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# Renewable Energy in Sub-Saharan Africa: A Prescriptive Analysis of Ghana

Leo Andoh Adjei Gyimah

Ghana National Gas Limited Company

Adjei Gyamfi Gyimah (Corresponding author)

The Eastern and Southern African Trade and Development Bank

E-mail: adjei195@yahoo.co.uk

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**Abstract**

This study assesses the state of play of renewable energy in Sub-Saharan Africa through the lens of the Ghana renewable energy sub-sector. Adopting a sector diagnostic approach, the study assesses the legal framework, institutional arrangements, emerging developments, and challenges of renewable energy development in Ghana. The study further prescribes key renewable policy instruments necessary to propel Ghana to achieve its 10% renewable energy target by 2030. Recommended amendments for the Renewable Energy Act are also proffered in this paper. The study provides innovative directions for policymakers and regulators while revealing new perspectives to the renewable energy puzzle in Africa.

**Keywords:** Renewable energy, RE policy instruments, Legal framework, Market-based instruments, Energy trilemma

## 1. Introduction

Renewable energy (RE) strategically employs energy sources that are constantly restocked by nature at an advanced rate than they are expended- the sun, water, wind, plants, and heat from the earth (NREL, 2001). The RE technologies involved in extracting energy from these sources convert the fuels into consumable energy forms - usually electricity, mechanical power or chemical, and heat. In our day, we principally employ fossil fuels to power and heat our residential facilities and fuel our cars. It is expedient to use oil, natural gas, and coal for satisfying our energy demands, but we are confronted with a restricted supply of these energies. Their usage significantly outpaces their generation or creation, thereby predicting a

gloomy future scarcity. As a result of safety alarms and waste disposal complications, the nations of the world will retire considerable amounts of their nuclear capacities within stipulated time periods (Olujobi et al., 2023).

Presently, global energy needs are projected to increase during the next 20 years (IEA, 2022; IEA, 2021; IRENA, 2018). Notwithstanding the fact that there is unlimited access to fossil fuels, the usage of RE is healthier for the environment; given that it produces fewer or no pollutants. Fossil fuels when used, conversely, send greenhouse gases into the air, catching the sun's heat and bringing about global warming. Switching some amount of petroleum with energies sourced from plants, for instance, could save resources and reinforce our energy security. RE is abundant, and ever advancing.

### *1.1 The Energy Trilemma*

The topical transition to clean energy geared towards addressing the climate challenge is obviously at no time going to be stress-free, and it will require expensive and strategic trade-offs between issues relating to climate and economics. On the other hand, the Russian incursion of Ukraine has rendered that transition considerably harder as energy security turns into a major problem for a lot of states. The energy trilemma is deep-seated in the predominant idea of sustainable development. The Brundtland Commission, in 1987, defined three pivots of sustainable development: economic growth, social equity and environmental protection. Their report underscored the interdependence between each concept and the need to assimilate all three thoughts in decision-making. The concept has deeply found expression in the Sustainable Development Goals; specifically, SDGs 3, 7 and 13 which are anchored on enhanced well-being and health, clean and affordable energy, and climate action respectively. This demonstrates a concerted effort by nations of the world in achieving balance as we strive to satisfy all competing interests based on available resources and interdependence on other nations of the world (Brundtland, 1987).

Suffice to say that, within a renewable energy context, the report branded the goals for sustainable development as economic viability, environmental protection and security of supply, collectively termed the 'energy trilemma'. The trilemma has also been defined by others as a trio of strains and pulls centred on infrastructure reliability, cost, and the environment; arguing that the trilemma should not be reduced to a challenge of money (Oliver & Sovacool, 2017). Several global energy establishments have validated the energy trilemma as a fitting model for energy-related decision-making in a progressively carbon-constrained territory. The World Energy Council since 2012, for instance, has deliberated on the subject of developing sustainable energy with diverse stakeholders based on the variables of the energy trilemma (World Energy Council, 2012; 2024). The International Energy Agency (IEA), by a similar token, has expressed the urgent necessity to fast-track the development of technologies based on low-carbon energy to tackle the three variables of the trilemma (IEA, 2021).

Irrespective of the marginal variances in the organisational definitions of the trilemma, basically the trilemma is regarded by many as economic, environmental concerns, and security. It is required in furtherance of sustainable energy development that policy decisions

and laws address all three interconnected priorities, acknowledging the position, however, that specific energy resolutions may by way of necessity involve some adjustment and compromise between each dimension.

The world has considerably evolved, especially in the area of energy resources. At present, deliberations on energy transition developments must be contextualised in the framework of the energy trilemma (see Figure 1 below), in which the rival interests and frequently conflicting goals of minimising climate impact, energy security, and energy affordability are in constant pulls and strains (Clifford Chance, 2021). Countries, transactions, policies and sectors are faced with varied trade-offs among the variables in Figure 1. The logical conclusion for the Energy Transition (as an eventuality) is delay, a greater diversity of energy types and sources, and higher costs.

### *1.2 Energy Security*

An interrogation of what energy security entails would require an appreciation of the realities of the three competing interests under the energy trilemma. The discussion starts with reliance on indigenous fossil resources. Invariably, a state that does not have those resources has to be strategic in its international relations and dealings. Largely, this means that countries with renewable resources - steady wind, hydrology and efficient solar radiation (uranium and enrichment, for some) - are being stimulated by the current crisis to fast-track the strides towards non-fossil generation and new patrons and allies also prospecting for new clean energy sources. However, it is important to note that not all states are similarly endowed with resources and allies, making this a very rutted solution. Countries endowed with resources in fossil fuel have had an exculpation from the climate challenge, placing a hiatus on the conversation on deserted assets. The products of these countries are in demand - particularly natural gas or liquified natural gas - which is observed by the global energy space as a cleaner fuel (Cevik, 2024; Feinstein, 2002).

### *1.3 Climate Concerns*

In a real-world situation, the climate emergency has revealed that the requirement to cut carbon emissions, decrease greenhouse gases (GHGs) and cut global warming, cannot be extricated from the need to offer supply-resilient and reasonably priced energy to consumers. As noted, some have argued that the current crisis is an attempt to make a case for quickening the implementation of climate-friendly energy technologies because it serves the dual purpose of energy security and emissions reduction (Cevik, 2024). More expensive fossil fuels render the price of power from clean sources more competitive. Even if heavy reliance on climate-friendly energy sources is the panacea, not all of the energy transition implements that exist, such as renewables, are correspondingly accessible and best fit for use in many nations and circumstances. The resource centres, fiscal component, policy conclusions and implementation periods greatly differ for each of these (Feinstein, 2002; Oliver & Sovacool, 2017).

### *1.4 Energy Affordability*

The price of energy has become an extremely important consideration during these times of

inflationary progression, intensified by increased prices of energy and fronting the outlook of a global downturn. It has become important, just as climate change or energy security issues are, to find the all-important balance among competing interests.

In putting in efforts to lessen the impact on their residents, governments are, as expected, inclined to control consumer prices either by direct control of prices, import regulation and tariffs or redistribution and taxation; the ultimate objective is to make softer, the upset of higher prices. These fiscal tools cannot take precedence over market first principles - a vast quantity of fossil fuel has been marked out of certain markets, and this will lead such markets to experience higher prices of energy. Even supplier markets, like the US, will experience higher prices due to crisis-induced inflation and competitive pricing (Cevik, 2024; Oliver & Sovacool, 2017; Feinstein, 2002).

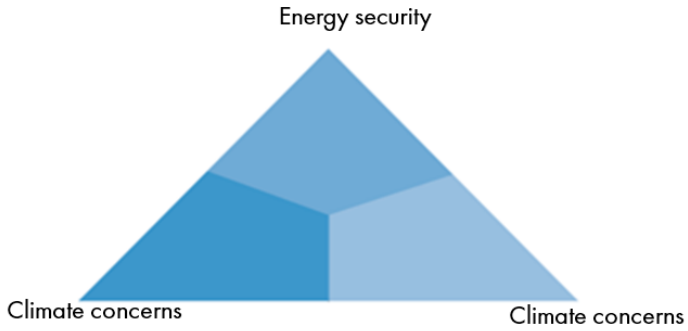


Figure 1. The Energy Trilemma

Source: Clifford Chance (2021)

## 2. Renewables in Ghana

### *2.1 Hydropower*

At present, hydropower is the most settled and biggest source of renewable energy within the electricity sector. It connects the energy of water coursing from higher to lower altitudes. It can equally be produced from rivers and reservoirs. Reservoir hydropower, often, has numerous uses, including drinking, irrigation, navigation services as well as energy supply. Hydropower plants transform energy from flowing water into electricity. Storage hydropower, which is the most popular, installs a dam on a river to hold a huge pool of water. An example is the Akosombo dam in Ghana, which is a hydroelectric dam found on the Volta River in Ghana's south-eastern part, specifically in the Akosombo Valley and part of the Volta River Authority.

As of 2016, the Ministry of Energy had publicly acknowledged the funding, in six hydropower sites, of a Hydropower Sustainability Assessment Project (HSAP) on the White and Black Volta Rivers by the Swiss Economic Cooperation. The sites earmarked for the project were Lanka, Koulbi, Ntereso, Daboya, Jambito, and Kalpawn with 362 MW combined available capacity.

*2.2 Bioenergy*

Bioenergy is the energy obtained from organic matter or biomass like plants. A Ministry of Energy report in 2014 showed that several grouped wood processing and agro sites produce a large quantity of biomass residues. The Environmental Protection Agency, in partnership with the Ghana Cocoa Board, is taking steps to realise the utilisation of cocoa waste for power generation (Ministry of Energy, 2014; SREP, 2015).

An interesting study graded Ghana as Africa's foremost producer of biodiesel (Lang, 2013). Another distinct exploration underscored the country's prospect for biodiesel production from oil palm fruit, which is one of the prominent producers in Africa (Niras International, 2019; Pelizan et al., 2019).

*2.3 Geothermal Energy*

The core of the earth, 4,000 miles underneath the surface, can attain 9000° F in temperature. This heat flows from the core, warming the immediate area and forming underground basins of steam and hot water. Through the use of geothermal heat pumps (GHPs), the steady temperature in the shallow ground can be exploited for heating and cooling buildings (NREL, 2001). The hot water or steam from underground is accessed by geothermal power plants through the drilling of wells by a mile or deeper into the earth. The hot water or steam is channelled up from the well to propel a conventional steam turbine, which propels an electric generator. The water recedes to the ground to revitalise the reservoir and end the cycle of renewable energy. There are three types of geothermal power plants: dry steam, binary cycle, and flash steam. Plants that are dry steam have steam reservoirs as their source, while binary cycle and flash steam source from hot water (AZO, 2007).

*2.4 Solar Energy*

Solar technologies exploit the unlimited sun power and employ that energy to manufacture heat, power, and light. Heating People and Passive Solar Lighting have taken advantage of the sun to light and heat homes for many years. From official records, as of 2017 and based on funding from the Japanese government, a 715kWp net-metered solar photovoltaic (PV) is installed and operating at the Noguchi Memorial Institute of the University of Ghana. Also, under the Scaling-up Renewable Energy Program (SREP), Ghana has commenced taking actions towards the completion of projects, including the solar PV systems (standalone) and RE mini-grids. Under the SREP, 55 lakeside or island communities are to be carefully chosen for mini-grid; while 600 households in 30 off-grid communities which are sparsely populated for solar PV (standalone) projects (SREP, 2015).

*2.5 Wind Energy*

Over the years, people have engaged in harnessing wind energy through the use of windmills. Presently, wind turbines, which function in a different way from windmills, are a far more resourceful technology. Mechanical drive methods, combined with systematic generators, are able to transform the energy into electricity. Hydrogen is abundant in energy, nonetheless, using it as fuel yields water as the only release. Reports from Ghana's Ministry of Energy

indicate that in recent history, the Ministry, from 2012, has continuously prospected for wind resources in 8 or more sites at 60m above the ground. This has been supported by the World Bank with the objective of acquiring bankable wind data to enhance organisation and support for wind IPPs (Asare-Addo, 2023; Puliti, 2022).

## 3. Methods

The study adopts a case study and sector diagnostic approach, focusing on Ghana and the renewable energy sub-sector in Ghana as a proxy for renewable energy in the Sub-Saharan African region. A sector diagnostic approach implied that the analysis gave extensive consideration to variables such as the legal framework, institutional arrangements, emerging developments, and challenges of renewable energy development in Ghana.

Expert opinions were sourced through oral interviews with two senior officials each from the Ministry of Energy, the Energy Commission of Ghana, the Ministry of Environment, Science, Technology and Innovation (MESTI), and two renewable energy companies.

Relevant laws, policies and regulations pertinent to Ghana's renewable energy ecosystem were consulted and reviewed. Extant literature on the subject was also reviewed to lend relevant previous knowledge and comparability to the study.

The review commences with a dissection of the energy trilemma, and its relation to climate concerns. The evolution and development of renewables in Ghana is also discussed. The analysis draws out the challenges encountered in developing and promoting renewables in Ghana. Global best practices and policy instruments are proposed to advance renewables in Ghana.

## 4. Challenges of Renewable Energy in Ghana

Notwithstanding the significant strides Ghana has made in its quest to promote and enhance renewable energy in the nation, some key barriers, as follows, continuously operate to erode the gains in the agenda towards a cleaner and safer use of energy resources.

To start with, the industry is plagued with burdensome licensing processes for renewable energy investments. Many a developer in Ghana's renewable energy space has bemoaned the rather disincentivising situation pertaining to the licensing regime for renewable energy projects. Such a drastic movement to renewables requires high motivation towards the adoption of renewable energy and dissuasion with respect to the heavy reliance on fossil fuels. The licensing regime for renewable energy projects in Ghana is fraught with cumbersome, prolonged and multi-layered approval processes (AB and David, 2024; Obeng-Darko, 2019). An applicant is required to acquire many permits and authorisations from several institutions, but there is an absence of well-coordinated arrangements between the various institutions, such as the Environmental Protection Authority, Lands Commission, the Energy Commission, and the Town and Country Department. These have the resultant effect of increasing the costs of renewable energy development in Ghana. It is proposed that the technological inroads made to the licensing process be further enhanced to ensure an effective and complete licensing process done via the internet. It is also recommended, in furtherance of easing up

the licensing regime, to further review the requirements for obtaining a provisional licence for RE, with the aim of among others reducing the number of documents required for submission (Lin & Ankrah, 2019).

Moreover, inadequate local capacity building is an impediment to the growth and promotion of RE in Ghana. A critical tool in carrying out to its fullness, the agenda to massively adopt renewable energy is an adequately resourced human resource base within various sectors of the country, including academia, NGOs, the public sector and the private sector alike. At present, the country doesn't have the needed skilled human resource base to effectively carry out this mandate in driving the development as well as deployment of RE technologies in alignment with the peculiar energy circumstances in Ghana, and to address the related technical, regulatory, legal, and institutional issues. The reliance on foreign experts is not a sustainable one worthy of our attention and consideration. This has resulted in poor planning, improper design, and installation of RE systems including but not limited to after-sales services, particularly repair and maintenance. With respect to this barrier, it is recommended that, incentives be provided for private sector entities with respect to competency-based training sessions for all renewable energy technologies. This will, in turn, enhance the capacity of local professionals to take up leading roles in the drive towards the promotion of RE technologies. It is also proposed that a comprehensive and standardised curriculum for capacity building be developed and effectively administered in our educational institutions (Takase et al., 2022; Yang et al., 2021; Mahama et al., 2021; Sendegeyaa & Chiguvareb, 2016; Kim, 2018).

Additionally, the renewable energy industry sub-sector is threatened by poor information sharing and knowledge management on RE technologies. Governments, over the years, have not demonstrated enough interest and prioritisation of research and development, demonstration and deployment (R&DDD) on RE. By and large, government funding for R&DDD activities has been insufficient and needs to be increased. A weak arrangement has also produced a fragile linkage between industry and academia, which is required to enhance R&DDD activities that provide RE technologies. Consequently, R&DDD has played a restricted role in furthering the development of RE technologies in Ghana. It is strongly proposed as a solution to this challenge that, the Energy Commission strengthens the regular interactions and discussions between the various stakeholders. That is, between research institutions, private sector, Ministry of Energy, Energy Commission, NGOs and others. At these fora, information regarding funding and other equally important issues relating to renewable energy should be discussed and shared among participants and the general public (Energy Commission, 2015).

Furthermore, the enforcement regime on the disposal of RE appliance wastes remains a challenge. It is the opinion of the authors that Ghana's bane has not been a poverty in laws but rather the low level of enforcing regulations, and in this instance, with specific reference to the disposal of electronic waste in Ghana. For instance, the space for the recycling of solar panels and accessories in Ghana continues to face serious challenges. To show how important this subject is, solar PV generates a fairly insignificant amount of solid waste, yet this volume cannot be disregarded during the discarding stage of the solar building blocks, taking into

account the projected growth of the PV industry in Ghana in the long term. This study proposes in this regard that, the Government should enforce to its fullness, the provisions contained in our laws but more particularly the law on the control and management of electronic waste, Act 917 of 2016, which provides among other things; the prerequisite for importers or producers of electronic apparatus to pay levies for electronic waste to the Environmental Protection Agency to cater for the control of electronic waste; and for the institution of a fund for e-waste recycling (Obeng-Darko, 2019; Seif et al., 2024; Massoud et al., 2023; Rezania et al., 2023; Venkatachary et al., 2020; Bajagain et al., 2020; Divya et al., 2023; Ghahremani et al., 2024; Gv et al., 2021; Rathore & Panwar, 2022; Xu et al., 2018).

Besides, inadequate financing of RE business opportunities and unaffordable RE Systems continually surface in the myriad of RE issues. A critical barrier that has attained notoriety in Ghana is the lacklustre credit profile of the principal off-takers of electricity, namely the state distribution utilities. RE power generation has recently, relative to traditional generation alternatives, in several nations. Nonetheless, the initial cost of RE systems remains high, especially for individual consumers. Initial patrons of RE services and systems have therefore been in the upper-income category. This underscores the need to institute mechanisms and policies to quicken the on-boarding of consumers in the lower-income category. The state is implored to implement restructurings to enhance the credit profile and finances of both the Northern Electricity Distribution Company (NEDCo) and the Electricity Company of Ghana (ECG), which operate as key off-takers of electricity from RE sources. Also, financial institutions should be incentivised to maintain RE investments through exemptions from taxes and other incentives for financial institutions on RE finance (Kumi, 2017; Ahali, 2016; Owusu-Manu et al., 2021; Aboagye et al., 2021; McCauley et al., 2022; Amo-Aidoo et al., 2022).

Last but not least is the uneven emphasis placed on on-grid RE systems. Off-grid RE systems are more economically viable and productive for remote rural areas that are comparatively distant from the main grid. Nevertheless, there has been a somewhat pintsize attempt to develop and implement empowering incentives and instruments to promote off-grid investments in RE systems in the quest to expand Ghana's energy access. Education and sensitisation on available on-grid and off-grid RE options have been low and quiet. Provision should be made for adequate funding from the Renewable Energy Fund as established under Section 31 of the Renewable Energy Act, 2011 (Act 9832) as amended by Act 1045 of 2020 to essentially support widespread public sensitisation among industry stakeholders on the diverse RE system alternatives obtainable. Enough support schemes and incentives should be provided for off-grid systems in the context of productive uses (Radley & Lehmann-Grube, 2023; Nyarko et al., 2023).

### *4.1 The Legal Framework for Renewables in Ghana*

The legal framework governing the renewable energy space in the country consists of several pieces of legislation and other policy documents. For the purposes of the present discussion, not all applicable legislations will prominently feature in the discussion. Ghana, in accordance with Article 106 of the 1992 Constitution enacted the Renewable Energy Act,

2011 (Act 832) to principally provide a structure for developing and utilising RE sources in the country. The Government further issued the Renewable Energy Master Plan (REMP) in 2019, which mainly extended the overarching aim to grow the percentage of RE in Ghana's energy portfolio to 10% by 2030 and offering an investment-oriented framework for the advancement of the nation's RE resources to facilitate economic growth that is realistic, and lighten the destructive effects of climate change.

The Renewable Energy Act, 2011 (Act 832) is the main law for the entire spectrum of RE industrial activities and the broader RE value chain, as well as all pertinent matters rightly captured in the long title to Act 832.

Also importantly, the Act offers the regulatory basis and fiscal motivations to increase investment by the private sector and stimulate RE use in a proficient and ecological fashion. It offers a supervisory licensing system and enforces a responsibility on bulk customers and utilities to acquire a fraction of their demand for electricity from renewable sources. The Act also instituted a manual for licensing RE service providers, spelling out a clear blueprint by which service providers are licensed. The Amendment of Act 832 by the RE (Amendment) Act, 2020 (Act 1045) was to permit electricity consumers to reap immense gains from the decreased electricity generation cost from RE sources by competitive procurement method instead of the erstwhile feed-in-tariff system as stated in Section 25 as amended.

*4.2 Proposed Amendments to Ghana's Renewable Energy Act*

Notwithstanding the fact that it has been three years since Act 832 of 2011 was amended by Act 1045 in December 2020, this study will proceed to make key suggestions for legislative amendment to Act 832 as amended by Act 1045. It is instructive to state from the onset that the scope of a legislative amendment not only attributes alteration to the existing wording, but also allows for the insertion of new provisions. It is against this background that this study ventures into the following proposals for amendment.

Firstly, it is recommended for the amendment of Act 832 by the insertion of a provision that will allow for policy instruments like carbon bonds, carbon offsetting and renewable energy certificates to receive legislative recognition and adoption in Ghana. This will in turn help the country achieve its renewable energy target of 10% by 2030 (Africa NDC Hub, 2024).

Secondly, a more tightened regime for sanctions should be adopted especially with respect to unlawful disposal of electronic waste, notwithstanding the provisions contained in the Hazardous and E-Waste Act. This furthers the cause of enforcing the penal aspects of the renewable energy regime (Opoku et al., 2024; Opoku et al., 2022).

Thirdly, it is also proposed that amendments that will see a less cumbersome licensing regime be put in place to reduce the burden of prospective applicants and incentivise them to pursue renewable energy projects in Ghana (AB & David, 2024; Obeng-Darko, 2019).

The Commission should be given a mandatory obligation to further the course of building the capacities of locals within the renewable energy space through specific provisions. This will relate also to the low level of research in the field or discipline.

Also, provisions for a net metering scheme, as amended, should be more detailed for the country to realise the full benefits embedded in these policy instruments (Energy Commission, 2023; AFDB, 2021; Adshead et al., 2022).

*4.3 Renewables Policy Instruments*

It is worth noting that worldwide, Renewable Energy Capacity and Investment are increasing at a fast rate. The World Bank Institute does indicate that from 2000 to 2011, the global size of wind power grew from to 238 GW from 17.4 GW. In 2011, for instance, RE investment was noticeably larger than natural gas investment (World Bank, 2012).

These have all been achieved partly and greatly as a result of various policy instruments that have been put in place with respect to RE technologies. RE policies globally have greatly enabled the development and adoption of RE. The world recorded 118 nations, in 2011, with some form of policy support for renewables or targets in place at the national level (El-Ashry, 2012).

For Renewable Energy, each country has some stated objectives it seeks to achieve within a stipulated time period. Policy instruments operate as vehicles to that destination where the objectives would have been achieved. Policy instruments are the media by which policy objectives are pursued (Capano & Howlett, 2020).

Renewable policy instruments are presented in various forms and media. They may be in the form of Regulations and Standards. These may be in the form of direct support or indirect support. In the case of direct support, examples are policy objectives contained in a regulation and carry the power to remove non-economic barriers and grow demand for RE. It may indirectly also impose restrictions on fossil fuel power usage by way of legislation (Song et al., 2022; Romanov et al., 2018).

It could also be in the form of Quantity Instruments. Quantity instruments are, by their nature, market-based instruments that specifically spell out an absolute quantity or precise target for RE production. The two main categories are Renewable Energy Credits or Certificates and Renewable Portfolio Standards. Renewable Portfolio Standards are policies which provide an unambiguous goal for RE (e.g., 30% RE by 2030). Its scope covers renewable obligations, renewable electricity standards, and mandated market share. RE Certificates are basically intangible tradable products that signify proof that one megawatt-hour (MWh) worth of electricity was produced from a RE resource. It is important to add that it can be purchased and vented bundled or unbundled with electricity (Río & Kiefer, 2022; Benitez, 2012).

Others are Price Instruments which apply to cut pricing and cost-related barriers by creating satisfactory price governance structures for RE compared to alternative sources of power generation. Examples include financial incentives (like investment tax credits) and feed-in tariffs. Moreover, through Public Procurement, the government's purchasing and procurement choices have a pronounced impact on the market. Procurement requirements, therefore, operate as tools for states to build capacity and grow RE markets. Additionally, auctions, if well-coordinated, could be employed to ascertain suitable tariff rates for FiT policy. They can be an eye-catching way for attracting new RE supply (Song et al, 2022; Benitez, 2012).

Generally, the factors that should be considered in the selection of a Renewable Energy Policy Instrument for a country include cost-effectiveness, distributional issues, the opportunity to leverage international funding, institutional feasibility and political issues, the complexity of the instrument, environmental effectiveness, and government costs (Gupta et al., 2007).

*4.4 Prescriptive Renewables Policy Instruments for Ghana*

The ensuing considers and discusses key Renewable Energy Policy Instruments which are not practised in Ghana and how these policies could help Ghana achieve its renewable energy policy target of 10% by 2030. Firstly, Renewable Energy Certificates (RECs) could enhance Ghana's renewable energy market growth. RECs are market-based instruments which embody property rights to the social, environmental, and other non-power attributes of RE generation. RECs may be issued for one megawatt-hour (MWh) of electricity, produced and transferred to the main electricity grid from a RE resource. Ghana needs to designate a state entity with officials to issue a certificate for each megawatt hour (MWh) produced from renewable sources. This certificate authenticates to the consumer that renewable sources produced that portion of energy. At the end of the financial year, all certificates issued will be listed in a n established Renewables Register allocated to the supplier that held them at that point (Río & Kiefer, 2022; Benitez, 2012).

Secondly, Carbon Offsets could be promoted at scale in Ghana's energy market. Both RECs and offsets signify the environmental gains of some initiatives that could mitigate GHG emissions. Offsets characterise reduced or avoided emissions per metric ton; while RECs signify attributes of 1 MWh of renewable electricity generated. RECs and Offsets, however, are primarily dissimilar instruments with diverse impacts, demonstrating peculiar criteria for crediting and qualification in relation to emissions footprints or inventory. Given that the environmental effect of carbon dioxide emissions does not change based on location; the carbon footprint in a given geography of the globe can be cancelled out by the same quantum of carbon in any other part of the world. Against this backdrop, Ghana could fulfil her targets in emissions reduction by contributing carbon credits or enabling the award of credits to projects that either remove carbon, for example forestry schemes, or those that produce less emissions, for example clean energy production. Each credit is the equivalent of a metric tonne of removed or reduced carbon emissions (Río & Kiefer, 2022; Song et al, 2022; Romanov et al., 2018; Benitez, 2012).

Thirdly, Carbon Bonds could be introduced in Ghana as a renewable energy policy instrument. The green bond instrument is another viable option Ghana may consider in its advocacy for RE use. The peculiarity of this instrument is that, it supports the transition to climate-resilient and low-carbon growth and development. This takes both climate change adaptation and mitigation into account (Song et al., 2022, Romanov et al.; 2018). Ghana should ensure that eligible projects, to be supported by the operation of this instrument, qualify based on well-captured suitability criteria and that these projects are selected by environmental experts. A further review by independent minds or a neutral second-party opinion is helpful. The process of implementation should broadly cover screening eligible

projects, allocating green bond proceeds and reporting progress to funding agencies or authorities and concluding with a thorough evaluation of the project. Ghana, through a Special Purpose Vehicle (SPV), issued an Energy Sector Levy Act (ESLA) Bond in 2017, raising over GHS4.7 billion by issuing 10-year and 7-year Corporate Bonds (Ministry of Finance, 2017).

Finally, the establishment of a well-functioning Carbon Emission Trading/Carbon Cap platform or system could better serve Ghana's renewable drive. Emissions trading is gaining momentum globally as a policy instrument. With respect to carbon caps, policy makers are faced with a trio of alternatives in efforts to cut GHG emissions. Firstly, a definite emissions ceiling can be fixed, not to be exceeded by companies by their operations and activities. Secondly, a carbon tax can be introduced to institute payments for the emissions of $CO_2$ by businesses for their operations and activities. Firms who consciously cut their emissions are likely to invest in cleaner alternatives which compare favourably to the tax. Thirdly, a system for emissions trading can be set up to facilitate an institutional arrangement to bring emissions producers and savers together, essentially a carbon market. This will allow firms to sell and buy 'a permit to pollute' from other firms. A ceiling can be instituted to align the volume of permits to a national, regional or sector-specific reduction target. From the initial stage of a trading cycle, businesses either get these permits for emissions allotted freely to them or purchase them at auctions. Based on the structure of a capped volume of permits in the market, the obtainable permits in the market fall over time. Consequently, firms are compelled by this market situation to resort to investing in models for cleaner manufacturing; thereby cutting their carbon footprint. The long-term expectation is to experience a wave of clean innovation in the market which causes a fall in the price of novel technologies. Carbon pricing may be mingled with offset credits (Olujobi et al., 2023; Cevik, 2024; Río & Kiefer, 2022; Song et al., 2022). These policy instruments will support Ghana in achieving its renewable energy policy target of 10% by 2030, if they are well administered and offered the necessary policy and statutory support.

Ghana established the Carbon Market Office, which established a Ghana Carbon Registry under the Environmental Protection Agency (EPA) in 2022 (Ghana Carbon Market Office, 2024a). Ghana also signed Article 6 agreements with Singapore and Sweden in May 2024, while agreements with Switzerland and South Korea are under negotiation (Ghana Carbon Market Office, 2024b). Ghana also earned $4.8 million from the World Bank, in 2023, for about a million tonnes of carbon emissions from forest degradation and deforestation, with up to $45 million projected by the close of 2024 (World Bank, 2023).

## 5. Conclusion

This study assesses the state of play of RE in Sub-Saharan Africa through the lens of the Ghana renewable energy sub-sector. The tone is set with an exposition of the Energy Trilemma. The major renewables in Ghana are established as hydropower, solar energy, and bioenergy. Major challenges to renewable energy are enumerated as burdensome licensing processes, inadequate capacity of local human resources, information sharing and poor knowledge management on RE technologies, weak enforcement regime on disposal of RE

appliance wastes, inadequate financing of RE Investments, unaffordable RE Systems and unbalanced highlighting of on-grid RE systems.

The study proposes amendments to the existing Renewable Energy Act, such as the insertion of a provision for policy instruments like carbon bonds, carbon offsetting and renewable energy certificates, adoption of a more tightened regime for sanctions for offences such as unlawful disposal of electronic waste, and amendments that will ensure a less cumbersome licensing regime. The study further prescribes RE policy instruments such as Renewable Energy Certificates (RECs), Carbon Offsetting, Carbon Bonds and the establishment of a well-functioning Carbon Emission Trading/Carbon Cap platform. For future research outlook, given that Ghana has set a few policy interventions in motion, future research could evaluate the impact, success or otherwise of these interventions.

**Authors' contributions**

Leo Andoh Adjei Gyimah was responsible for study design, data collection and revision. Adjei Gyamfi Gyimah was responsible for drafting the manuscript, literature review and analysis of the data. All authors read and approved the final manuscript.

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**Informed consent**

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**Data availability statement**

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

**Data sharing statement**

No additional data are available.

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