision of grants, soft loans, the flexible financial scheme as well as organising awareness and training programs. Notwithstanding the barriers such as market, technical, regulatory, social and environmental contributions to its development [25], consultation of various institutions on policy implementation, tax exemption, credit facilities, and incentive-based mechanism could minimise financial and market challenges. Although Ghana is endowed with renewable energy sources, exploitation of these sources for electricity generation is relatively low. Gyamfi et al. [15] further highlighted five main barriers to renewable energy utilisation, such as (1) technical—which includes trained personnel, voltage fluctuations (2) social (3) environmental (4) economics, and (5) policy. Kemausuor et al. [26] identified extra three main barriers such as (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.

Bensah et al. [24] also conducted a survey that presented the various findings of Ghana's renewable energy policies in conjunction with China's renewable energy policy and the factors that constrain the development and the deployment of the various stakeholders. Their study concluded that poor financing of renewable energy investments, lack of affordability of renewable energy systems, cumbersome licencing processes, challenges with enabling instruments for RE investment, and unbalanced emphasis on on-grid RE systems. Bensah et al. [24] stated that one of the driving forces of access to renewable energy technology is 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 dependence on charcoal and wood fuels, renewable energy market size, high-interest rate to finance RE projects, among others, are the main obstacles of renewable technology transfer in Ghana. Even so, renewable energy sources do not only provide energy to the society but help in the reduction of massive indoor pollution from biomass resources [27], hence, a contribution to health improvement. Therefore, a solution that minimises the barriers to renewable energy production and consumption 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, inter alia, weak energy policy framework, financial constraints, and weak information systems.

3. Methodology

This chapter utilised both primary and secondary data. Purposive sampling technique was used to select key scientific publications and experts that have key knowledge in the field. Data were obtained from published articles and non-published papers, reports that include relevant renewable energy policy documents,

questionnaires and interviewing of stakeholders namely public institutions, renewable energy private companies, universities and owners of solar rooftop installations.

To analyse the information on the implementation of RE policies, the following equation was applied and the summary of the methodology is presented in **Figure 2**.

$$\frac{n}{N} * 100\% \quad (1)$$

Country		Economic aspect
Morocco	Has the largest solar plants in the world and made improvement in their renewable energy sector	Inflation rates: 1.6%
		Steady interest rate: 2.25%
		Government taxes: 10–15%
South Africa	Largest wind installed capacity (1053 MW) in Africa (2015)	Inflation rate: 4.4%
		Steady interest rate: 6.5%
		Government taxes: 21–28%
Ghana		Inflation rate: 15%
		Interest rate: 30%
		Government taxes: 25% and above

Source: [26–29].

Table 2.
Reasons for the choice of countries.

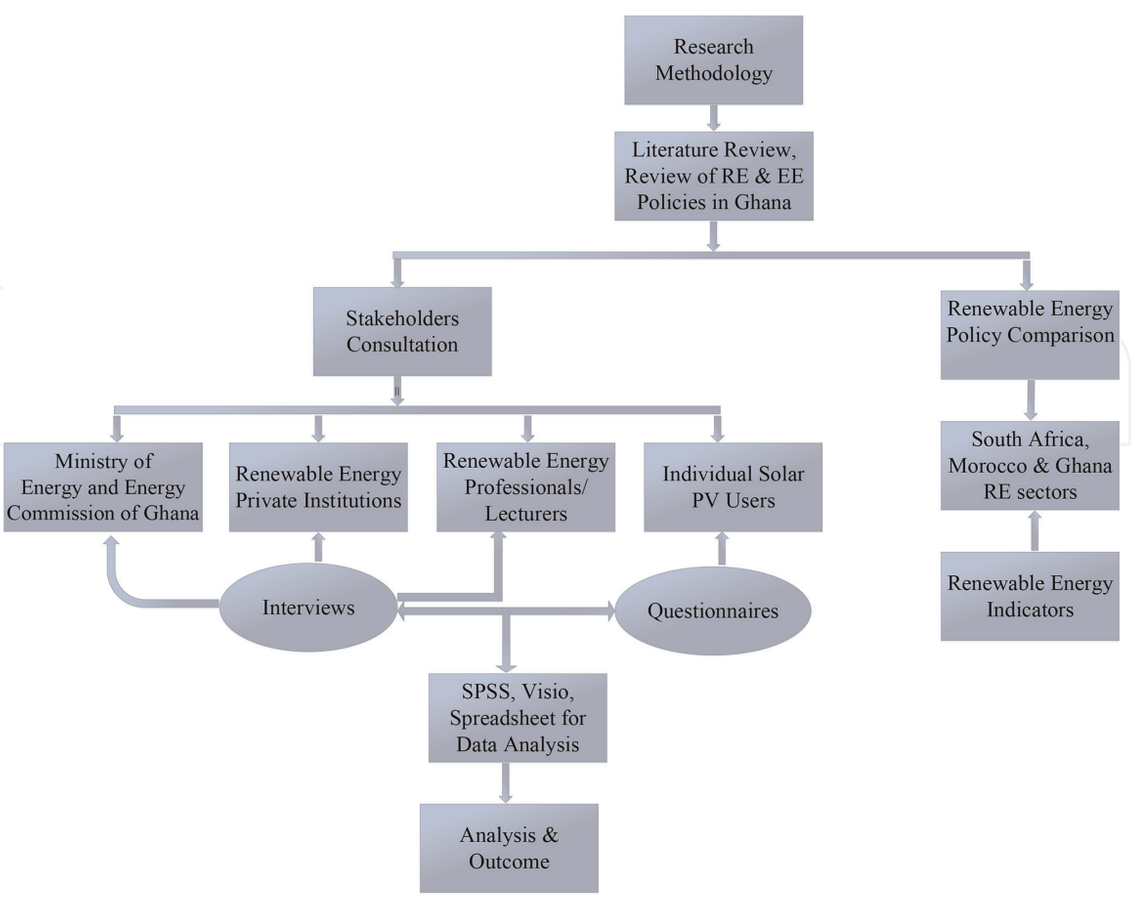

Figure 5.
Summary of research methodology.

where n represents the number of respondents who agreed policies are not implemented and N is the sample size, expressed as a percentage.

3.1 Renewable energy indicators

For business purposes, one needs to take into account the interest rate, inflation rate, exchange rate, and government taxes. These indicators are useful to examine a country's business environment. In the case of RE generator, other indicators are incorporated to assess the market attractiveness and these include; *policy incentives*: net metering scheme, feed-in-tariff, RE funds, renewable energy purchase obligation, and *economics aspects*: interest rate, government taxes, and inflation rate.

Table 2 shows the reasons for the choices of countries made for the comparative analysis between South Africa, Ghana and Morocco while **Figure 5** presents a summary of the methodology employed.

4. Results and discussion

The results of this chapter identified two major issues encountered in Ghana's renewable energy sector. 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

4.1 Summary response on policy implementation issues identified by the stakeholders

Table 3 shows the views from stakeholders regarding RE development and policy implementation issues in Ghana.

4.2 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 while the Volta River Authority (VRA) is in charge of paying feed-in-tariff for the Northern Sector. The Government of Ghana (GoG) is the main body responsible for the implementation of RE funds. There is no meter for calculating excess power fed into the grid, since feed-in-tariffs are currently not in operation because of the poor management of the scheme, although rates are published by the PURC every 2 years. **Figure 6** shows the policy incentives and the bodies responsible for implementation.

	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.

Table 3.
Stakeholders response on policy instruments.

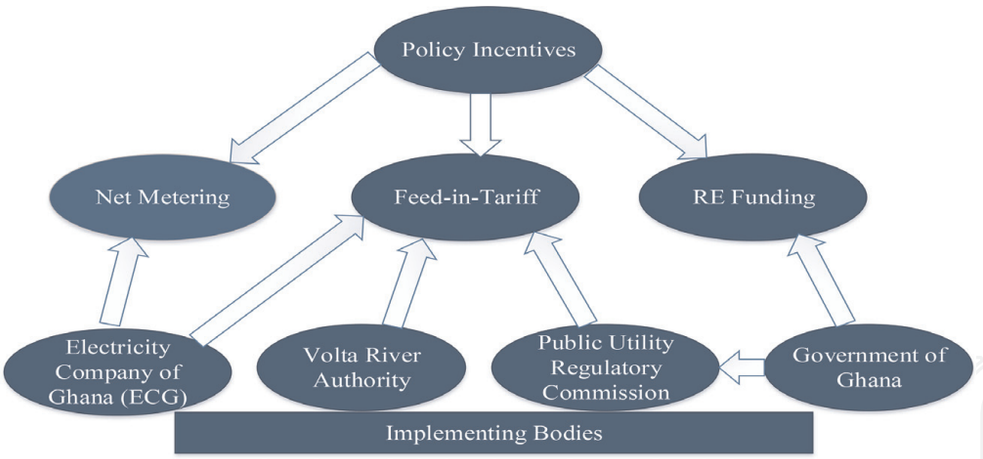

Figure 6.
Ghana's renewable energy policy incentives and implementing bodies.

4.3 Barriers identified by the stakeholders

The main policy implementation issue affecting renewable energy development in Ghana is the non-implementation of the Net Metering Scheme whereas the main barrier identified is attributed to the RE policies in Ghana. **Figure 7** shows the barriers identified by the Stakeholders whiles **Table 4** shows the percentage level of implementation issues affecting the grid and off-grid RE generators.

Figures 8 and **9** further explain **Table 4**.

The RE policies are not attractive to generators who generate excess power and feed into the national grid (i.e. there is no cash reward for injecting excess power into the grid, however, the government gets the benefit from the excess power fed charge into the grid). The implementation of the net metering scheme has been ineffective since it was passed in 2012. Thus, connecting to the national grid has become problematic—since there are no incentives for onsite power generators and the slow rate of passing legislation to back the initiative. This in effect hampers the financial status of grid-connected system developers.

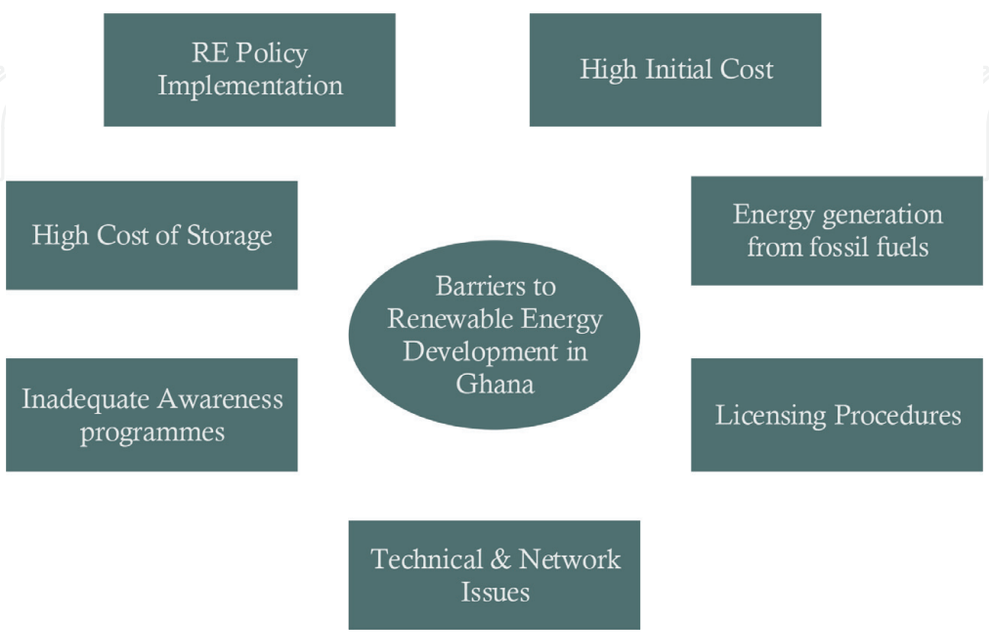

Figure 7.
Renewable energy barriers identified by the stakeholders.

RE policy implementation issues in Ghana	Net metering	Feed-in-tariffs	RE funding	Barriers to RE development in Ghana					High initial cost	
				RE policies	High initial cost	Existence of fossil fuel energy resources	Licensing procedure	High cost of storage	Technical and network	Inadequate awareness
Stakeholders' response (%)	100	85	42	80	53	21	25	42	15	25

Table 4.
Implementation issues affecting grid and off-grid renewable energy generators.

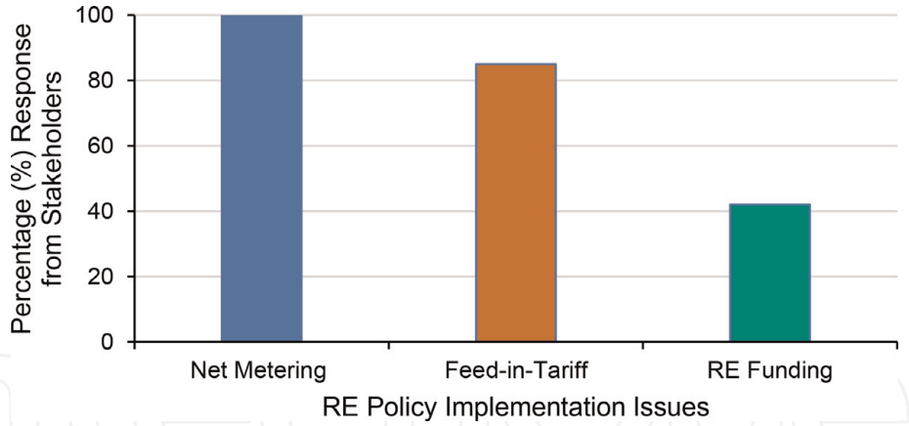

Figure 8.
Graph representing non-implementation level of renewable energy policy incentives in Ghana.

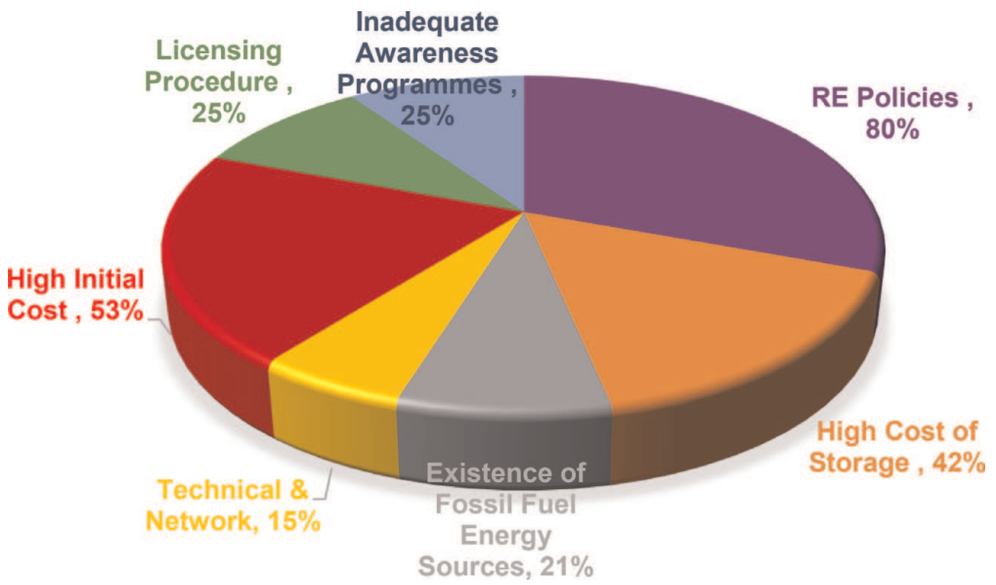

Figure 9.
Graph representing the percentage level of renewable energy barriers in Ghana.

4.4 Evaluation of renewable energy and energy efficiency policies in Ghana

In recent years, the country has been battling with energy crisis (i.e. frequent power outages) mainly attributed to the over-reliance on hydropower generation due to variability in rainfall patterns affecting water levels [30]. Measures were put in place to reduce energy consumption through energy management practices that were implemented across the country. Equally, 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 and diversify power generation from hydro sources coupled with energy efficiency measures. **Table 5** shows the areas covered by Ghana's renewable energy policies. The country has set policy instruments to match the policy objectives. In addition to the policy instrument, measures and activities were outlined to achieve the goals of the policy to increase the development of renewable energy technologies in the country. The various policies include laws and regulations that govern the sector.

4.4.1 Evaluation of renewable energy policies in Ghana

Table 6 shows the achievements of the various RE targets set in Ghana.

Energy policies	RE policy objectives	Regulations	Activities
Strategic national energy plan, (2006–2020)	Increase the share of RE up to 10% and universal access by 2020 (later changed to 10% by 2030) Promotes energy efficiency and conservation	Energy efficiency standards and labelling Energy management scheme	Standards and labelling programmes, e.g. enforcing standards for room air conditioners and CFLs, ensuring energy management practices, building codes, energy audits, load management programmes
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) Promote energy efficiency and conservation in the country	**Activities** Encourage the use of clean cooking alternatives such as efficient cookstoves Use of efficient appliances such as refrigerators, CFLs, LEDs	
Energy sector strategy and development plan, 2010 Sustainable energy for all (SE4All), 2012	Increase the percentage of renewable in the total national energy mix and its efficient use Universal access to electricity to islands and riversides communities in Ghana	**Activities** To encourage the development of renewable energy technologies Provision of tax incentives on the importation of RE devices Promote off-grid and mini-grids electrification projects Solar street lightings Solar lantern project 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** Net metering Feed-in-tariff RE funding Purchase obligations	

Source: [14, 19].

Table 5.
An overview of renewable energy and energy efficiency policy in Ghana.

4.4.2 Evaluation of energy efficiency policies in Ghana

Table 7 shows the achievements of the energy efficiency targets set in Ghana. 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 are good wind, solar, and mini-hydro resource potentials, these resources have not been utilised to expectation [32–34]. In addition, all efforts made to boost the RE market in Ghana have not yielded much. The Government of Ghana, on the other hand, has not fully funded RE projects although the government has facilitated other energy efficiency projects. The Government of Ghana has in 2018, laid aside $230 million to cushion private companies for the development of off-grid and mini-grids across the country but the funds are yet to be released [35].

4.5 Comparative analysis: renewable energy policies in South Africa, Morocco, and Ghana

A comparative analysis was carried out to compare Ghana's RE policies and their targets to Morocco and South Africa's RE policies and targets. Morocco and South Africa have increased their renewable energy sector capacities, hence, we

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 dependence 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 dependence on the source of hydro dam and thermal
Energy sector strategy and development plan 2010	Provision of tax incentives on the importation of RE devices 10% of power generated from renewables by 2030 in the national energy mix	The tax incentive was removed 0% renewable	Due to wrong importation of devices
Renewable energy act 2011, act (832)	10% of power generated from renewables by 2030 in the national energy mix Implementation of the RE policy instrument	0% of renewables as of 2012	Non-implementation of RE incentives Unfavourable RE environment to generators
Sustainable energy for all action plan 2012	Off grid and mini-grids electrification projects 10% of power generated from renewables by 2030 in the national energy mix	6 mini grid monitored, 3 mini grid was constructed as of 2015 16 wind and 23 mini hydro assessed as at 2015 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 No wind power till date No mini hydropower constructed Unavailability of funding options Only <1% renewables achieved after a 9-year period of RE policies (2006–2015) Policies unattractive to some energy Institutions Unfavourable policies to generators
Source: [13, 15, 18, 30, 31].			

Table 6.
Evaluation of renewable energy achievements in Ghana.

investigated what these two countries have done to increase their RE market and what Ghana can learn from their achievement. The Government of Morocco has instituted regulations and laws to promote the utilisation of renewable energy—institutions have been commissioned to manage and promote renewable energy investments [36]. In 2008, the National Renewable Energy and Energy Efficiency Plan were launched to achieve 42% of its energy from renewable sources by 2020 and 52% by 2030 [37]. Feed-in-tariff rates in Morocco are not fixed but an agreement of the rates is between the power producer and the government (**Figure 10**).

To promote renewable energy technologies in Morocco, the country set competitive bidding in 2006 to issue certificates to renewable energy generators which allowed them to commission a minimum of 10 MW plant from wind and other

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 Reduction in traditional biomass from 60 (2006) to 50% by 2015	Charcoal consumption 917 (2007)–1210 ktoe (2015) 24.2% increment within 8 years 69% of biomass consumed as of 2016	Target not met Increase in population growth Increase LPG especially 2011 (30,000,000 MMBtu) (free distribution of gas cylinders, subsidizing of LPG to wood fuel) Impacts: demand for LPG increased; increase import 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 Incandescent: 68% in 2007, 3% in 2009 Some population still uses inefficient refrigerator although (32,257 recycled) [12]	Target met Almost all households in Ghana use these efficient lamps A reduction in peak power electricity demand of 200–220 MW (2009) Target still in progress
Energy sector strategy and development plan 2010	Ensure the efficient use of wood fuels to reduce deforestation	There has been an increase in biomass consumption	Target not met
Sustainable energy for all action plan 2012	Install solar street lightings, solar lantern project	A number of the street solar lantern has been installed in the cities 200 each solar lantern distributed as of 2013 and 2017	Target in terms of (% cannot be determined). More of the street lighting project needs to be expanded to towns and villages Will help reduce subsidise on kerosene Projects ongoing
	Other efficiency project Solar rooftop programme 20,000 solar panels to households	1,006 units of solar panels distributed since its implementation	Target has not yet been met The problem from the service provider (energy commission)/from the government of Ghana

Source: [12, 27, 29, 31].

Table 7.
Evaluation of energy efficiency achievements in Ghana.

renewable energy sources [38]. The 10 MW bid was then increased to 50 MW in 2009, thus, investors were allowed to construct RE plants of 50 MW. This led to financial constraints on the part of the local renewable energy companies to fund the 50 MW projects. As of 2018, the country generated ~34% of its electricity from renewables [39]. In addition to the efforts made, the government of Morocco has funded its RE sector with $40 billion to help achieve its goal by 2030 [40].

In South Africa, the integrated resource plan (2010) set a target to generate 17.8 GW (9%) of electricity from renewables by 2030 [41], which has 5.2 GW of renewables as of 2016—contributing 3% of installed electricity capacity [42]. Competitive bidding was issued to investors and a private body was commissioned to oversee the bidding process for RE sector procurement, an effort attributed to the

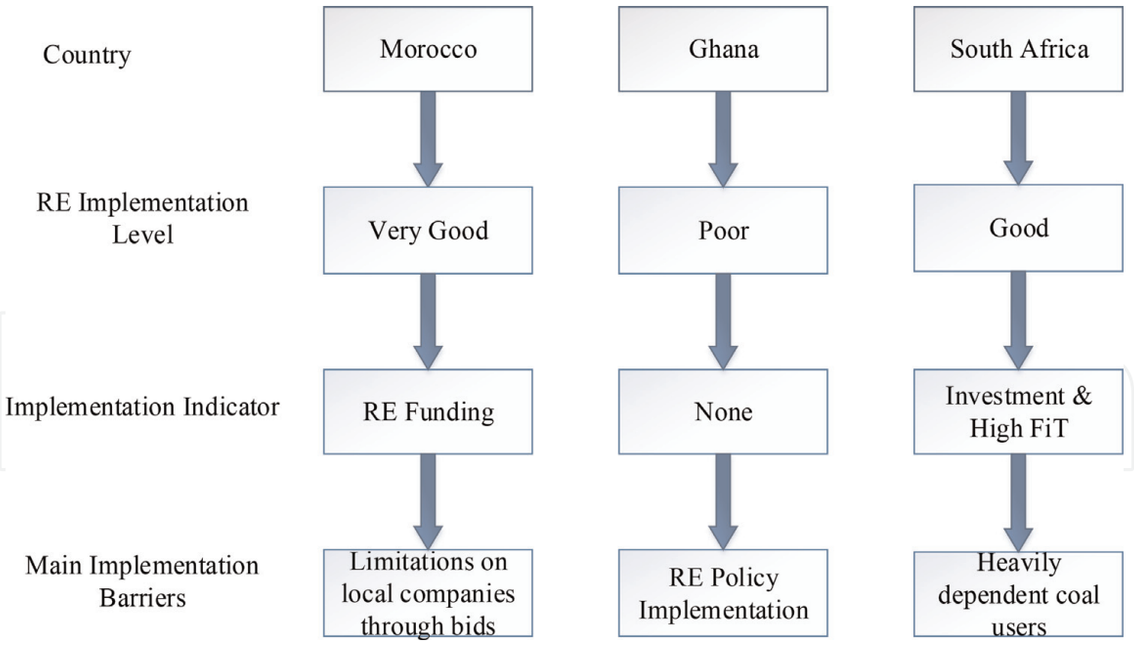

Figure 10.
Comparative analysis of RE in Ghana with Morocco and South Africa.

Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) launched in 2011. Financially, an investment of $100 million in 2011, $5.7 billion in 2012, $4.5 billion in 2013 [43] with a capacity of 3922 MW were injected to the various renewable energy technologies—making South Africa one of the countries with clean energy investments [44, 45]. To add up to the investment plan, the country set high FiT rates of 26, 15.6, and 46 Eurocent/kWh for solar, wind and concentrating solar power technologies. Renewable energy users are reported to have received a drastic subsidy on RE utilisation. Net metering in South Africa works for customers connected to Eskom medium-voltage and large power [46].

Comparing Ghana with Morocco and South Africa, the rate at which Morocco has increased its electricity generation from renewables is higher than that of South

Instruments	**Country**		
	South Africa	**Morocco**	**Ghana**
Feed-in-tariffs	Present	Agreement between the generator and the government	Present (poorly implemented)
Net metering scheme	Present (grid) For customers connected on Eskom medium voltage and 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 the distributor and/ transmitter

Source: [32, 37, 40, 47].

Table 8.
Summary on comparison analysis in South Africa, Morocco and Ghana.

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 achieve its remaining 20% target by 2030—if the same pace of RE development is followed. For the case of South Africa, though the generation of RE has been slower than Morocco over the last 10 years, however, their performance could be labelled as good with respect to the three countries. Referring to Ghana's situation, the various incentives instituted for renewable energy generators have not been implemented, except that the feed-in-tariff is under implementation for RE connected to the grid—creating challenges in terms of fee payment. 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. Currently, the country has held two bids and the power plants are yet to be constructed. The lesson from Morocco and South Africa mean that Ghana would have to fund its renewable energy sector and set a private body to supervise the bidding process as well as increase the FiT rate to attract investors. The summarised renewable energy comparison analysis is shown in **Table 8**.

5. Conclusion

Renewable energy resources such as wind, hydro, solar, and biomass abound in Ghana—with policies developed to harness these resources. Policy interventions and energy efficiency measures have been instituted to achieve the objectives of increasing power generated from renewable sources by 10% in 2030. Despite the numerous attempts, these interventions have been slow in execution, notably, the percentage share of installed grid-connected renewable energy is ~0.5%. The principal cause is attributed to energy institutional bodies responsible for implementing the policies, for they envisage it as unattractive and will lose revenue to the renewable energy generators. Likewise, the various incentives instituted for renewable energy generator have not been executed, and the proposed feed-in-tariffs have encountered challenges in fee payment and low tariff rates criticised by investors. Drastic action is required to encourage more renewable energy deployment by responsible institutions. Pushing for solar photovoltaic alone would not necessarily increase the percentage share and diversification of supply, but the incorporation of other energy technologies like wind and bioenergy in the energy portfolio.

Conflict of interest

Authors declare no conflict of interest.

Author details

Margaret Adobea Oduro[1], Samuel Gyamfi[2], Samuel Asumadu Sarkodie[3*] and Francis Kemausuor[4]

1 Pan African University Institute of Water and Energy Sciences (Including Climate Change), Algeria

2 University of Energy and Natural Resource, Sunyani, Ghana

3 Nord University Business School (HHN), Bodø, Norway

4 Kwame Nkrumah University of Science and Technology, Ghana

*Address all correspondence to: asumadusarkodiesamuel@yahoo.com

References

[1] Owusu PA, Sarkodie SA. A review of renewable energy sources, sustainability issues and climate change mitigation. Cogent Engineering. 2016;**3**(1):1167990

[2] IRENA. Evaluating Policies in Support of the Development of Renewable Power. 2012. Available from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2012/Evaluating_policies_in_support_of_the_deployment_of_renewable_power.pdf [Accessed: 20 May 2019]

[3] IRENA. Global Energy Transformation: A Roadmap to 2050. Abu Dhabi: International Renewable Energy Agency. 2018. Available from: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf [Accessed: 20 May 2019]

[4] Klein A et al. Evaluation of Different Feed-in Tariff Design Options: Best Practice Paper for the International Feed-in Cooperation. Germany: Energy Economics Group & Fraunhofer Institute Systems and Innovation Research; 2008

[5] Böcher M. Forest policy and economics a theoretical framework for explaining the choice of instruments in environmental policy. Forest Policy and Economics. 2012;**16**:14-22

[6] Bergek A, Berggren C. The impact of environmental policy instruments on innovation: A review of energy and automotive industry studies. Ecological Economics. 2014;**106**: 112-123

[7] Eurosai. Market Based Instruments in Environmental Protection ISSAIs of Environmental Auditing. 2016. Available from: https://www.eurosaiwgea.org/meetings/Documents/14%20AM/14AM_report_0602.pdf [Accessed: 20 May 2019]

[8] Schmitt S, Schulze K. Choosing environmental policy instruments: An assessment of the 'environmental dimension' of EU energy policy. European Integration Online Papers. 2011;**15**(1):1-27

[9] Niles MT, Lubell M. Integrative frontiers in environmental policy theory and research. Policy Studies Journal. 2012;**40**:41-64

[10] Stavins RN. Experience with market-based environmental policy instruments. In: Handbook of Environmental Economics. Vol. 1. Amsterdam: Elsevier; 2003. pp. 355-435

[11] Energy Commission of Ghana. Energy Supply and Demand Outlook for Ghana. 2017. Available from: http://www.energycom.gov.gh/planning/data-center/energy-outlook-for-ghana?download=76:energy-outlook-for-ghana-2018 [Accessed: 20 May 2019]

[12] UNDP. In Ghana, a Victory in Energy Efficiency. 2012. Available from: https://www.undp.org/content/undp/en/home/ourwork/ourstories/in-ghana–a-victory-for-energy-efficiency.html [Accessed: 20 May 2019]

[13] Gboney W. Policy and regulatory framework for renewable energy and energy efficiency development in Ghana. Climate Policy. 2009;**9**(5): 508-516

[14] Energy Commission of Ghana. Electricity Supply Plan for Ghana. 2017. Available from: http://energycom.gov.gh/files/2017%20Electricity%20Supply%20Plan%20-%20Final%20Report.pdf [Accessed: 20 May 2019]

[15] Gyamfi S, Modjinou M, Djordjevic S. Improving electricity supply security in Ghana: The potential of renewable energy. Renewable and Sustainable Energy Reviews. 2015;**43**:1035-1045

[16] VRA. Power Generation: Fact & Figures. 2017. Available from: https://www.vra.com/resources/facts.php [Accessed: 20 May 2019]

[17] Energy Commission of Ghana. Energy Supply and Demand Outlook for Ghana. 2018. Available from: http://www.energycom.gov.gh/planning/data-center/energy-outlook-for-ghana?download=76:energy-outlook-for-ghana-2018 [Accessed: 20 May 2019]

[18] Ministry of Energy. Strategic National Energy Plan, Main Report (2006–2020). 2006. Available from: http://www.energycom.gov.gh/files/snep/MAIN%20REPORT%20final%20PD.pdf [Accessed: 20 May 2019]

[19] Ministry of Energy. National Energy Plan, 2010-Final Report. 2010. Available from: http://www.petrocom.gov.gh/assets/national_energy_policy.pdf [Accessed: 20 May 2019]

[20] Appiah FK. Background to the Renewable Energy Act. 2015. Available from: http://wacee.net/Home/Documents/Implementing-the-Renewable-Energy-Act.aspx [Accessed: 20 May 2019]

[21] Energy Commission of Ghana. National Energy Statistics 2005–2014. 2015

[22] Verbruggen A et al. Renewable energy costs, potentials, barriers: Conceptual issues. Energy Policy. 2010; **38**:850-861

[23] Mezher T, Dawelbait G, Abbas Z. Renewable energy policy options for Abu Dhabi: Drivers and barriers. Energy Policy. 2012;**42**:315-328

[24] Bensah E, Kemausuor F, Antwi E, Ahiekpor J. China-Ghana South-South Cooperation on Renewable Energy Technology Transfer: Identification of Barriers to Renewable Energy Technology Transfer to Ghana. 2015. Available from: https://info.undp.org/docs/pdc/Documents/CHN/ProDoc%20-%2091276.pdf [Accessed: 20 May 2019]

[25] Painuly JP. Barriers to renewable energy penetration: A framework for analysis. Renewable Energy. 2001;**24**: 73-89

[26] Kemausuor F, Obeng GY, Brew-Hammond A, Duker A. A review of trends, policies and plans for increasing energy access in Ghana. Renewable and Sustainable Energy Reviews. 2011;**15**(9): 5143-5154

[27] Pegels A. Renewable energy in South Africa: Potentials, barriers and options for support. Energy Policy. 2010;**38**(9):4945-4954

[28] Santander. Morocco: Tax System. 2018. Available from: https://en.portal.santandertrade.com/establish-overseas/morocco/tax-system [Accessed: 20 May 2019]

[29] Van Buskirk R, Ben Hagan E, Ofosu Ahenkorah A, McNeil MA. Refrigerator efficiency in Ghana: Tailoring an appliance market transformation program design for Africa. Energy Policy. 2007;**35**(4):2401-2411

[30] Sarkodie SA, Owusu PA. A review of Ghana's energy sector national energy statistics and policy framework. Cogent Engineering. 2016;**3**(1):1155274

[31] Alberini A, Segerson K. Assessing voluntary programs to improve environmental quality. Environmental and Resource Economics. 2002;**22**:157-184

[32] Asumadu-Sarkodie S, Owusu PA. The potential and economic viability of solar photovoltaic power in Ghana. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects. 2016;**38**(5):709-716

[33] Sarkodie SA, Owusu PA. A review of Ghana's solar energy potential. AIMS Energy. 2016;**4**(5):675-696

[34] Asumadu-Sarkodie S, Owusu PA. The potential and economic viability of wind farms in Ghana. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects. 2016;**38**(5):695-701

[35] Graphic.com.gh. Govt Earmarks $230m for Renewable Energy Project. BusinessGhana. 2018. Available from: https://www.businessghana.com/site/news/general/162735/Govt-earmarks-230m-for-renewable-energy-project [Accessed: 20 May 2019]

[36] Leidreiter A, Boselli F. 100% Renewable Energy: Boosting Development in Morocco. 2015. Available from: https://www.worldfuturecouncil.org/wp-content/uploads/2016/01/WFC_2015_100_Renewable_Energy_boosting_Development_in_Morocco.pdf [Accessed: 20 May 2019]

[37] Moulin S. Renewable energy in Morocco. In: Road to Rio+20 a Dev. Green Econ. 2011. pp. 83-87

[38] Haas R, Resch G, Panzer C, Busch S, Ragwitz M, Held A. Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources—Lessons from EU countries. Energy. 2011;**36**(4):2186-2193

[39] Abdelbari R. Business Opportunities Report for Morocco's Renewable Energy Sector. 2018. Available from: https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2018/06/01/business-opportunities-report-for-morocco%E2%80%99s-renewable-energy-sector/business-opportunities-report-for-morocco%E2%80%99s-renewable-energy-sector.pdf [Accessed: 20 May 2019]

[40] Morocco World News. Morocco to Invest USD 40 Billion in Energy Sector by 2030. 2018. Available from: https://www.moroccoworldnews.com/2018/02/240667/morocco-to-invest-usd-40-billion-in-energy-sector-by-2030/ [Accessed: 20 May 2019]

[41] Oxford Business Group. South Africa's Push for Renewables. 2016. Available from: https://oxfordbusinessgroup.com/news/south-africa%E2%80%99s-push-renewables [Accessed: 20 May 2019]

[42] Power Africa. South Africa Power Africa Fact Sheet. 2007. Available from: https://www.usaid.gov/sites/default/files/documents/1860/South_Africa_-_November_2018_Country_Fact_Sheet.pdf

[43] Baker L. The evolving role of finance in South Africa's renewable energy sector. Geoforum. 2015;**64**:146-156

[44] Eberhard A, Kolker J, Leigland J. South Africa's Renewable Energy IPP Procurement Program: Success Factors and Lessons. Washington DC, USA: PPIAF; 2014. pp. 1-56. Available from: https://openknowledge.worldbank.org/bitstream/handle/10986/20039/ACS88260WP0P1482120Box385262B00PUBLIC0.pdf [Accessed: 20 May 2019]

[45] Suryapratim R, Tsidiso D, Sheila K. Clean Energy Investment in Developing Countries: Domestic Barriers and Opportunities in South Africa. International Institute for Sustainable Development. 2010. Available from: https://www.iisd.org/pdf/2009/bali_2_copenhagen_rsacase.pdf [Accessed: 20 May 2019]

[46] Eskom. Connection of Small-Scale Renewable Generation to Eskom's Network Background (Customer Small-Scale Renewable Generation). 2016. Available from: http://www.eskom.co.za/Whatweredoing/Documents/CustBulletinSPU.pdf [Accessed: 20 May 2019]

[47] Energy Commission. Final Report-CFL Exchange Programme Impact Assessment. 2009. Available from: http://www.energycom.gov.gh/files/CFL%20Report%20final.pdf [Accessed: 20 May 2019]