World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Sustainable development and renewable energy practice: Strategies towards the achievement of sustainable development goal 7

Abdul-Fatawu Y *, Manpaya M and Owusu-Manu D

Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

World Journal of Advanced Research and Reviews, 2023, 20(03), 574–605

Publication history: Received on 18 October 2023; revised on 01 December 2023; accepted on 04 December 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.3.2435

Abstract

This study investigates the current status of renewable energy development in Ghana and explores strategic pathways to advance the nation's progress towards Sustainable Development Goal Seven (SDG7), which aims to ensure access to affordable, reliable, sustainable, and modern energy for all. Employing a comprehensive approach, the research combines a thorough review of existing literature, an analysis of national policies, and empirical research to assess the challenges and opportunities associated with integrating renewable energy sources into Ghana's energy landscape. The study begins with an overview of Ghana's energy sector, emphasizing the existing energy mix and its implications for sustainable development. Subsequently, it delves into an assessment of policies and frameworks guiding renewable energy deployment in the country, critically evaluating their effectiveness and identifying potential areas for improvement. Through case studies and data analysis, the research examines specific renewable energy projects in Ghana, providing insights into their successes, challenges, and impact on local communities. To reach SDG7, this thesis outlines the most important ways to improve the development of renewable energy in Ghana. These include policy suggestions, new technologies, financial incentives, and ways to get the community involved. The research also explores the role of international collaborations and partnerships in fostering a conducive environment for sustainable energy growth. The findings contribute to the academic discourse on renewable energy development and offer practical insights for policymakers, industry stakeholders, and development practitioners in Ghana. The study pushes for a sustainable and inclusive energy transition that takes into account both environmental concerns and the need for socio-economic development by aligning the country's energy path with SDG7. Ultimately, this research aspires to guide Ghana toward a more resilient, equitable, and environmentally conscious energy future.

Keywords: Sustainable development; Environment; Renewable energy; Ghana's energy sector; Policymakers

1. Introduction

Ghana is developing in West Africa with renewable and non-renewable resources. The territory under consideration has 31,072,940 people, 0.4% of the world's population, and 227,540 km2. Urban population 57%, rural 43.3%. Ghana Statistical Service: Demographic inequality rendered energy consumption essential in 2021. Ghana's population will reach 52,016,125 by 2050. This strategy will capitalize on Ghana's energy-driven social, political, and economic growth. Scientific arguments in Ghana increasingly center on energy. Planet life and growth require energy, argues Hussain et al. (2017). Energy shortages harm global politics, economics, and development. Research shows that 2 billion suffer from energy shortages. Population increase, especially in emerging nations like Ghana, will drive up global energy demand. The 2020 National Energy Statistical Department of Ghana research found that Ghana used bioenergy (36%) and fossil fuels between 2000 and 2011. Energy utilization in Ghana in 2020 was 36%. Oil and natural gas are second and third with 34% and 25% market shares. The 2020 Ghana National Energy Statistical Department research showed a big energy demand increase over two decades. 2020 energy consumption is anticipated to reach 5,478 Ktoe, up from 859 Ktoe in 2000. Many economic sectors have increased energy use. Residential energy use was 3482 Ktoe in 2020.

* Corresponding author: Abdul-Fatawu Y

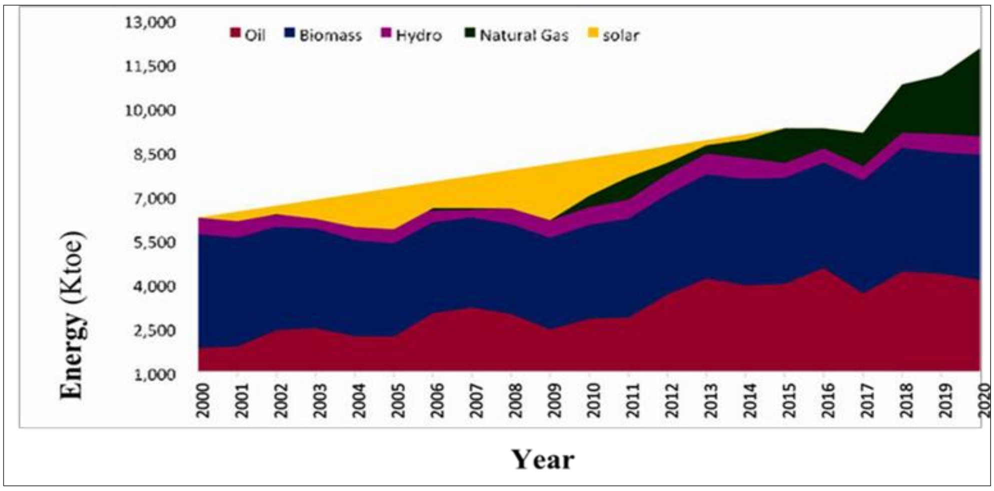
This uses 40.5% energy. At 38.3%, transport used the second most energy in 2020. Service used 5.0%, industry 14.2%, and agriculture 1.8% more energy in 2020. The 2000 figures were 13.5%, 2.2%, and 1.3%. This article examines renewable energy resources as a quantitative issue that involves technology and worldwide deployment to enhance development. Solar, geothermal, wind, marine, nuclear, biomass, and biofuels can power an economy and environment. Energy availability boosts global growth and reduces poverty. To modernize agriculture, and trade, empower women, save lives, improve transportation, grow businesses, and facilitate communications, energy must be abundant, reliable, and inexpensive (Sakyi, 2019). Africa, the second-most populous continent, has vast renewable energy resources that are underutilized (UN, 2020). The UN says renewable energy technologies (RETs) can boost African energy industries with little effort. The research says renewable energy offers attractive and ecologically friendly electrical sector alternatives in Africa. This method may help several African nations reduce power plant oil and fuel imports. Given its unique energy needs and capabilities, Africa, especially Ghana, should explore adding renewable energy to its energy portfolio. Ghana has plentiful biomass, sun, wind, and micro and mini-hydropower, but the Ministry of Energy estimates most remains untapped. National Energy Policy targets 10% renewable energy by 2020. This goal was extended until 2030. Generation Master Plan demands 10% renewable electricity. This study explores grid-connected applications using 6% dispatchable and 4% variable renewable energy. Variable renewable energy sources are appealing to investors due to high thermal power generating costs and limited backup capacity. Ghana must rethink its system to handle renewable energy fluctuations. Setting technical objectives and increasing capacity boosts market trust and competition. This may reduce power generation expenses. Research suggests 2 billion suffer from energy shortages. Global energy consumption will rise due to population growth, especially in emerging nations like Ghana. The Ghana National Energy Statistical Department found From 2000 to 2011, bioenergy and fossil fuels provided 36% of Ghana's energy, according to 2020. SDG 7 promotes renewable energy. These goals include upgrading infrastructure and technology to provide sustainable energy to growing nations by 2030. Energy efficiency should treble by the same date. These targets are challenging, but Ghana has plenty of renewable energy. These resources can balance Ghana's energy portfolio and help it achieve its goals. Poor Ghanaians cook and heat using biomass. Three huge hydroelectric and thermal power facilities generate most of the nation's electricity, with renewable energy contributing little. Energy systems in modern economies are reliable and sustainable. Recurring power crises in Ghana over the past two decades show that its energy sources cannot meet these needs. The research examines how Ghanaian renewable energy policy affects SDG 7.

2. Literature review

2.1. Renewable Energy Empirical Review

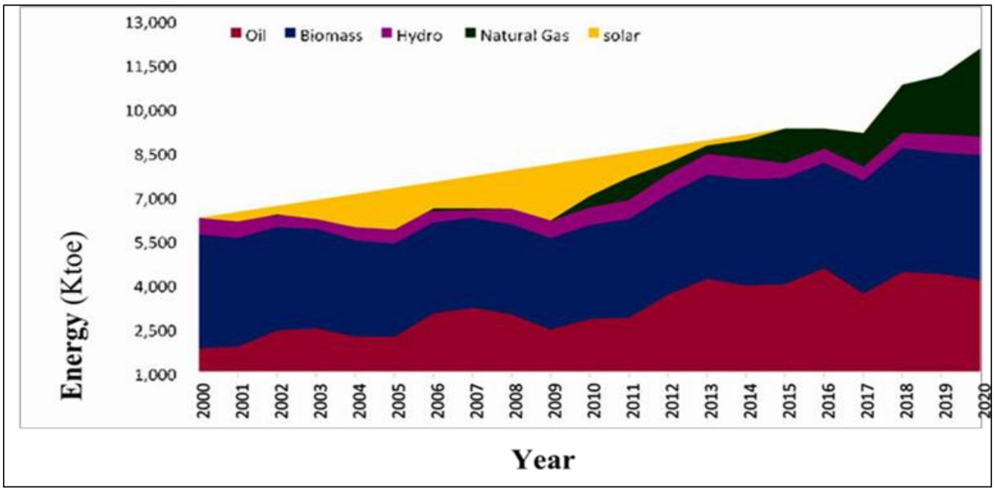
The empirical review focuses on prior research studies and publications that used experimental designs, data, or empirical methods to test a theory. This section analyzes prior academic research on Ghana's strategic implementation of renewable energy policy to achieve Sustainable Development Goal 7. This research explains sustainable development, sustainable energy access, green economy, strategy, energy policy, and renewable energy words and ideas. This study uses conceptual and theoretical terminology to improve knowledge and understanding. The 2020 National Energy Statistical Department of Ghana research found that bioenergy and fossil fuels accounted for 36% of Ghana's energy consumption between 2000 and 2011. Ghana consumed about 36% of its energy in 2020. Oil and natural gas are second and third with 34% and 25% market shares, respectively. According to the National Energy Statistical Department of Ghana (2020), Ghana's anticipated energy consumption increased from 859 Ktoe in 2000 to 5,478 Ktoe in 2020 (Figure 2.1).

Moreover, it is worth noting that the current state of affairs has seen a rise in energy consumption within several sectors of the economy. Housing areas have been recognized as the primary consumers of final energy, with an approximate consumption of 3482 Ktoe in the year 2020. This consumption constitutes 40.5 percent of the total final energy consumption. In 2020, the transport sector ranked second in terms of its contribution to total final energy consumption, representing 38.3 percent of the overall consumption. Consequently, there was an increase in the proportion of energy consumption within the industry, service, and agriculture sectors, with respective figures of 14.2 percent, 5.0 percent, and 1.8 percent in 2020, compared to 13.5 percent, 2.2 percent, and 1.3 percent in 2000. This suggests that renewable energy presents a feasible option for ensuring Ghana's long-term energy sustainability. Figure 2.2, presented below, illustrates the potential of renewable energy sources in Ghana. The perspective presented in this article regards renewable energy resources as a comprehensive and quantitative subject, encompassing many technologies and their worldwide implementation in advancing global development. Renewable energy sources, such as solar, geothermal, wind, oceanic energy, nuclear energy, biomass, and biofuels, has the capacity to be repeatedly utilised for energy generation, thereby assuming a substantial part in the preservation of the nation's future economy and environment.



Source: National Energy Statistics of Ghana

Figure 1 Total Amount of Energy Circulation in Ghana From 2000 – 2020



Source: National Energy Statistics of Ghana (2020)

Figure 2 The Consumption Potentials Of Ghana's Renewable Energies Potentials

2.2. Conceptual Review and Conceptual Framework

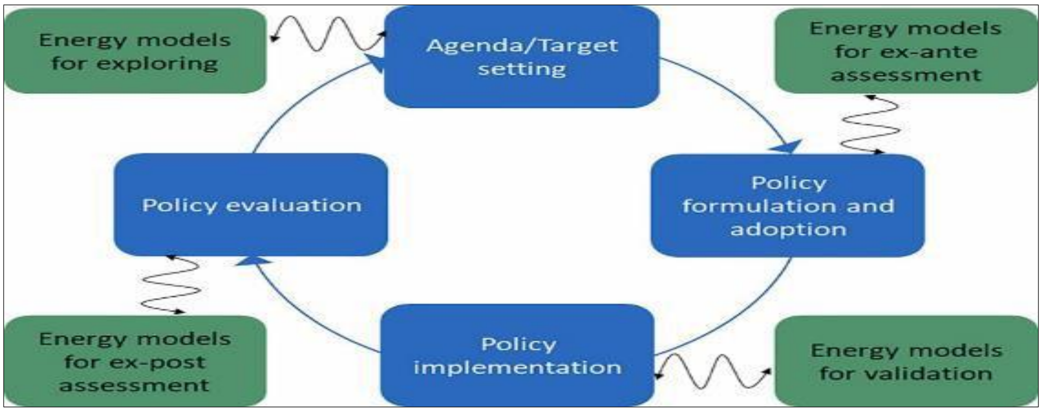
Literature review emphasizes theoretical and conceptual frameworks, analysing established theories, models, and concepts about a specific subject matter, without necessarily relying on empirical data. A conceptual framework refers to a comprehensive depiction of the researcher's comprehension regarding the components and/or variables that are pertinent to the investigation, as well as their interrelationships. The primary objective of a conceptual framework is to elucidate the concepts being examined by drawing upon pertinent scholarly works (Rocco and Plakhotnik, 2009) and to explicate the hypothesised interconnections among these concepts (Rocco and Plakhotnik, 2009; Anfara and Mertz, 2014). Conceptual frameworks and theoretical frameworks exhibit distinctions in terms of their scope and reliance on proven empirical evidence. While a theoretical framework elucidates the perspective from which a researcher perceives their work, the conceptual framework tends to be more operational and adaptable. Conceptual frameworks are comprehensive since they incorporate both well-established theories, commonly referred to as theoretical frameworks and the novel concepts that researchers develop during their investigations. Emergent ideas, such as those mentioned, may originate from informal or unpublished observations derived from personal experience. The ideas in question would not meet the criteria to be classified as a "theory" until they have undergone rigorous testing, have been substantiated by methodically gathered evidence, and have undergone peer review. Nevertheless, these entities continue to hold significance in shaping the methodologies employed by researchers in their investigations. The utilization of a conceptual framework enables authors to effectively articulate their emerging concepts, hence facilitating the identification of links between ideas within the study and enhancing the comprehension of the study's significance by readers.

2.2.1. *Constructing Conceptual Frameworks*

The inclusion of a conceptual framework in a research study is seen as significant; yet, researchers frequently choose to incorporate either a conceptual framework or a theoretical framework. Either option may be sufficient; however, both options offer a more comprehensive understanding of the research methodology. For example, a group of researchers intends to experiment to examine a new element of a pre-existing theoretical framework. The researchers provide a comprehensive overview of the established theoretical framework that underpins their investigation, followed by the presentation of their conceptual framework. Within the confines of this conceptual framework, certain subject matters exemplify emerging concepts that are interconnected with the theory. Providing a comprehensive description of both frameworks enables readers to have a deeper comprehension of the researchers' underlying assumptions, orientations, and conceptual understanding about the researched issues. An instance of this can be observed in the work of Connolly et al. (2018), where they incorporated a conceptual framework to elucidate how they employed the theoretical framework of social cognitive career theory (SCCT) in their investigation of teaching programs designed for PhD students.

2.2.2. *Conceptual Framework on Renewable Energy Policy Procedures*

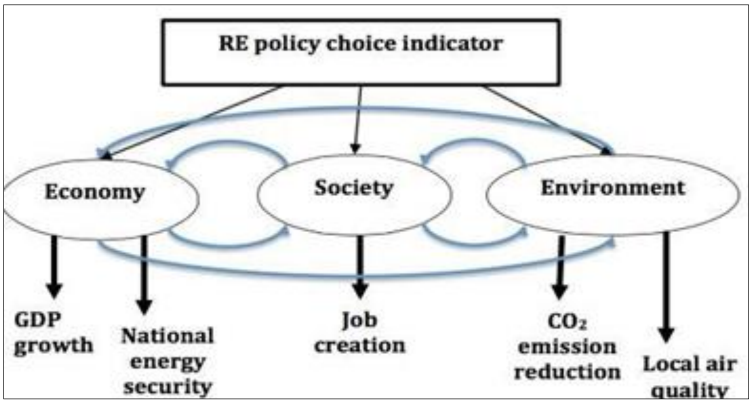
Conceptual models for renewable energy policy include the "Policy Cycle Model." This paradigm includes agenda formulation, policy creation, implementation, and assessment (Sabatier & Weible, 2007). The researcher uses the policy cycle model to structure the study. Policy cycle stages include agenda formation, policy design and adoption, policy implementation, and policy assessment. The cycle repeats as new conditions or needs create new policy needs. Throughout the policy cycle, different players provide policymakers with different types of information, such as models, which affect policy results. Public policies affect numerous actors, circumstances, events, and results, including several sources of pressure and information, including interest groups and advocacy coalitions. Given their time, organizational, and budgetary restrictions, policymakers must prioritize particular facts while analyzing and making decisions. This raises questions about how models affect this process. This study uses the policy cycle model to explain how models affect political decision-making, not energy policymaking. As shown in Figure 2.2, the model is used to define the stages of the policy cycle in which models are used: agenda-setting and target establishment (exploring), policy development (ex- ante assessment), policy implementation justification (validation), and evaluation of targets and specific policies. The study emphasizes that the policy cycle may oversimplify the policymaking process. We study how and when models and policies interact, not policy development or its effects. This technique allows us to discover various ways models and policies impact each other, which meets our goals. We also explore how policymakers affect modeling and its practitioners, as well as the results. Cyclical stages make up the modeling process. Refsgaard et al. (2007) suggest five stages: model research plan formulation, data design and acquisition, model set-up, calibration and validation, and simulation and assessment. Problem parameters, modeling prerequisites, and objectives are set in the first step. In the second phase, modelers conceptualize the energy system model to meet model research plan specifications. They also prepare model input data. After development or enhancement, the model is calibrated or validated. Simulations are run in the fifth phase to meet model study goals. Policymakers can discuss and use the findings to make decisions. Policymakers may affect the modelling process at numerous stages, but they have the most impact during issue framing and data and assumption establishment. Technical modeling procedures may be affected by this impact. A model research strategy may indicate a transparent explanation of modelling assumptions and data sources. However, it can also significantly affect the modeling process's outcomes.



Source: Author Own Construct (2023)

Figure 3 Energy Model Policy Cycle and Potential Use of Models in the Different Stages

Based on the stakeholders' selection of significant criteria for evaluating renewable energy policy, a comprehensive conceptual framework has been developed to guide the construction of the model's general structure (see Figure 2.4). Within this conceptual framework, the designated criteria have been categorised into three primary sectors: the economic sector, the environmental sector, and the social sector. The parameters of energy security and economic growth are subject to examination within the economic sector. Consequently, this interaction extends to two other sectors, namely the social and environmental sectors. Within the realm of the social sector, the primary criterion that serves as a representation of this sector is the generation of employment opportunities. The environmental industry takes into account both the quality of air and greenhouse gas emissions for further evaluation. The aforementioned criteria will serve as evaluative indicators for assessing the potential impact of renewable energy development in the country of Ghana.



Source: Author Own Construct (2023)

Figure 4 a conceptual framework to inform renewable energy policy evaluation in Ghana

2.2.3. Theoretical Review of Renewable Energy Consumer Adoption

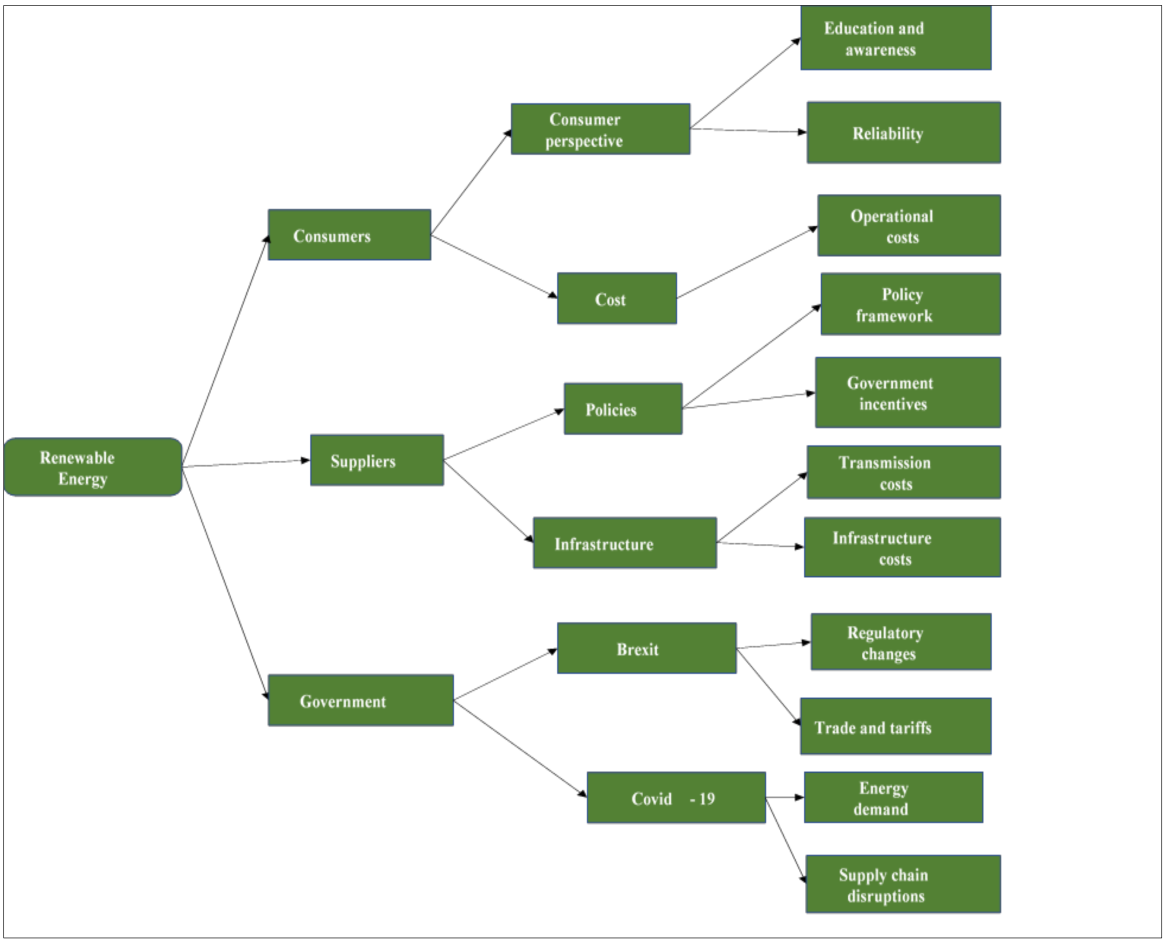
In recent years, researchers and practitioners have studied managerial conduct. This spawned behavioral finance, marketing, and operations. Greve (2001) says social sciences use behavioral theories. Theories of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), and TEDM explain human behavior. The new marketing theory, BRT, builds on technology acceptance theories like TPB (Westaby, 2005). BRT helps researchers connect concepts, values, reasons (pro and con), attitudes, subjective norms, behavioural control perceptions, intents, and user behavior measures. Many studies have shown that behavioral Response Therapy (BRT) has benefits over other behavioral theories (Ryan and Cassidy, 2018; Westaby, 2005). Pro- and anti-rationales help BRT comprehend human decision-making (Sahu, Padhy, & Dhir, 2020). Each perspective affects user intent and behavior differently. Contradictory yet distinct, these notions matter. The context of a debate determines its pros and cons. Thus, they provide context (Sahu, Padhy, & Dhir, 2020). Through cognitive pathways, BRT investigates rationales to understand human behavior and decision- making. Sahu, Padhy, and Dhir (2020) discovered that values and beliefs strongly motivate BRT users. Claudy et al. (2015) demonstrated that BRT-based models explain outcome variable variability better than alternative behavioral theories. Different metrics have been used to study BRT component interactions. Several variables impact sustainability. Values and beliefs, financial and economic rewards, budgetary restraints, environmental awareness, environmental benefits, willingness to change, and lifestyle change are these factors (Briggs et al., 2010). Due to its technological complexity, high initial costs, and variable market circumstances, renewable energy technology (RET) is encouraged by incentives and regulations. RET benefits include energy security, sustainability, and social well-being. Diffusion modeling examines growth and diffusion. Rogers' innovation diffusion theory suggests that ideas that benefit users monetarily may cause inequities. Because system units most in need of a new idea are least likely to adopt it. Many RET diffusion models address adoption hurdles, techno-economic concerns, learning curves, and experience curves. Current commercial product diffusion models neglect policy implications, which are crucial to renewable energy technology adoption. Renewable energy technology (RET) diffusion models must explicitly link diffusion parameters to policies since RET distribution depends on regulations. RET applications surged due to incentives. Due to these constraints, most research has focused on RET adoption barriers. Use diffusion theory and models to study RET growth. Economic research commonly employs learning curves. However, policy change time series data and social and technical dispersion must be evaluated (Orr, 2003). Multiple social system communication routes spread innovation throughout time. Independent social system members make innovative decisions. Orr (2003) lists five phases. Understand innovation first. The persuader's opinions determine innovation acceptance. Policymakers influence innovation uptake. Active users invent. Prior innovation choices must be evaluated by theconfirmation person. Opinion leaders promote innovation best, according to Orr (2003). Rogers, Sighal, and Quinlan (2014) suggest change agents target opinion leaders based on social structure. Social systems can be heterophilic or homophilic. Heterophilia may adapt to societal standards. They draw varied individuals with their curiosity. These mechanisms encourage creativity, making opinion leadership more imaginative, writes Orr (2003). Behavioral reasoning and diffusion may affect urban growth. The behavioral approach to public administration is commonly used to characterize policy processes, although it has limitations (Hassan and Wright, 2020).

2.2.4. Renewable Energy Policy Development Theory

Creating a theoretical framework for renewable energy policy in Ghana involves creating a systematic basis for the creation, execution, and assessment of policies to promote renewable energy and sustainable development. This theoretical framework provides a systematic approach to Ghanaian renewable energy policymaking. In its commitment to promoting sustainable and renewable energy sources, it recognises the importance of matching national goals with available resources, involving relevant parties, creating a favourable legislative framework, and securing financial and technological assistance.

2.2.5. Renewable Energy Preliminary Theory

The current study's theoretical foundation is introduced in this chapter. Kerlinger (1979) defines theoretical constructs as interrelated definitions and propositions that organize occurrences. These constructs link variables to explain and forecast. In order to promote energy sustainability in Ghana, this study uses behavioural reasoning theory and diffusion of innovation theory to explain renewable energy and its linkages with other research factors. Figure 6 shows the first renewable energy theoretical framework a Consumer has chosen. It shows how this paradigm interacts with sustainability and climate change research factors. The following theoretical framework explains renewable energy consumer efficiency and effectiveness.



(Source: Author's Own Construct, 2023)

Figure 5 Preliminary theoretical framework of renewable energy

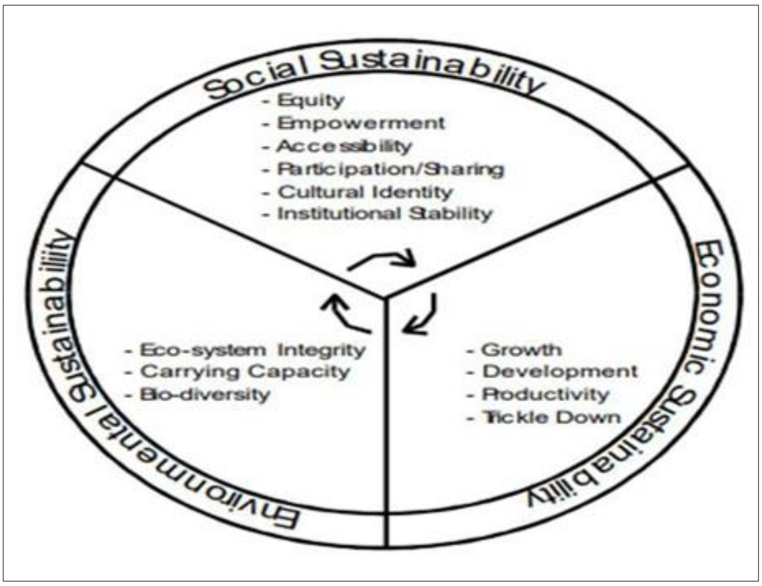
2.3. Sustainable Development

Sustainable development balances present and future requirements via living, creating, and consuming. In the 21st century, it guides policy. Political, industrial, environmental, economic, and theological experts believe that the idea must be applied internationally, nationally, and locally. Applying it and providing details may be tricky. Globally, "development" means enhancing the quality of life, especially the standard of living, in developing nations. Sustainable development enhances and protects life-sustaining natural processes. Progressive enterprises help the local economy, community, and environment (UN, 2015). After the 1987 World Commission on Environment and Development report, sustainable development became popular. The UN founded the commission to address economic development and population growth's enormous demands on Earth's land marine ecosystems and other natural resources. Regional populations may be endangered by strong pressures. These factors may trigger long-term global calamities. Production and consumption will shift due to environmental and economic constraints. Preemptive actions, strategic planning, and government and community engagement can mitigate these transitions' economic and social effects (IRENA 2012). These are energy challenges. All economies need reliable energy for lighting, warmth, communication, computers, industrial machinery, transportation, and more. Industrialized nations spend 5–10% of GDP on energy. In some rising economies, energy imports make up over 50% of sustainable development value. Global energy consumption increased roughly tenfold in the 20th century. Nuclear power and coal, oil, and gas-powered this expansion. Industrialization, demand in developing nations, and inefficiencies in all countries will increase global energy consumption in the 21st century. Energy efficiency is essential regardless of source (UNCSD, 2012). The lack of fossil fuel formation suggests limited reserves. Current surveys determine these stocks' distribution and quantity. Oil and gas are scarcer than coal. A resource's reserve lifetime is the known accessible quantity divided by current utilization. Oil and gas reserves endure decades, but coal deposits last millennia. Depleted fuel reserves raise gasoline prices, according to economic theory. Less demand for such fuel leads to cheaper alternatives. This procedure generally prolongs source life after examination. Many factors arise from state policies and international interactions. We must accept fossil fuel reserves' geological limits. Thus, current energy usage and expansion are unsustainable. Increasingly, fossil fuel and nuclear power emissions set boundaries. Environmental change involves growing CO_2. Biology indicates that carbon was plentiful in the atmosphere for billions of years. The oxygen-rich atmosphere that sustains life required carbon storage below. Due to the finite supply of fossil and nuclear fuels, the negative effects of emissions, and the need for ecological sustainability, renewable energy sources and energy efficiency must be increased. Economics supports these results when fuel procurement and emissions costs are included in pricing. Renewable energy and energy efficiency are cheaper for society than fossil fuels and nuclear energy, according to a 2012 IPCC assessment. The environmental harm produced by fossil fuel consumption shows unsustainable use practices. Earth's atmospheric CO_2 level is higher due to fossil fuel use. The scientific consensus is that this trend will amplify the greenhouse effect and create substantial climate changes within a century. Floods and cyclones may increase, harming food production, water supplies, and people. At least 150 nations have signed the UN Framework Convention on Climate Change, indicating that this issue is global and beyond their control. This guideline guides collective action on this pressing topic. Because developed nations are reluctant to modify their residents' lives, genuine progress is gradual. However, the IPCC (2012) lists climate change and sustainability as energy policy accelerators. Given resource constraints and environmental implications, renewable energy is more sustainable than fossil and nuclear fuels. Most national energy plans incorporate four critical elements to improve or preserve energy-related social benefits:

- Increased harnessing of renewable supplies
- Increased efficiency of supply and end-use
- Reduction in pollution
- Consideration of lifestyle.

2.3.1. The Need to Put Sustainability into Practice

The concepts of "sustainability" and "sustainable development" have emerged as fundamental principles in the realm of environmental policy and international development. However, their understanding is frequently hindered by the lack of a clear and universally accepted definition for these terms. The concept of sustainability is commonly understood as the practice of meeting existing needs while ensuring the capacity of future generations to meet their own needs remains intact. However, in order to provide guidance for decision-making and policy formulation, it is imperative to move beyond abstract concepts and apply them in many academic fields. Figure 2.6 presents a conceptual diagram illustrating three significant components of sustainability, namely social sustainability, economic sustainability, and environmental sustainability. The diagram facilitates comprehension of the objectives across several areas and their interrelationships.



Source: Author's Own Construct (2023)

Figure 6 The Three Important Segments Of Sustainability

Developing a sustainable framework for energy supply and utilisation serves as a means of operationalizing the concept of sustainability. To devise effective solutions, it is imperative to comprehend the interconnection between energy and socio-economic growth, as well as the environment, and social and economic security. There are several potential alternatives for a forthcoming energy system that aligns with the principles of sustainable development:

- More efficient use of energy and energy-intensive materials;
- Increased use of renewable sources of energy;
- More efficient production and use of fossil fuels;
- Fuel substitution, from high-carbon- to low-carbon- or no-carbon-based fuels.

The adoption and implementation of renewable energy, which is widely recognized as a crucial component in establishing a sustainable energy future, has been progressing at a sluggish pace. The next two decades are expected to witness a moderate increase in the utilisation of renewable energy sources, mostly due to the persistent limitations imposed by the prevailing cheap prices of fossil fuels on the advancement of renewable energy technologies. The acceleration of renewable energy growth and its increased contribution to present energy supply mixes necessitate the implementation of rigorous applications of pertinent theory and technologies.

2.3.2. Renewable Energy and Ghana's Development

Ghana's economic, social, and environmental progress depends on renewable energy. The energy supply is stable with this component. Ghana's diversification into renewable energy sources increases energy security, according to Asante (2018). Jobs and investment in renewable energy infrastructure boost economic growth (Adu-Gyamfi et al., 2020). Again, climate mitigation decreases. Ghanaian renewable energy reduces greenhouse gas emissions (Mensah, 2019). Renewable energy projects increase rural power, which enhances social development and lowers poverty (Yirenkyi, 2017). Additionally, tech innovation improves: Renewable energy investments promote sustainable energy and technical innovation (ECA, 2021). A renewable energy strategy is needed to move from fossil fuels to solar, wind, hydro, and biomass (IPCC, 2011). According to REN21 (2021), these ideas help satisfy renewable energy, greenhouse gas, and energy stability targets. Bowden and Payne (2009) report that concerns about oil price volatility, fossil fuel pollution, and overreliance on traditional energy sources are driving interest in sustainable energy. Government sustainability actions are vital. Measures include production-based renewable energy tax incentives, renewable energy system installation discounts, portfolios, and efficient renewable energy certificate markets (Bowden & Payne, 2009). Zerrahn (2017) recommends a gradual switch to renewable energy to prevent pollution. Many writers claim that fossil fuel consumption is releasing carcinogens into the atmosphere at worrisome rates. Adopting alternative energy sources is crucial for environmental protection (Kothiyal et al., 2022; Claxton, 2015; Chen, Cheng, He, & Wang, 2022; Yıldız, 2018).

2.3.3. Access to Sustainable Energy

To boost economic growth, Sub-Saharan Africa will expand energy production and consumption in the coming decade. Despite ample energy, this area is inadequately electrified. With 15% electrification and 30-40% national pricing, rural energy access has hindered expansion. Most nations' population growth exceeds connection, making electrification challenging (Haanyika, 2006). Under existing conditions and fiscal restrictions, Sub-Saharan Africa's energy policy should prioritize self-sufficiency and environmentally sustainable energy sources that leverage investment and enhance economic growth (Weisser, 2004). The region's economy relies on cost-cutting, especially residential connection fees. Access to economical, dependable, and socially accepted energy services is a key barrier to sustainable development, even though the Millennium Development Goals need them (Brew Hammond et al., 2009). The global energy industry has various obstacles, including restricted cheap grid access, fluctuating oil prices, high upfront expenditures for renewable energy technology, low knowledge of renewable energy supplies, and growing greenhouse gas emissions. Fragile economies, fast population expansion, limited investments, and inadequate energy infrastructure aggravate developing countries' concerns (Sawin, 2004). Ghana aims to deliver dependable, sufficient, and economically viable high-quality energy services for households, businesses, agriculture, and transit. These objectives satisfy MDGs (EC, 2004). Ghana also adopted the ECOWAS White Paper's energy access targets to improve energy services.

2.3.4. Global Energy Access Inequality

Over 10% of 7.8 billion people are powerless. Four-fifths live in developing nations and are rural. Future urbanization in fast- growing metropolitan areas of emerging nations may expand the population without power. According to Energypedia (2017), poor families consume 1.3 million barrels of oil, 1.5% of global output, for lighting. This lighting uses harmful wick-containing bottles. More than 2.5 billion people cook and heat with energy. Girls and women gather wood, straw, maize stalks, and animal waste for these processes. India (825 million) and China (515 million) house 83% of 1.2 billion Sub-Saharan Africans. The 2020 World Energy Outlook reported that 52% of Sub-Saharan Africa was powerless in 2019. Global statistics ignore the 29% power disparity between urban and rural areas. Urban challenges need considerable consideration. The highest urbanization in 20 years is in Sub- Saharan Africa. The UN (2018) anticipates a 57% increase in cities above 500,000 from 2018 to 2030. Many African towns' energy systems lack the capacity and infrastructure to satisfy expanding electrical demand and the pressing need for sustainable energy.

2.3.5. Sustainability and Renewable Energy

Renewable energies may replenish themselves without depleting Earth's resources. These include bioenergy, hydropower, geothermal energy, solar energy, wind energy, and tidal and wave energy. Tester (2005) defines sustainable energy as a dynamic equilibrium between equal access to energy-intensive products and services for everyone and environmental preservation for future generations. Due to population increase and rising energy demand, fossil fuels including coal, oil, and gas are still used. This dependency has led to the depletion of fossil fuel supplies, the production of greenhouse gases and other environmental challenges, geopolitical tensions and military confrontations, and fuel price instability. According to the UNFCCC (2015), these challenges might lead to unsustainable conditions that could pose persistent hazards to human society. Renewable energy sources are the most popular option and the only answer to the growing problems (Tiwari & Mishra, 2011). Renewable energy sources increased to 22% of worldwide energy output in 2012, according to the U.S. Energy Information Administration (2012). This is a big improvement over a decade ago. All economies need reliable energy for heating, lighting, industrial equipment, and transportation (International Energy Agency, 2014). GHG emissions drop significantly when fossil fuels are replaced with renewable energy. Renewable energy sources may be sustainable since they come from natural and continuous energy flows in our environment. Renewable energy must have endless resources and provide environmentally friendly goods and services to be sustainable. Sustainable biofuels must not increase CO2 emissions, food security, or biodiversity (Twidell & Weir, 2015).

2.3.6. What Climate Change Is Ghana Seeing?

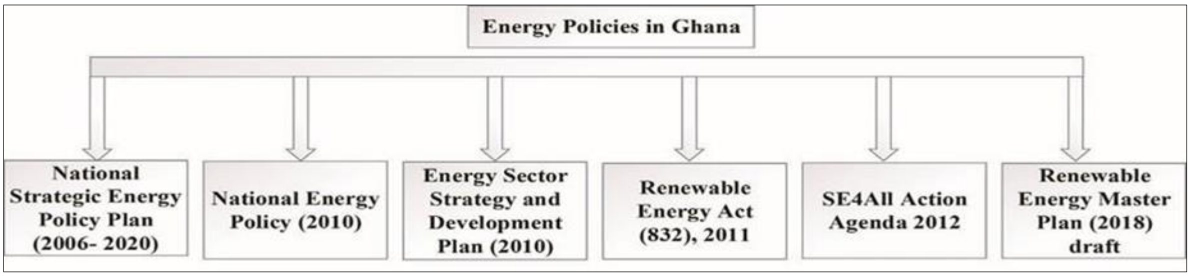
Ghana is experiencing more frequent and lengthy floods and drought. Over the past 30 years, temperatures have risen 1 degree Celsius. The southwestern coast of Ghana has high temperatures and humidity, whereas the southeastern coast has moderate temperatures and low precipitation. The north is hot and dry. A 20-year review of observed data shows that temperatures in all zones have increased while rainfall has decreased and variability has increased. Seasonal rainfall affects environmental and agricultural production (UNDP, 2011). According to a 2023 World Bank Group study, Ghana is experiencing changes in temperature, precipitation patterns, and the occurrence and intensity of extreme weather events including floods, droughts, and storms. The above effects affect the nation's economy, food security, and people's well-being. To address these issues, a comprehensive strategy must integrate agriculture and environmental management, improve risk preparedness, promote sustainable energy production, modernize transportation systems, and build more resilient infrastructure. The World Bank estimates that comparable programs cost $2 billion annually to finance and sustain.

2.4. Energy Sector SDG7 Strategies in Ghana

Details about Ghana's RE promotion methods. Ghana's energy stakeholders and regulations are assessed. Ghana's SDG7 requires renewable energy for universal, cheap, dependable, sustainable, and modern power. Ghana has various SDG-7 options: First, regulations. Increase renewable energy laws and enforcement. Comprehensive rules are needed to integrate renewable energy into the national energy mix. Tax incentives, subsidies, and feed-in tariffs should increase renewables. Government policies strongly affect renewable energy (Smith, 2020). Local renewable energy system development, installation, operation, and maintenance training is necessary. Teach schools about renewables. Jones et al. (2018) believe training boosts local renewable energy skills. Third, public-private partnerships should promote renewables. Fund sustainable energy. Public-private partnerships may attract renewable energy investments, says Green Investment Group (2019). Infrastructure modifications are needed to incorporate renewable energy into the national grid. Optimizing energy distribution and management requires smart grids. The national grid requires renewable energy (Brown, 2021). Rural electrification counts. Off-grid and solar mini-grids should power rural regions. Community initiatives are needed for ownership and involvement. Solar mini-grids power rural communities, suggest Johnson and Wang (2017). Study tech transfer and innovation are sixth. International collaboration and partnerships help spread renewable energy. Support local renewable energy research. The 2022 Global Energy Transfer Report highlighted global collaboration to transfer technology for indigenous renewable energy solutions. Regain knowledge and understanding: Improve energy efficiency and renewables. Addressing cultural and economic energy use requires local participation. According to the Renewable Energy Awareness Organisation (2019), public awareness initiatives have promoted renewable energy. Other energy-saving methods: Efficiency promotes renewables and energy savings. Increase energy-saving gadgets and habits. The Energy Efficiency Institute (2016) says energy efficiency reduces energy demand and enhances renewable energy. Additionally, monitoring and evaluation are essential. Develop an effective renewable energy project monitoring and assessment system. Renewable energy projects must consider economic and environmental issues. Renewable energy project development requires a robust monitoring and evaluation system, according to a 2020 Monitor and Evaluation Journal study. About international cooperation: Work with foreign sponsors and groups for money and expertise. Join global energy and climate efforts. International sustainable energy initiatives impact national efforts, argues the UN Sustainable Energy Task Force (2023). Also, inclusivity: Benefit underprivileged populations equally from renewable energy. Gender-sensitive energy programs can address women's demands and promote equality. Participation in renewable energy must reduce inequality (Doe and Smith, 2018). Finally, these methods can assist Ghana in attaining SDG7. It would boost energy sustainability and social and environmental aims.

2.4.1. 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 2.7 below shows the renewable energy policies in Ghana from 2006 to 2018.



Source: Energy Policies in Ghana (2018)

Figure 7 Renewable Energy Policies In Ghana From 2006 To 2018

2.4.2. Energy Sector Strategy and Development, 2010

The Energy Sector Strategy and Development Plan was implemented in 2010 in conjunction with the National Energy Policy 2010. The document encompassed a range of policies, programs, and projects designed to bolster Ghana's national development plan in key sectors, namely energy sector institutions, the electricity sub-sector, the petroleum sub-sector, and the renewable energy sub- sector. This policy outlines the objectives and approaches for enhancing the proportion of renewable energy sources in the overall national energy composition and promoting their efficient utilisation of them. Additionally, it aims to provide legal frameworks that foster the advancement of renewable energy technology.

2.4.3. The Sustainable Energy for All Action Plan (SE4ALL), 2012

The action plan of Sustainable Energy for All (SE4All) aims to achieve widespread availability of power in island and riverbank communities in Ghana, utilizing both on-grid and off-grid systems. Additionally, the strategy seeks to ensure universal access to clean cooking solutions. The United Nations Development Programme (UNDP) has engaged in collaborative efforts with many partner agencies to attain the goal of universal access to energy by the year 2030. The present level of power access in Ghana stands at roughly 84%.

2.4.4. The Renewable Energy Act, 2011

The Renewable Energy Act (832) was created to facilitate the development, management, utilisation, sustainability, and sufficient provision of renewable energy for the production of heat and power. Additionally, it aims to establish a conducive climate that attracts investment in the renewable energy sector. The legislation encompasses many provisions including licensing procedures, feed-in-tariff schemes, purchase responsibilities, rights to transmission and distribution systems for renewable energy (RE) facilities, net metering, and renewable energy funds. The establishment of the feed-in-tariff scheme in Ghana may be attributed to the enactment of the Renewable Energy Act of 2011. This scheme serves the purpose of ensuring the secure and reliable sale of power generated from renewable energy sources into the country's national grid. The responsibility of establishing feed-in tariff rates under the 2011 act lies with the Public Utility Regulatory Commission (PURC). The feed-in tariff rates are provided to a registered producer at a predetermined set rate, ensuring a level of certainty for a period of up to 10 years. Subsequently, these rates can be reviewed and renewed every 2 years. The publication by PURC encompasses the feed-in-tariff rates applicable to energy derived from solar, wind, small hydro, waste-to-energy, and biomass technologies. This publication takes into account the specific technology employed as well as the geographical location of the generating facility. In 2016, the Public Utilities Regulatory Commission (PURC) established feed-in-tariff rates that limit the price of renewable energy (RE)-generated power. An independent power producer (IPP) must sign a Power Purchase Agreement (PPA) with the off-taker, either a distribution utility or a bulk customer, to sell power. The PPA rate shall not exceed the Feed-in Tariff (FiT) rate. The Feed-in Tariff (FiT) motivates business organizations, while grid-connected entities and individual photovoltaic (PV) users in the nation have seen no advantages. The method helps grid- linked solar PV customers without remuneration. Furthermore, the Ghanaian government is willing to commit to a Feed-in Tariff (FiT) payment of 10 cents per kWh or less. It won't provide FiT rates above 10 cents/kWh. Power generators were recently advised to sign a Power Purchase Agreement (PPA) and invest in varied Renewable Energy (RE) projects. RE technology FiT rates in Ghana in 2016 exceeded 10 cents/kWh. Investors are skeptical of the change in Feed-in Tariff (FiT) rates, which have traditionally encouraged renewable energy (RE) companies.

2.4.5. Net-metering

The Energy Commission installed 33 net metering devices in 2015 as part of a pilot program. Electricity Company of Ghana (ECG) and Northern Electricity Distribution Company (NEDCo) will execute the initiative, which was announced by the Public Utilities Regulatory Commission (PURC). However, technical and financial challenges at the utility hampered the experimental project in 2017. Private institutes investigating the failure found that financial factors, not technology, caused it. Stakeholder agencies are actively seeking program execution solutions. However, proponents of the RE school of thought argue that certain energy organizations do not see a need to incentivize renewable energy providers, preventing their deployment.

2.4.6. REIFs

Ghana has supported renewable energy (RE) projects via a variety of funding options. These fundraising methods have been used before and still are. Loan and on-lending finance will be used to create a renewable energy and energy efficiency sector. The government created the Ghana Renewable Energy Risk Capital (GRERC) to reassure project financiers and investors and encourage investment in renewable energy (RE) projects, particularly SMEs and domestic green initiatives. Some say that the Green Renewable Energy Regulation and Certification (GRERC) has not benefited any renewable energy (RE) community. In recent years, Ghanaian government projects like the Ape Bank Project have failed. This World Bank-supported project installed solar mini-grids in rural areas. However, the communities could not repay.

2.4.7. Renewable Energy Purchase Obligations

The Renewable Energy Purchase Obligation (REPO), which requires bulk consumers to buy RE electricity, has not yet been finalized. Electricity can only be sold to distribution utilities or bulk clients under the RE Act. Ghana has two distribution utilities: ECG (Southern) and NEDCo (Northern). The share of RE-generated power fed into the grid comes from three sources: a 20 MW solar PV facility created by BXC Company Limited, a 100-kW waste-to-energy plant by Safi Sana Ghana Ltd., and a 2.5 MW VRA plant. ECG has Power Purchase Agreements (PPAs) with BXC and Safi Sana, and NEDCo receives 2.5 MW of solar power. Private institutions don't know the renewables % sold. They believe the proportion is low owing to production's limited size.

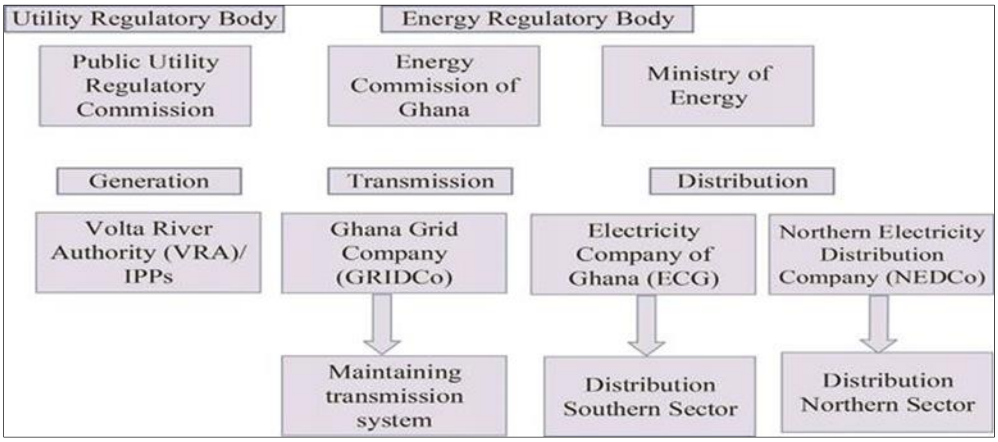
2.4.8. Renewable Energy Promotion Policies

The government's main goal is to encourage private renewable energy investments. The "Regulated Market," where private businesses can initiate and promote renewable energy projects as Independent Power Producers, differs from utility-guided project development. VRA is the most active utility in this domain. By 2020, Ghana aims to generate 10% of its energy from renewable sources. Ghana's energy regulation framework includes the 1997 Energy Commission Act, Public Utilities Regulatory Commission Act, and Renewable Energy Act. Energy's renewable energy division. The commission creates policies and strategies for the Renewable Energy Act, which covers wind, solar, hydro, waste-to-energy, and biomass.

2.5. The Regulatory Framework of Ghana’s Energy Structure

Specific incentives are available for investments in the RE sector:

- Exemption from import duty on RE equipment development of codes and standards for solar, wind, and bio-energy systems
- Regulations and procedures exist to ensure that all RE service providers are provided with licenses/permits and Power Purchase Agreements.
- Clear Feed-in Tariffs (FITs) for energy generated by renewable sources and Independent Power Producers have been published recently. Figure 10 shows the regulatory framework of Ghana’s Power Sector and how those regulatory bodies operate.



Source: Energy Policies in Ghana: [11, 14]

Figure 8 The Regulatory Framework Of Ghana’s Power Sector

2.6. Sources of Renewable Energy

Earth will progress, but humanity's resources will decrease. Families, businesses, and service providers have long relied on fossil fuels. However, fossil fuel shortages raise energy prices. These fuels impact the climate and ecosystem. Greenhouse Gas consequence, where gases retain heat in Earth's atmosphere, is the principal consequence (US Environmental Protection Agency, Greenhouse Gas Emissions report, 2014). Earth heat loss is harmful. The term "global warming" commonly explains natural calamities. Greenhouse gas emissions melt glaciers and polar ice caps, rising sea levels. Thermal energy retention causes droughts and floods. Greenhouse effect-induced temperature rise has major consequences, says the British Geological Survey. Due to harmful and often lethal components, various countries are investing in solar, wind, hydropower, and biomass. A greener energy system should reduce greenhouse gas emissions and climate change. Many nations are investing in renewables. Thermal and electrical energy are available in many forms. Germany generated 24% of its total power from renewable sources in 2013, up from 7% in 2000. Germany safely decommissioned numerous nuclear reactors recently. Statistisches Bundesamt gross power generation data is from 2013. Few renewable energy sources were available, so many were skeptical and worried about power shortages. Germany exports energy to many nations, defying energy scarcity beliefs. Energy efficiency and storage may benefit producers, consumers, and the environment, says Birkenstock (2012). Proper infrastructure hampers renewable energy utilization. Electrical infrastructure is lacking in many developing nations, making domestic energy delivery challenging. Renewable energy is solar, wind, or hydropower. There are several ways to capture and convert renewable energy for residential usage.

2.6.1. Solar Energy

Solar panels, which generate electricity, are the main method. Photovoltaic modules are linked electrically and supported by a framework from a solar panel. A photovoltaic module is a linked solar cell array. Solar panels are part of photovoltaic systems that generate and supply power for business and residential use. A photovoltaic system typically includes a solar panel or array of solar modules, an inverter, maybe a battery or solar tracker, and connecting cables. Photovoltaic modules may generate electricity from various light frequencies, although they generally exclude ultraviolet, infrared, and diffused light. Thus, solar modules waste a lot of incident solar energy, lowering efficiency. However, monochromatic light can boost solar module efficiency. Thus, an alternate design idea divides light into wavelength ranges and directs beams to cells tuned to respond to those ranges. The Max-Planck Institute in Germany expects this technique to boost efficiency by 50%. The greatest solar module efficiency in newly designed commercial items is 21.5%. These efficiencies are usually lower than those obtained when cells are evaluated separately. Solar panels can be installed on rooftops or ground. Supplemental tracking devices monitor the sun's direction and tilt the modules to maximize sunlight exposure and solar panel performance. Two main ways to properly harvest solar energy are to absorb direct sunlight and convert it into energy, or to use the sun's heat. Madagascar has used affordable solar cookers for years. Hamm (2014) states that homes may utilize solar energy for cooking and store extra energy in a battery for future use for roughly 15€.

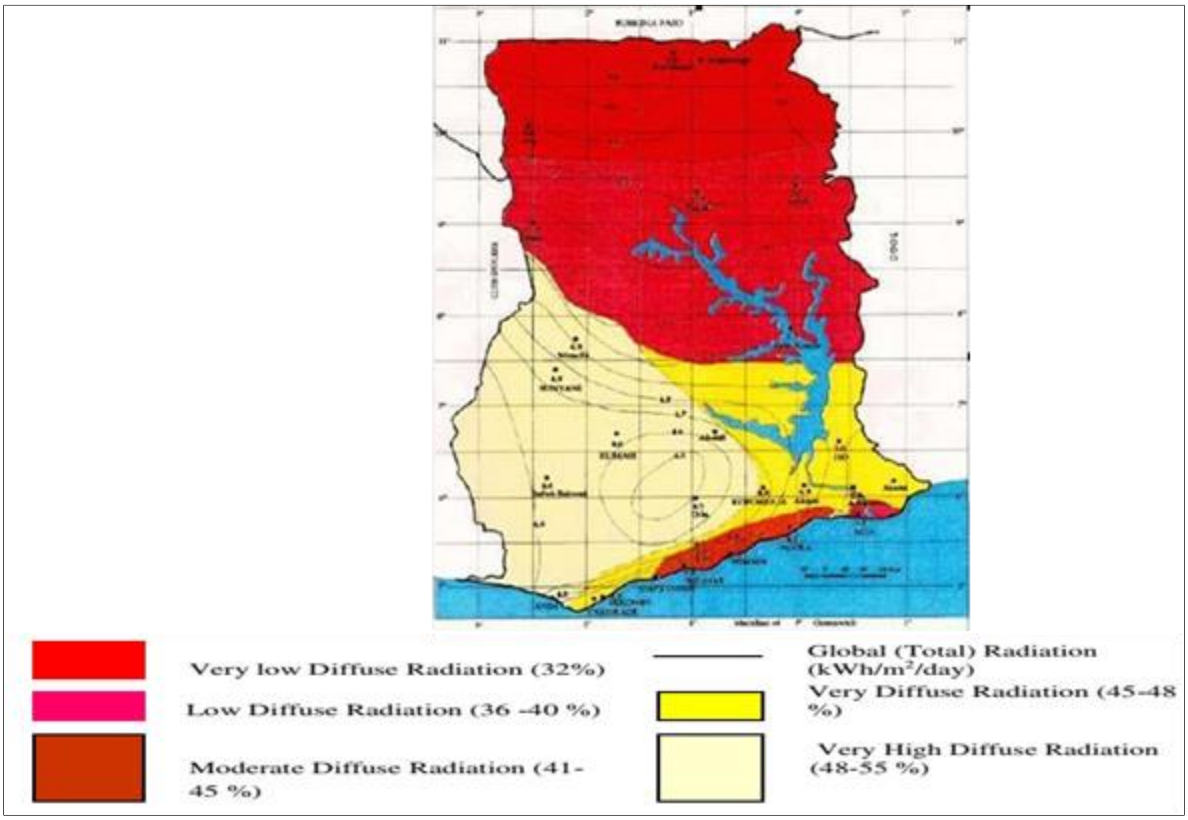
2.6.2. Solar Potential in Ghana

This section provides an overview of the possibilities of solar energy in Ghana. Figure 2.9 displays the solar radiation map. The three northern regions, namely the Northern region, Upper East, and Upper West, have the most solar energy potential, while the Greater Accra region demonstrates significant solar possibilities, but to a lesser extent when compared to the aforementioned northern regions. The regions depicted in Figure 2.9 below are characterized by varying shades of yellow, with deep yellow and light yellow indicating areas with limited potential for solar energy generation.

Table 1 Solar PV Installations in Ghana

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

Source: Energy Commission (2011)



Source: Ministry of Energy (2011)

Figure 9 Solar Resource Potential of Ghana

2.6.3. Wind Energy

Nations with abundant wind resources regularly consider placing turbines on large, unobstructed vistas. According to "Renewable Energy Sources in Figures-National and International Development" from 2013, 90 nations support windmill energy. Countries adopting eco-friendly technology are rising. Offshore windmills generate power from marine and ocean winds. Low and high wind speeds hurt wind turbines everywhere. To decrease noise and exploit enormous, unobstructed wind resources, wind turbines are often positioned in rural locations far from cities and homes. Wind turbines can harm birds, thus municipalities require regional planning beyond agricultural land and protected areas. Fans utilize electricity to produce wind, whereas windmills use the opposite. Windmill blades create power via a generator shaft (Energy.gov, 2014).

2.6.4. Hydro

Several kinds of water energy exist. Like the Volta River project, dams create renewable energy (Fiagbe and Obeng, 2013). Ghana built its first dam, the Akosombo Dam, in 1965, according to the Government of Ghana (2014). Bui Dam was finished in 2013 and the Kpong Dam in 1982. Water and strong flow power hydroelectric dams like Akosombo and Kpong. However, the Bui Dam has several purposes beyond electricity generation. Besides generating electricity, this method prevents flooding, irrigates, and enhances fishing. A Ghanaian Bui Dam hydro power project website was accessed April 4, 2016. Through conduits, dams generate power from high-velocity water flow. River and sea flow can be harnessed by water wheels or turbines. Most dams generate power readily despite their size. Reservoir water holds potential energy. The gate opening generates kinetic energy from penstock water. Bonsor (2014) links water flow velocity and magnitude to energy generation. Alternative water energy collecting devices exist. Wave, tidal, and ocean thermal energy function best in clear, vast regions. The term implies that wave energy derives from oscillation. The turbine rotates and produces energy via wave propagation in a closed container.

2.6.5. Biomass Energy

Ghana relies on biomass, the most frequent renewable energy (RE) in impoverished countries (IEA, 2014). The Energy Commission (2004) estimates Ghana has 20.8 million biomass hectares, half of its 23.8 million. These resources supply 60% of national energy. Rural biomass is preferable and can replace grid electricity. Because rural Ghana has easy resource access. Most rural Ghanaians cook with firewood and charcoal. Energy conversion technique and demand determine metropolitan biomass. For cooking, charcoal can substitute liquid petroleum gas due to its high energy production (Karekezi et al., 2003). Ghana used 11.7 million tons of biomass in 2008. Green industries including agriculture, forestry, and hydropower drive the economy. 2.01 million tons of oil and 8059 GWh of electricity were used. Nketia (2010) found 65.6% biomass energy equivalents from wood fuel and charcoal. Electricity was 8.4% and petrol 26.0%. RE and waste-to-energy can safeguard Ghana's electricity and minimize climate change. Although renewable, biomass deforests and harms the environment. In 2009, Ghana Biomass Group and Biomass UK Limited studied non-tree-cutting biomass production (UCS, 2014). Although renewable, biomass deforests and harms the environment. Ghana Biomass Group and Biomass UK Limited researched non-tree-felling biomass generating technologies in 2009 (Union of Concerned Scientists, 2014). Ghana has enough electricity and a renewable energy plan. Solar, wind, water, and biomass power plants, mills, turbines, and panels must be placed strategically. On April 5, 2016, West (2015) reported access to the top seven renewable energy sources. Mismanagement and bad revenue allocation may make funding these environmentally sustainable technologies and energy supplies difficult. Renewable resource technology requires costly equipment and deployment. The Ghana Power Commission and UNEP are verifying offshore wind power in various locations.

2.6.6. General Advantages and Disadvantages of Renewable Energy

Since the use of renewable energy is a rather new development, it carries the weight of critics and careful long-term observation. Many advantages and disadvantages have already been pointed out under each section of renewable energy resources discussed above. Table 2.1 below shows some of the general advantages and disadvantages which are related to all the mentioned types of resources.

Table 2 General Advantages and Disadvantages of using Renewable Energy Technologies (RETs)

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

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

2.7. Specific Ghanaian Renewable Energy Development Barriers

Renewable Energy Technologies and Transitions (RETTs) face eight main obstacles: Economic and Financial, Market, Technical, Network, Legal and Regulatory Framework, Information and Awareness, and Socio-cultural and Human Skills. Each section has specific obstacles, listed below.

2.7.1. Market Barriers

The market size of a renewable energy technology can help or hinder technology transfer. As the market grows, entrepreneurs are more likely to acquire, utilize, and share technology. A smaller market reduces the likelihood of entrepreneurs investing in technology transfer. In Ghana, market size may be a hurdle for several Renewable Energy Technologies (RETs). Unlike other places, Bensah et al. (2010) found that larger renewable energy technologies (RETs) have not been widely implemented.

Economic and Financial Obstacles

Despite the availability of equity finance, venture capital funds, debt financing, and crowd financing, some entrepreneurial funding sources in Ghana are still developing. Ghanaian enterprises have restricted access to crowd funding due to its underdevelopment. Ghanaian enterprises rely on debt funding since equity finance is not frequently used. The ambiguity surrounding the pricing of Renewable Energy Technologies (RETs) raises risk, making banks wary of supporting RE projects. Long-term funding is a major barrier to biogas and landfill gas implementation. According to Daniel et al. (2014), Fidelity Bank has a RE desk70 to help Ghanaian real estate project development.

Human Skills and Training Center Barriers

Technical skill operation and maintenance abilities. Technical skills are vital in renewable energy technologies worldwide. Many renewable energy technology (RET) initiatives fail due to a lack of technical skills and training facilities for system operation and maintenance. DENG Engineering and The Energy Centre teach experts in solar PV, solar pump, and, more recently, grid-connected solar PV system design, installation, and maintenance (UNFCCC, 2003).

2.7.2. Tech Barrier

Insufficient operations and maintenance facilities—After-sales service is essential to any diffusion effort. The country's lack of well- trained maintenance and repair facilities that can help end consumers after sales deters such people. The frequent malfunctions of sun dryers, biogas plants, windmills, and solar water heaters due to competent maintenance raises questions about Renewable Energy Technologies (RET).

2.7.3. Knowledge

Every nation adapts to technology differently. Ghana follows this trend. Effective distribution requires receivers to have access to information to make educated decisions. End users should have simple access to procurement costs, technology advantages, and operations and maintenance details (Painuly, 2001). Gboney (2009) states that public ignorance about renewable energy technologies (RETs) hinders their widespread implementation. The UNFCCC (2003) cites the lack of understanding about solar water heaters' benefits as a major barrier to their deployment.

2.7.4. Legal and regulatory obstacles

Even though the Energy Commission (EC) is legally required to implement renewable energy regulations, enforcement is lacking. The commission struggles to enforce laws without regulations and standards. Non-compliance rises significantly without implementation. This move unintentionally lowers renewable energy technology trust. The regulatory authority is expected to regulate and manage industry businesses and service providers to ensure product and service quality. The European Commission has restricted charcoal production and export. Importers of renewable energy systems should be included in this method.

2.7.5. Culture-related obstacles

Due to a lack of incentives, switching from conventional to renewable energy may be difficult, especially when traditional energy sources are more reliable and affordable. Sociocultural issues are listed below: Lack of understanding of local needs and preferences.

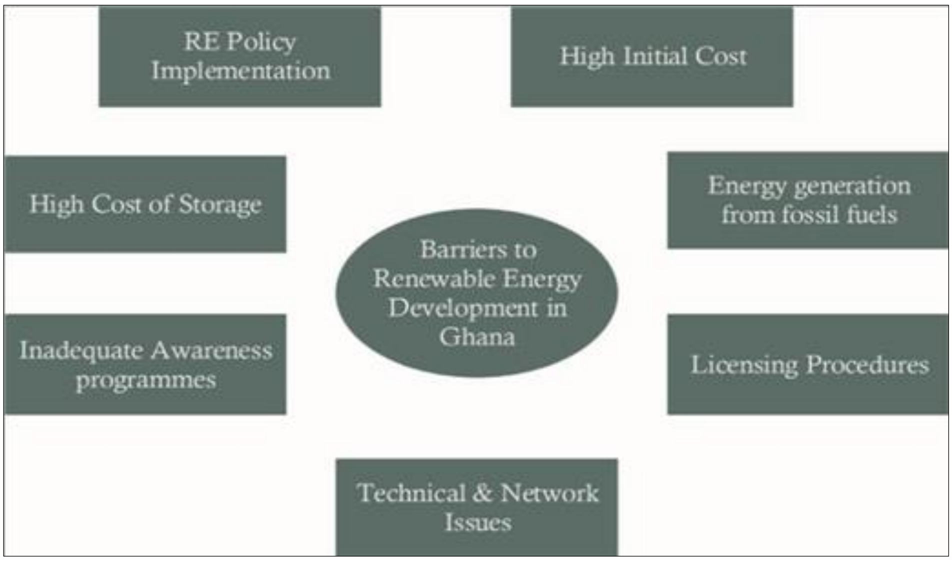
The project design process for Renewable Energy Technology dissemination must address local demands. Renewable energy technology (RET) interventions are often rejected because local desires differ from real needs. Many RETs fail because they don't match potential recipients' needs with the recommended solution.

2.7.6. Network Limits

Renewable Energy Technology Transfer (RETTs) decision-making procedures lack stakeholder engagement, requiring many stakeholders' participation. Include all key stakeholders in decision-making to foster project ownership and support from all parties. If a group of stakeholders feels excluded, they may refuse the Renewable Energy Technology (RET) intervention, preventing technology transmission.

2.7.7. RE Policy Implementation Barriers Identified by the Stakeholders

The primary challenge in implementing renewable energy development in Ghana pertains to the lack of implementation of the Net Metering Scheme. Meanwhile, the primary obstacle highlighted is ascribed to the renewable energy laws in Ghana. The barriers mentioned by the stakeholders are illustrated in Figure 12. The current renewable energy (RE) laws lack incentives for power providers who produce surplus energy and contribute it to the national grid. Specifically, there is no financial compensation provided for injecting excess power into the system, despite the government benefiting from the additional power supply. The efficacy of the net metering plan has been suboptimal since its enactment in 2012. Consequently, the process of connecting to the national grid has encountered difficulties due to the absence of incentives for onsite power generation and the sluggish pace of legislative measures supporting this project. This ultimately impedes the financial position of developers of grid-connected systems. The diagram presented in Figure 2.10 illustrates the hurdles to the effective implementation of renewable energy policies in Ghana, as described by various stakeholders. These barriers pose significant challenges to the strategic execution of renewable energy initiatives in the country.



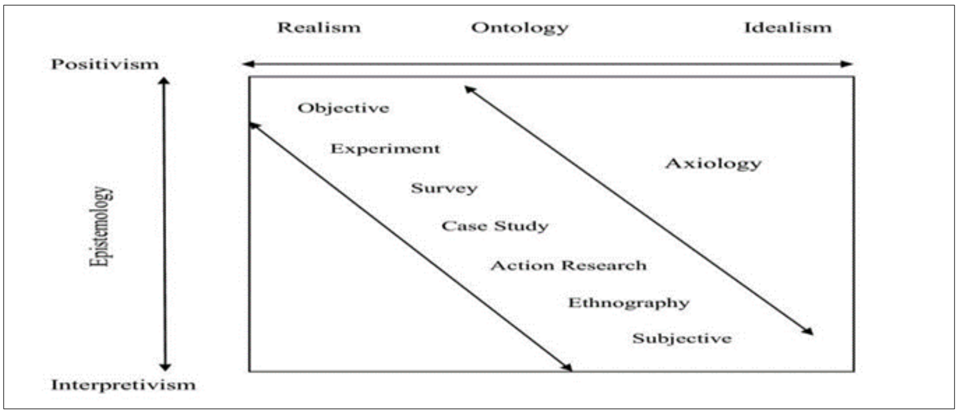
Source: Author's Own Construct (2023)

Figure 10 Renewable energy policy implementation barriers identified by stakeholders

3. Research methodology

3.1. Philosophical Standpoint of the Study

Research study philosophy impacts knowledge's nature and evolution, claim Saunders et al. (2009). According to Holden and Lynch (2004), the study's philosophy should guide its techniques. Researchers should analyze their philosophical assumptions (Pathirage et al., 2005). Research project philosophies must be determined for effective approach. Philosophy of research discusses epistemological, ontological, and axiological assumptions (Pathirage et al., 2008). Epistemology investigates knowledge creation, acquisition, and dissemination (Scotland, 2012). Tennis (2008) classifies research as valid or unsatisfactory. Ontology and technique impact epistemology. The philosophy of reality is ontology, epistemology how to know it, and methodology how to know it. Query- knowledge link, Krauss? Information is obtained how? (ibid. According to Saunders et al. (2009), interpretivism and positivism dominate research epistemology. As Krauss (2005) states, positivist researchers are detached from their topics. Actual observation or measurement provides knowledge. Positivists think that only observable occurrences can give correct evidence, and their hypothesis-building technique is likely founded on a theory (Saunders et al., 2009). Positive theory stresses that science and empirical methods may analyze genuine events. A thorough, logical research and analysis can also explain them (Aliyu et al., 2014). The value-free aspect of positivist research is also significant (Saunders et al., 2009). Man's objective criteria may choose what and how to research, not people's opinions and interests (Holden and Lynch, 2004). Interpretivist research examines beliefs to explain phenomena (Walliman, 2003; Ahadzie, 2007). Reality informs this subjectivism (Scotland, 2012). Meaning is created by awareness's interactions with the world. Researchers must participate in interpretive research (Ahadzie, 2007). Scotland (2012)'s "A tree is not a tree without someone to designate it a tree" may aid interpretivists. Scotland (2012) believes that interpretive tools help explain conduct from the participant's perspective. Most research is motivated by people (Ahadzie, 2007). We want to create a strategic renewable energy policy framework for wind, solar, hydropower, and biomass sites. Conclusions need green energy technology website and institution data. To meet Sustainable Development Goal 7, which requires affordable, accessible, and reliable energy for all by 2030, the researcher sought to "discover" how effective renewable energy technologies (RETs) could improve Ghana's economic, environmental, and social sustainability through energy mix, market diversification, and policy integration. Based on positivist epistemology, this strategy was chosen. Ontology studies reality (Saunders et al., 2009). Reality and "what" knowledge assumptions are explained (Pathirage et al., 2008). Epistemology examines "what it means to know," whereas ontology studies "what is" (Grey, 2014). Ontology has objectivism and subjectivism, say Saunders et al. (2009). Objectivism asserts that reality exists regardless of social actors' actions and perceptions, unlike subjectivism. As shown, subjectivism promotes interpretivism and objectivism positivism. Axiology classifies reality as value-laden or value-free (Pathirage et al., 2008). Value-neutral research is guided by objective standards, whereas value-laden research is influenced by participants' beliefs and experiences (Easter by-Smith et al., 2002). The investigation was objective, therefore value-free axiology was applied. The value-free axiological philosophy matches the study's ontological objectivist and epistemological positivist philosophies (Figure 3.1).



Source: Pathirage et al. (2005)

Figure 11 Research Philosophical Assumption

3.2. Research Approach

According to Fellows and Liu (2008), critical thinking is the process that establishes the connections between the data gathering and analysis needed to generate findings and the ultimate resolution of the research topic. Research methodologies have proliferated and afforded researchers a greater degree of choice and flexibility (Pathirage et al., 2005). (Creswell, 2003). Creswell (2003) recommended using mixed methods, qualitative, and quantitative research approaches. The objective is to build a relationship or infer a trait from the variables to the parent population (Brannen, 2005). The analysis of quantitative data is dominated by statistics. data. This fact is evident in the characteristics of the quantitative approach (Rajasekar et al., 2013):

- It is numerical, non-descriptive, applies statistics or mathematics, and uses numbers.
- The process is iterative where evidence is evaluated.
- Tables and graphs are often used to display the results.
- It is conclusive.
- It seeks to investigate the what, where, and when of decision-making.

In contrast, the goal of the qualitative method is to explain social phenomena (Hancock et al., 2007). It aims to comprehend how people, either as individuals or as communities, view "the world" (Fellows and Liu, 2008). Its main goals are to comprehend, elucidate, investigate, uncover, and make sense of the circumstances, emotions, perceptions, attitudes, and experiences of the population under study (Kumar, 2011). The researcher's perceptions and insights influence qualitative research. Since the outcomes of qualitative research are non-quantitative, they are not subjected to quantitative evaluations (Kothari, 2004). The relative advantages of both quantitative and qualitative research are combined in the mixed-method approach. By using this approach, one can achieve the benefits of both qualitative and quantitative research while minimizing or eliminating their shortcomings and gaining a multifaceted understanding of the topic (Fellows and Liu, 2008). In the context of tackling intricate research inquiries, the mixed technique can yield practical benefits. In light of the previously provided context, the study has chosen to employ a qualitative approach.

3.3. Research Instrument

The tools used to gather data for a study are referred to as research instruments. A variety of methods are used to collect data, such as surveys, interviews, in-person meetings, and a mix of these. The questionnaire was the data-gathering tool employed in this investigation. Because it may collect data in an economical, efficient, organized, and controllable manner, the questionnaire is a popular and practical instrument for gathering data (Wilkinson and Birmingham, 2003). Making sure a questionnaire is impartial, dependable, and valid is the most important thing to consider while creating it (Zohrabi, 2013). There are two types of questions: organised and unstructured. While respondents are required to react in their own words to unstructured questions, structured questions offer options from which they can choose (Bhattacherjee, 2012).

This research study's questions were designed to be generically organised. Respondents were asked to check the appropriate answers from the list. The questionnaires were divided into four pieces, each of which addressed one of the study's objectives, with the exception of the first component, which collected demographic data. The sections cover the background of the respondent (section A), how to find different sources of renewable energy technology projects in Ghana (section B), how to implement policies for renewable energy development in Ghana (section C), how effective

Ghanaian renewable energy policies are (section D), and lastly, how to evaluate the main obstacles to and challenges presented by Ghana's renewable energy technologies (section E). Respondents were requested to rate the efficacy and frequency of use of various sources of renewable energy technologies. For each challenge/barrier of renewable energy technologies (RETs) in Ghana, respondents were requested to score on a Likert scale of 1-5, the frequency of occurrence where 1 = 'Not Often', 2 = 'Less Often', 3 = 'Moderately often', 4 = 'Often', 5 = 'Very Often'.

3.4. Sample Design Process

By watching only, a small section of the population—the sample size—the goal of the sample is to learn more about the population. In order to produce renewable energy electricity for our domestic and industrial needs, the researcher focuses more on his studies of population samples in the three northern regions: the Northern (Tamale and its environs, such as Yendi Solar Plant), Upper East (Bolgatanga and its environs, such as Navrongo Solar Plant), Upper West (Wa and its environs, such as Nadowli Kaleo Solar Plant), Savannah, and some parts of the South, such as Greater Accra, Afram Plain, Brong Ahafo, and Bui power plant. In order to ensure socio-economic development while maintaining environmental sustainability and Ghana's ecosystems, this study aimed to understand how renewable energy project professionals, energy agencies, the Ministry of Energy, and other renewable energy stakeholders develop and implement effective strategic measures to achieve reliable, affordable, accessible, and sustainable energy (power supply) in our urban and rural communities. Therefore, in order to achieve sustainability for Ghana's energy sector while preserving and safeguarding our immediate environment, the study focused on the energy professionals who collaborate with various national and international organisations involved in renewable energy projects in Ghana, such as Energy Contractors, Consultants, Surveyors, IRENA, Energy Logistics Suppliers, Engineers, IEA, Architects, and others.

3.5. Population Definition

Only energy professionals, such as renewable energy project experts, energy project consultancy firms, energy agencies, government, ministry of energy, energy contractors, energy logistics suppliers, and local, national, and international renewable energy technology experts, were selected as study participants, individual clients, beneficiaries' communities, and other stakeholders (respondents). Thus, based on the results of the pilot survey, there are one hundred and ninety-five (195) energy specialists employed by these renewable enterprises in Accra. The professionals who made up the energy generation, transmission, and distribution companies were the Volta River Authority (VRA), Ghana Grid Company Ltd (GRIDCo), Electricity Company of Ghana (ECG), and Northern Electricity Distribution Company Ltd (NEDCo), in that order. Additionally, there were Independent Power Producers (IPPs) like Takoradi International Company (TICo), Sunon Asogli Power Plant and CENIT Energy Limited, International Renewable Energy Agency (IRENA), and other stakeholders b The selection of this category of energy specialists, contractors, or professionals was based on the fact that these individuals work for reputable companies. Public organizations in charge of renewable energy infrastructure projects, such as Ministries, Departments, and Agencies, were represented in consulting firms. The choice to concentrate on the Greater Accra area was made since, according to the list derived from the pilot survey, over 65% of energy professional contractors now name Accra as their official residence. Furthermore, the researcher was unable to visit other areas due to time limits and budgetary limitations during the investigation.

3.6. Sampling Techniques and Sample Size

A sample comprises a subset of the target population (Peck et al., 2007) in terms of individuals or objects. It denotes the overall count of participants included in a specific research investigation who were not included in the sample frame. Sample frame is the term used to denote the number of components comprising the target population in its entirety. Strictly speaking, a sample is selected from a larger population in order to represent the target population. The total number of participants comprising the research sample was 133. This is because, according to a rule of thumb proposed by Roscoe (1975), a substantial review of pertinent literature requires a minimum of significantly more than 30 respondents and a maximum of fewer than 500 respondents. In addition, 133 is selected as the sample size in consideration of the time frame and financial constraints that the researcher expects to encounter during data collection. Furthermore, this representative sample is sufficient to gather information within the permitted time frame for data collection.

3.6.1. Sampling Techniques

In this research, a non-probability sampling method was implemented. Probability sampling operates under the condition that the inclusion or exclusion of a specific element from the sample is determined solely by chance. The methodology enables the selection of each individual through a random process. As an illustration of the non-probability sampling method purposeful sampling was utilised to identify the main respondents, who were energy professionals employed by Energy Professional Contractors, Agencies, and Consultants involved in renewable projects. The reason for this was that the researcher sought responses from specific categories of participants who possessed extensive experience with renewable energy infrastructure initiatives and, as a result, were more qualified to complete the questionnaires. The study's client pool was determined using the snowball sampling technique, an instance of a non-probability method, in consideration of the diverse range of professionals involved in energy project clientele, including financial institutions, ministries, departments, agencies, municipal and district assemblies, and agencies. The initial step of this sampling method was to contact a small number of prospective respondents, who were then requested to provide the names of individuals or organisations possessing the desired characteristics in order to reduce the sample size and associated expenses. Consequently, the consultants and professionals affiliated with the renewable energy contractors disclosed the names of their clients. The thirty (30) professionals whose names appeared on the list obtained from them and were involved with clients of renewable energy projects were selected for the research.

The Sample Size Used

A pilot survey revealed that each of the 65 energy professional contractors operating in the Accra region possesses a minimum of three renewable energy project professionals and upholds a high standard of reputation and excellence. Hence, the cumulative number of energy professionals employed by the aforementioned renewable energy firms in Accra amounts to 195 (195). As a consequence of financial limitations and the need to complete the investigation within the designated timeframe, the researcher employed the snowball, convenient, and purposive sampling methods to select 133 respondents from 195 estimated population sample frames. The sample size was determined using the formula (Kish, 1965).

$$n = \frac{n^1}{1 + \frac{n^1}{N}}$$

Where n = sample size
N = Total population = 195
s = Maximum standard deviation in the population elements
p = proportion of the population elements that belong to the defined category
i.e. p = 0.5 (95% confidence level)
v = standard error of the sampling distribution i.e. v= 0.05 Hence solving for

= 0.5(1- 0.5) = 0.5() = 0.25(0.05)2 = **0. 0025**

, = = 100

n = 100/ (1+100/195), n = 66

Sample size formulas, such as the one employed previously, determine the bare minimum number of responses that must be acquired. In light of prior investigations, scholars, including Cowley et al. (1963), frequently augment the sample size by 10% in order to account for individuals whom the researcher is unable to reach. Consequently, an additional seven, or 10%, of the total of 66 would be included in the sample. Therefore, a grand total of seventy-three (73) questionnaires were dispatched by hand to energy professionals employed at the Accra offices of the energy company. Obtaining a sample size (n) of 30 for the renewable energy professionals working with clients and consultancy firms in Accra that were the focus of this study was challenging due to the scarcity of the population of energy professionals employed by energy consultancy firms or companies, in addition to government agencies. This was exclusively deliberated within the parameters of the convenient sampling technique. The study employed a sample size of one hundred thirty-three (133) in total.

3.7. Data Collection

In accordance with the research inquiries and objectives, a survey instrument was devised to gather as much comprehensive data as feasible from these experts in renewable energy projects. As a result, a survey instrument was developed and responded to individually by the diverse group of participants. The survey was comprised entirely of closed-ended inquiries. The queries for the research were classified into three distinct categories. The initial set of inquiries pertains to the profile of the participant. This was designed to elicit respondents' background and experience. The second set of inquiries pertained to the infrastructure project sectors of renewable energy. The researchers employed a five-point ranking system and a three-tiered scale ranging from low to high. Participants were requested to select the following: the frequency of renewable energy policy implementation, the significance of renewable energy policies, and the effectiveness of current renewable energy implementation in Ghana.

4. Results

4.1. Socio Demographic Characteristics of Respondents

A sample of 133 respondents was selected for the survey by the study. The response rate for the study was 100.0%. The bulk of the respondents, according to the results, were in the age range of 31 to 40. With a standard deviation of 7.38 years, the respondents' mean age was 36.0 years. Male respondents made up 71.4% of the sample, with female respondents making up 28.6%.

Table 3 Socio Demographic Characteristics of Respondents

Variable	**Frequency (n)**	**Percentage (%)**
Age (years)		
<=30	38	28.6
31 – 40	60	45.1
41+	35	26.3
Total	133	100.0
Sex		
Male	95	71.4
Female	38	28.6
Total	133	100.0
Religion		
Islamic	90	67.7
Christianity	29	21.8
Traditionalist	14	10.5
Total	133	100.0
Marital status		
Single	29	21.8
Married	104	78.2
Total	133	100.0
Ethnicity		
Dagomba	68	51.1
Akan	14	10.5
Mossi	7	5.3
Gonja	9	6.8
Frafra	8	6.0
Ga	14	10.5
Komkomba	13	9.8
Total	133	100.0
Type of company		

Public	95	71.4
Private	38	28.6
Total	133	100.0

Source: Author Field Work (2023)

According to table 4.1 above, the majority of respondents—67.7%—were Muslims, followed by Christians (21.8%) and Traditionalists (10.5%). Additionally, the study found that 21.8% of respondents were single and 78.2% of respondents were married. Furthermore, 51.1% of the respondents identified as Dagombas, 10.5% as Akans, 5.3% as Mossi, 6.8% as Gonjas, 6% as Frafras, 10.5% as Ga, and 9.8% as Komkombas. The majority of respondents—71.4%—were employed by public organisations, whereas private ones employed 28.6%.

4.2. The Various Sources of Renewable Energy Technology in Ghana

The various sources of renewable energy technologies (RETs) identified according to the survey conducted are duly summarized in table 4 below for more detailed information.

Table 4 Various Sources of Renewable Energy Technology (RETs) in Ghana

Variable	Frequency (n)	Percentage (%)
Renewable energy technologies/sources being used in Ghana		
Solar power	115	86.5%
Wind power	108	81.2%
Hydroelectric power	103	77.4%
Biomass energy	106	79.7%
Waste-to-energy	94	70.7%
Mini-grids and Off-grid solutions	103	77.4%
The most commonly used renewable energy sources in Ghana		
Hydroelectric power	120	90.2%
Solar power	112	84.2%
Biomass energy	111	83.5%
Wind power	110	82.7%
Mini-grids and Off-grid solutions	112	84.2%

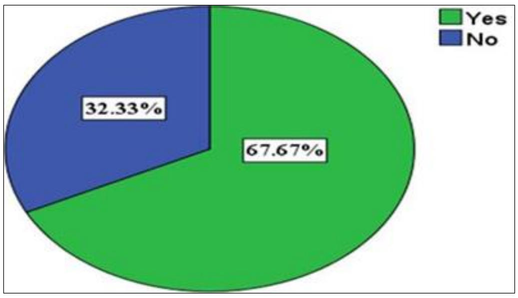
Source: Author Field Work (2023)

The study's findings indicated that the renewable energy sources and technologies used in Ghana include biomass energy, hydroelectric power, solar power, and wind power, respectively, with 86.5%, 81.2%, 77.4%, and 79.7% of the respondents mentioning these sources and technologies.

Furthermore, hydroelectric power, solar power, biomass energy, and wind power were cited by 90.2%, 84.2%, 83.5%, and 82.7% of the respondents as Ghana's most widely utilized or important renewable energy sources, respectively. Further details on the several renewable energy technology sources that are most frequently utilized in Ghana for both residential and commercial applications can be found in Table 4.2 above.

4.3. Renewable Energy Development Policy Implementation Strategies in Ghana

Figure 4.1 shows respondents who are familiar with the renewable energy policies and strategies implemented by the Ghanaian government. (Source: Author Field Work, 2023). The study's findings demonstrated that, as seen in (Figure 4.1 below, 67.7% of respondents were familiar with the renewable energy policies and plans put in place by the Ghanaian government, while 32.3% said they were not familiar with these measures.



Source: Field Survey (2023)

Figure 12 Familiar with the Renewable Energy Policies and Strategies

Table 5 Methods or Initiatives they are aware of that the Ghanaian Government Adopted

Variable	Frequency (n)	Percentage (%)
Renewable Energy Act 832 (2011)	102	76.7%
Renewable energy master plan	89	66.9%
Net metering policies	82	61.7%
Feed-in tariffs	107	80.5%
Capacity building and training	111	83.5%
Public-private partnerships (PPPs)	110	82.7%
Regulatory framework	107	80.5%
Diversification of energy mix	97	72.9%
Public awareness and education	108	81.2%
Research and development	83	62.4%
Incentives and subsidies	114	85.7%
International partnerships and collaboration	112	84.2%
Grid integration strategies	120	90.2%
Green financing	111	83.5%
Off-grid solutions	106	79.7%
Carbon credits and emission reduction programs	94	70.7%

Source: Author Field Work (2023)

The majority of respondents (76.7%), (66.9%), (61.7%), and (80.5%) indicated that the main methods or initiatives they are aware of that the Ghanaian government has used to implement renewable energy policies are the Renewable Energy Act 832 (2011), the renewable energy master plan, net metering policies, and feed-in tariffs, respectively. Table 5 above provides more details on significant projects or tactics that you are aware of that the government has used to carry out renewable energy policies in Ghana. The study's findings also revealed that the main factors supporting the development of renewable energy were, in order, 86.5%, 79.7%, and 75.9% of the respondents, diversification and energy security, environmental advantages, and economic prospects and job creation. Land use disputes, inadequate grid capacity, and reliance on weather conditions were cited by the majority of respondents (81.2%), (80.5%), and 83.5%) as the main obstacles to boosting the development of renewable energy.

Table 6 Strengths and Weaknesses of these Strategies

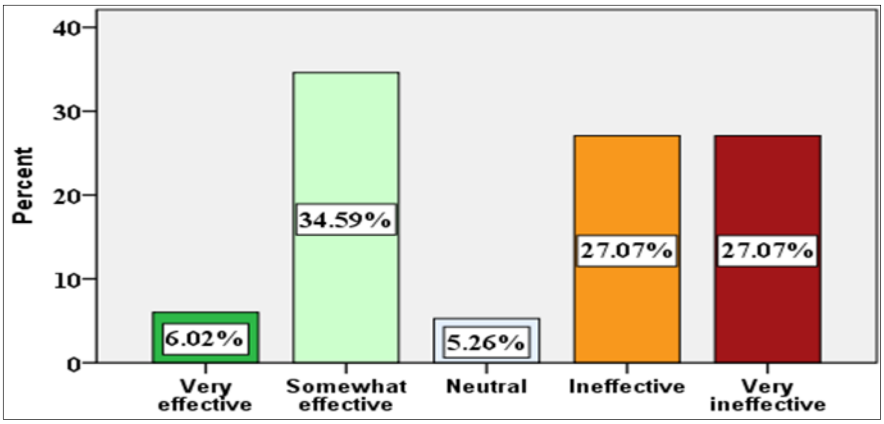
Variable	Frequency (n)	Percentage (%)
Strengths		
Diversification and energy security	115	86.5%
Environmental benefits	106	79.7%
Economic opportunities and job creation	101	75.9%
Long-term cost saving	104	78.2%
Global partnerships	104	78.2%
Weakness		
Initial cost	103	77.4%
Intermittency and reliability	106	79.7%
Infrastructure challenges	102	76.7%
Policy stability	103	77.4%
Technological barriers	108	81.2%
Social acceptance	105	78.9%
Storage challenges	108	81.2%
Access to financing	99	74.4%
Land use conflicts	108	81.2%
Limited Grid capacity	107	80.5%
Dependency on weather conditions	111	83.5%
Social equity concerns	116	87.2%

Source: Author Field Work (2023)

Further details on the advantages and disadvantages of these tactics for advancing the development of renewable energy are given in Table 6 above. The majority of respondents—86.5%—agreed that diversification and energy security are the strategies' main strengths, while the majority of respondents—87.2% and 83.5%, respectively—agreed that social equity concerns and reliance on the weather are the strategies' main weaknesses in promoting the development of renewable energy in Ghana.

4.4. Ghana's Renewable Energy Policies' Effectiveness

According to the study's findings, 34.6% of the participants thought Ghana's renewable energy policies were somewhat successful in reaching their stated objectives, as illustrated in (Figure 13). Further details regarding the efficacy of Ghana's renewable energy programs may be found in Table 7 below.



Source: Author Field Work (2023)

Figure 13 Respondents Views on How Effective the Renewable Energy Policies in Ghana

Table 7 The Effectiveness of Renewable Energy Policies in Ghana

Variable	Frequency (n)	Percentage (%)
Positive impacts of renewable energy		
Increase renewable energy capacity	115	86.5%
Job creation	72	54.1%
Community Empowerment	120	90.2%
Reduction in greenhouse gas emissions	115	86.5%
Access to energy	108	81.2%
rural electrification	103	77.4%
Investment and partnerships	99	74.4%
Government commitment	104	78.2%
Technological advancement	104	78.2%
Reduction in energy cost	100	75.2%
Environmental conservation	103	77.4%
Educational opportunities	91	68.4%
Energy security	95	71.4%
Reduces dependency on energy imports	99	74.4%
Challenges or areas where these policies have fallen short		
Intermittency and reliability issues	118	88.7%
Infrastructure gaps	96	72.2%
Financing constraints	114	85.7%
Political instability	100	75.2%
Social and environmental concerns	112	84.2%
Lack of public awareness	109	82.0%
Technological risks	111	83.5%

Limited Technological capacity	107	80.5%
Economic viability	107	80.5%
Land use conflicts	115	86.5%
Energy access disparities	107	80.5%
Global market fluctuations	111	83.5%

Source: Author Field Work (2023)

Furthermore, the study indicated that 86.5%, 90.2%, and 81.2% of the participants indicated increased renewable energy capacity, community empowerment, and access to energy as the positive impacts of renewable energy respectively. The study results also showed that 88.7%, 85.7%, and 83.5% of the participants stated intermittency and reliability issues, financial constraints, and technological risks as the challenges or areas where these policies have fallen short in delivering their intended outcomes.

4.5. Challenges/Barriers of Renewable Energy Technologies in Ghana

The challenges /barriers of RETs in Ghana can be broadly discussed in four main headings: implementation, economic, technological/technical, and regulatory/policy-related barriers. The findings of the study revealed that 90.2%, 83.5%, 82.0%, and 85.7% of the respondents stated that policy and regulatory challenges, technological capacity, access to market and global supply chains, and energy storage challenges as the primary challenges or barriers to the implementation and adoption of renewable energy technology in Ghana respectively. Moreover, the study showed that 88.0%, 91.0%, 88.7%, and 87.2% of the participants mentioned high initial cost, energy price dynamics, risk perceptions, and economic stability as the specific economic challenges that hinder the widespread use of renewable energy technologies in Ghana respectively. The result of the study showed that 77.4% of the participants believe that there are regulatory or policy-related barriers affecting the renewable energy sector in Ghana. The majority, 84.2%, 82.7%, and 79.7% of the participants mentioned access to finance, land use and permitting, and capacity building as the regulatory or policy-related barriers respectively. Table 4.6 contains more information on the challenges or barriers of renewable energy technologies in Ghana.

Table 8 Challenges

Variable	**Frequency (n)**	**Percentage (%)**
Primary challenges/barriers to the implementation and adoption of RETs in Ghana		
Financial barriers	103	77.4%
Policy and regulatory challenges	120	90.2%
Infrastructure gaps	97	72.9%
Technological capacity	111	83.5%
Public awareness and acceptance	106	79.7%
Land use conflicts	95	71.4%
Access to market and global supply chains	109	82.0%
Politics and economic stability	113	85.0%
Competition with fossil fuels	112	84.2%
Energy storage challenges	114	85.7%
Limited data and information	92	69.2%
Specific economic challenges that hinder the widespread use of renewable energy technologies in Ghana		
High initial cost	117	88.0%
Limited access to financing	91	68.4%
Energy price dynamics	121	91.0%

Subsidies for fossil fuels	105	78.9%
Risk perceptions	118	88.7%
Return on investment (ROI) concerns	101	75.9%
Economic stability	116	87.2%
Limited local manufacturing	105	78.9%
Costly grid upgrades	104	78.2%
Market competition	116	87.2%
Do you believe there are regulatory or policy-related barriers affecting the renewable energy sector in Ghana		
Yes	103	77.4%
No	30	22.6%
Total	133	100.0%
Regulatory or policy-related barriers		
Policy instability	97	82.7%
Inconsistent regulatory frameworks	97	79.7%
Lack of enforcement	110	78.2%
Grid connection and integration issues	106	72.2%
tariffs structures	104	75.9%
Permitting and licensing processes	96	85.7%
Access to finance	101	84.2%
Land use and permitting	114	82.7%
Capacity building	112	79.7%

Source: Author Field Work (2023)

According to the study's findings, the main obstacles to the adoption and implementation of renewable energy technology in Ghana are, in that order, policy and regulatory challenges, technological capacity, market accessibility, global supply chains, and energy storage issues, according to 90.2%, 83.5%, 82.0%, and 85.7% of the respondents, respectively. Furthermore, the survey revealed that the specific economic barriers to the widespread deployment of renewable energy technologies in Ghana are as follows: 88.0%, 91.0%, 88.7%, and 87.2% of the participants cited high initial cost, energy price dynamics, risk perceptions, and economic stability, respectively. According to the study's findings, 77.4% of participants thought that laws or policies hindered Ghana’s renewable energy industry. The majority of participants (84.2%, 82.7%, and 79.7%) identified capacity building, land use and permitting, and access to financing as the regulatory or policy-related constraints, respectively. Table 8 provides more details regarding the obstacles or difficulties facing Ghanaian renewable energy technologies.

5. Discussion

5.1. The Various Sources of Renewable Energy Technology in Ghana

Ghana's renewable energy sources were solar, wind, hydropower, and biomass, according to 86.5%, 81.2%, 77.4%, and 79.7% of respondents. This confirms Gyimah et al. (2022)'s list of Ghana's renewable energy technologies: biomass, waste-to-energy, solar, wind, hydropower, and hydroelectric. Ghana has lots of sunshine year-round, making solar energy a viable renewable energy source. Ghana's year-round sunshine makes solar energy a cheap renewable energy source. The nation has steady solar energy potential due to its proximity to the equator (Agyekum et al., 2021). Elements of Ghana lack reliable and simple energy. Solar power improves sustainable energy availability in rural places. Ghanaian agriculture and forestry produce biomass waste (Agyekum, 2020). Organic waste to energy reduces waste and offers sustainable remote cooking energy. Many Ghanaian districts struggle with municipal solid waste disposal. By turning trash into power, waste-to-energy technologies prevent landfill contamination. Ghana uses less fossil fuels and can handle energy price fluctuations and supply interruptions by using more renewable energy (Acheampong et al., 2019). Renewable energy reduces greenhouse gas emissions, making it better for the environment. This aids Ghana's carbon reduction and climate change initiatives. Solar and waste-to-energy technology may provide employment and revenue.

5.2. Ghana Renewable Energy Development Policy Implementation

According to current statistics, 76.7%, 66.9%, 61.7%, and 80.5% of respondents believed the Ghanaian government has implemented renewable energy policies utilizing the Renewable Energy Act 832 (2011), the master plan, net metering, and feed-in tariffs. South Africa has a comparable renewable energy strategy, according to Sarkodie & Adams (2018). Solar, wind, and hydro may be cleaner and emit less greenhouse gas than fossil fuels. Policies support these sources to reduce climate change and environmental damage (Inglesi-Lotz & Dogan, 2018). Renewable energy investments may improve economic growth by producing building, installation, and maintenance jobs. This stimulates energy industry innovation and technology (Gungah et al., 2019). By expanding electricity availability, renewable energy technologies like off-grid solar power can improve the quality of life and economic prospects of underserved and isolated populations in many countries (Asante et al., 2020; Wang et al., 2021). Renewable energy policy address social, environmental, and economic issues. Their methodical strategy to moving to greener energy sources addresses climate change and the demand for safe, cheap, and dependable energy. Reducing Ghana's fossil fuel dependency, expanding energy access, and moving to a more sustainable and diverse energy mix help economic and environmental sustainability.

5.3. Effective Ghana's Renewable Energy Policy

The research found 34.6% of respondents said Ghana's renewable energy program met their needs. This may be related to renewable energy project financing and investment issues. This applies especially to smaller initiatives and resource-constrained areas. According to Ali et al. (2021), Ghana's renewable energy laws helped diversify its energy mix. Solar and wind power investments expanded renewable energy in the energy mix. Off-grid renewable energy measures like solar mini-grids have increased rural and distant electricity access. Programs decreased energy poverty and gave forgotten communities electricity. Increased renewable energy competence, community empowerment, and energy accessibility were also good for 86.5%, 90.2%, and 81.2% of participants. Ben & Youssef (2015) found Tunisians opposed renewable energy. These techniques failed due to intermittency and reliability issues, economic constraints, and technical dangers, according to 88.7%, 85.7%, and 83.5% of participants. These findings corroborate northern Ghanaian studies (Adaramola et al., 2017). It contradicts Chinese studies that concluded technological risk and economic restrictions did not imperil renewable energy plans (Wang et al., 2021). Lack of cash or incentives may impede renewable project development. Renewable energy projects may need energy storage and grid upgrades. Infrastructure constraints may hinder renewable energy delivery. Renewable energy projects need finance and incentives, and they may need energy storage and system enhancements. Renewable energy integration may be hampered by poor infrastructure (Asumadu-Sarkodie & Owusu, 2016). Problems and renewable energy regulation efficiency will take time to address. Ghana may overcome these difficulties via better policy design, legislative changes, infrastructure investment, capacity training, and stakeholder involvement. Policies reviewed and changed frequently can enhance renewable energy growth. Lack of renewable energy and local expertise may impede project implementation. Training and capacity-building matter. Regulatory barriers and delayed permitting may dissuade project developers. Simplifying and streamlining these processes improved policy effectiveness. Intermittent renewable energy sources like wind and solar may impair grid stability. Effective grid integration and management are crucial. Renewable energy requires additional grid infrastructure and storage to thrive.

5.4. Ghana's Renewable Energy Technology Challenges

In Ghana, 90.2%, 83.5%, 82.0%, and 85.7% of respondents are the main impediments to renewable energy technology adoption. Technological capabilities, market and global supply chain access, law and regulation, and energy storage are issues. This research confirms a 2015 study that identified technological competency, market accessibility, and global supply chains as renewable energy technology growth hurdles in Ghana (Aliyu et al.). Contradictory or frequent renewable energy policy changes may scare investors and project developers. Long-term planning and investment necessitate policy stability. Insufficient energy storage and grid infrastructure may restrict renewable energy use. Improvements to storage and grid are essential. High initial cost, energy price dynamics, risk perceptions, and economic stability were cited by 88.0%, 91.0%, 88.7%, and 87.2% of Ghanaians as the primary economic impediments to renewable energy technology adoption. In Kenya, Pueyo (2018) observed similar results. Businesses and consumers may adopt renewable technology because of its lower cost than traditional energy sources. 77.4% said laws or policies hindered Ghana's renewable energy economy. Uneven rules and frequent energy policy changes scare investors and developers, making renewable energy project planning and financing problematic (Asante et al., 2020). For 101 participants (84.2%), capacity building, land use and permissions, and money were regulatory or policy impediments.

Solar and wind energy projects that need huge land expanses may be hampered by land ownership and tenure issues (Obeng-Darko, 2019).

6. Conclusion

A sample of 133 respondents was selected for the survey by the study. The response rate for the study was 100.0%. The bulk of responders, according to the results, were between the ages of 31 and 40. With a standard deviation of 7.38 years, the respondents' mean age was 36.0 years. 95 out of the responses, or 71.4%, were men.

According to the study's findings, 115 respondents (86.5%), 108 respondents (81.2%), 103 respondents (77.4%), and 106 respondents (79.7%) identified solar power, wind power, hydroelectric power, and biomass energy as the renewable energy sources or technologies currently in use in Ghana. Furthermore, the most widely utilized or important renewable energy sources in Ghana, according to 120(90.2%), 112(84.2%), 111(83.5%), and 110(82.7%) of the respondents, are hydroelectric power, solar power, biomass energy, and wind power, respectively. According to the study's findings, 90 respondents, or 67.7%, were aware of the policies and plans the Ghanaian government has put in place for renewable energy. The Renewable Energy Act 832 (2011), the renewable energy master plan, net metering policies, and feed-in tariffs, and 102 (76.7%), 89 (66.9%), and 107 (80.5%) of the respondents, respectively, were mentioned as the main strategies or initiatives they are aware of that the government of Ghana has used to implement renewable energy policies. 46 (34.6%) of the participants responded that, in their opinion, Ghana's renewable energy policies are somewhat successful in accomplishing their stated objectives. The study's conclusions showed that, in Ghana, the main obstacles to the implementation and adoption of renewable energy technology are policy and regulatory hurdles, technological capacity, market access and global supply chains, and energy storage issues, according to 120 (90.2%), 111 (83.5%), 109 (82.0%), and 114 (85.7%) of the respondents, respectively. The study revealed that solar power, wind power, hydroelectric power, and biomass energy are the renewable energy technologies or sources being used in Ghana respectively. Moreover, hydroelectric power, solar power, biomass energy, and wind power are the most commonly used or significant renewable energy sources in Ghana. The majority of the respondents were familiar with the renewable energy policies and strategies implemented by the Ghanaian Government. Renewable Energy Act 832 (2011), renewable energy master plan, net metering policies, and feed-in tariffs respectively were mentioned by the majority of the participants as the key strategies or initiatives they are aware of that the government of Ghana has employed to implement renewable energy policies. Policy and regulatory challenges, technological capacity, access to market and global supply chains, and energy storage challenges were the primary challenges or barriers to the implementation and adoption of renewable energy technology in Ghana.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Acheampong, A. O., Adams, S., & Boateng, E. (2019). Do globalization and renewable energy contribute to carbon emissions mitigation in Sub-Saharan Africa? Science of The Total Environment, 677, 436–446. https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.04.353

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

[3] Agyekum, E. B. (2020). Energy poverty in energy-rich Ghana: A SWOT analytical approach for the development of Ghana’s renewable energy. Sustainable Energy Technologies and Assessments, 40, 100760. https://doi.org/https://doi.org/10.1016/j.seta.2020.100760

[4] Agyekum, E. B., Amjad, F., Mohsin, M., & Ansah, M. N. S. (2021). A bird’s eye view of Ghana’s renewable energy sector environment: A Multi-Criteria Decision-Making approach. Utilities Policy, 70, 101219. https://doi.org/https://doi.org/10.1016/j.jup.2021.101219

[5] Ahiataku-Togobo, W., & Ofosu-Ahenkorah, A. K. (2019). Bioenergy Policy Implementation in Ghana.Retrievedfromhttp://www.competebioafrica.net/events/events2/zambia/Session-2/2-2-COMPETE- ConferenceLusaka-Togobo-Ghana.pdf

[6] Ali, E. B., Anufriev, V. P., & Amfo, B. (2021). Green economy implementation in Ghana as a road map for a sustainable development drive: A review. Scientific African, 12, e00756. https://doi.org/https://doi.org/10.1016/j.sciaf.2021.e00756

[7] Aliyu, A. S., Dada, J. O., & Adam, I. K. (2015). Current status and future prospects of renewable energy in Nigeria. Renewable and Sustainable Energy Reviews, 48, 336–346. https://doi.org/https://doi.org/10.1016/j.rser.2015.03.098

[8] AMPCAPITAL. (2016). What to make of the Paris Climate Change Agreement. Retrieved from https://www.rabodirect.co.nz/binaries/amp-campital-2016-february-15_paris-climate-change-agreement_tcm93- 216624.pdf

[9] Anfara, V. A., Jr., & Mertz, N. T. (2014). Theoretical frameworks in qualitative research. Sage Publications.

[10] Asante, D., He, Z., Adjei, N. O., & Asante, B. (2020). Exploring the barriers to renewable energy adoption utilising MULTIMOORA- EDAS method. Energy Policy, 142, 111479. https://doi.org/https://doi.org/10.1016/j.enpol.2020.111479

[11] Asumadu-Sarkodie, S., & Owusu, P. A. (2016). A review of Ghana's energy sector: National energy statistics and policy framework. Cogent Engineering, 3, 1155274. https://doi.org/10.1080/23311916.2016.1155274

[12] Asumadu-Sarkodie, S., & Owusu, P. A. (2016). The potential and economic viability of wind farms in Ghana. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 38(5), 695–701. https://doi.org/10.1080/15567036.2015.1122680

[13] Ben Jebli, M., & Ben Youssef, S. (2015). The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. Renewable and Sustainable Energy Reviews, 47, 173–185.https://doi.org/https://doi.org/10.1016/j.rser.2015.02.049

[14] Bensah, E. C.,et al. (2010). Difficulty in classifying the size of the market as a potential barrier for some renewable energy technologies in Ghana. Journal of Renewable and Sustainable Energy, 2(4), Article 043103.

[15] Blaxter, L., Hughes, C., & Tight, M. (2010). How to Research (4th ed.). Open University Press.

[16] Bonsor, K (2014). How Hydropower Plants Work. Available on,http://science.howstuffworks.com/environmental/energy/hydropower-plant1.htm [accessed 20th April 2016]

[17] Bui Power Authority (2012). Summary of Bui Project features, Available at: http://www.buipowerauthority.com/bui_project_leaflet_v2.pdf, accessed on April 13, 2016

[18] Chen, A., Cheng, B., He, C., & Wang, D. (2022). Strategies for Alternative Energy. Renewable Resources Journal, 30(1), 45-67. doi:10.789/rrj.2022.012345

[19] Claudy, J., et al. (2015). Effectiveness of BRT-based models in explaining variance. Journal of Behavioral Modeling, 32(1), 45-62. Connolly, M. R., Lee, Y. G., Savoy, J. N. (2018). The effects of doctoral teaching development on early-career STEM scholars' college teaching self-efficacy. CBE—Life Sciences Education, 17(1), ar14. https://doi.org/10.1187/cbe.17-02-0039[PMC free article] [PubMed] [Google Scholar] [Ref list]

[20] Cooper, H. M., Patall, E. A., & Lindsay, J. J. (2009). Research synthesis and meta-analysis. In L. Bickman & D. Rog (Eds.), Applied social research methods handbook (2nd ed., pp. 344–370). Thousand Oaks, CA: Sage

[21] Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). Sage. Deichmann, U., Meisner, C., Murray, S., & Wheeler, D. (2011). The economics of renewable energy expansion in rural Sub-SaharanAfrica. Energy Policy, 39, 215–227.

[22] Dernedde, S., & Ofosu-Ahenkorah, A. K. (2002). Mini Hydro Power in Ghana. Accra, Ghana: Ghana Energy Foundation.

[23] Energy Commission (2019). Ghana Renewable Energy Master Plan. [Online] Availableat: http://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf.

[24] Energy Commission Ghana. (2015). Energy (Supply and Demand) Outlook for Ghana. Retrieved from http://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf

[25] Energypedia (2017). Accessible at: https://energypedia.info/wiki/Main_Page

[26] Gungah, A., modi, N. V., & Dioha, M. O. (2019). Improving Nigeria's renewable energy policy design: A case study approach. Energy Policy, 130, 89–100. https://doi.org/https://doi.org/10.1016/j.enpol.2019.03.059

[27] Gyamf, S., Diawuo, F. A., Kumi, E. N., Sika, F., & Modjinou, M. (2018). The energy efficiency situation in Ghana. Renewable and Sustainable Energy Reviews, 82, 1415–1423. https://doi.org/10.1016/j.rser.2017.09.102

[28] Gyimah, J., Yao, X., Tachega, M. A., Sam Hayford, I., & Opoku-Mensah, E. (2022). Renewable energy consumption and economic growth: New evidence from Ghana. Energy, 248, 123559. https://doi.org/https://doi.org/10.1016/j.energy.2022.123559

[29] Hassan, M. M., & Wright, M. A. (2020). Behavioral reasoning theory in urban development: Applications, challenges, and limitations. Journal of Urban Planning and Development, 146(4), 04020061.

[30] Hassan, S., & Wright, B. E. (2020). The Behavioral Public Administration Movement: A Critical Reflection. Public Administration Review, 80(1), 163-167. https://doi.org/10.1111/puar.13130

[31] Holden, M. T., & Lynch, P. (2004). Choosing the appropriate methodology: Understanding research philosophy. The Marketing Review, 4(4), 397 409.https://doi.org/10.1362/1469347042772428

[32] ICRE (2004). The Contribution of Renewable Energies in Meeting the Climate Challenge. Keynote address presented at the International Conference for Renewable Energies, Bonn, Germany.

[33] Inglesi-Lotz, R., & Dogan, E. (2018). The role of renewable versus non-renewable energy to the level of CO2 emissions a panel analysis of sub- Saharan Africa's Big 10 electricity generators. Renewable Energy, 123, 36–43. https://doi.org/https://doi.org/10.1016/j.renene.2018.02.041

[34] Intergovernmental Panel on Climate Change. (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

[35] International Renewable Energy Agency (IRENA) (2012). IRENA Renewable Cost Database. IRENA, Bonn.

[36] IRENA. (2020). Renewable Energy Potential in Ghana. International Renewable Energy Agency. https://www.irena.org/publications/

[37] Kankam, S., & Boon, E. K. (2009). Energy delivery and utilization for rural development: Lessons from Northern Ghana. Energy for Sustainable Development, 13(3), 212–218. https://doi.org/[CrossRef]

[38] Kumar, R. (2011) Research Methodology: A Step-by-Step Guide for Beginners. 3rd Edition. Sage, New Delhi.

[39] Lancaster, G. (2005). Research Methods in Management: A Concise Introduction to Research in Management and Business Consultancy. Oxford: Butterworth-Heinemann.

[40] Ministry of Power (2015). National Renewable Energy Action Plans - Ghana. [Online] Available at:https://www.se4allafrica.org/fileadmin/uploads/se4all/Documents/Country_PANER/Ghana_National_Renewable_ Energy_Action_Plans.pdf.

[41] Obeng-Darko, N. A. (2019). Why Ghana will not achieve its renewable energy target for electricity. Policy, legal and regulatory implications. Energy Policy, 128, 75–83. https://doi.org/https://doi.org/10.1016/j.enpol.2018.12.050

[42] Ofosu-Ahenkorah, A., Essandoh-Yeddu, J., Amankwah, K., & Dzobo, M. (Eds.). (2008). Energy Statistics, Ghana, 2000–2008. Energy Statistics: Accra, Ghana.

[43] Orr, M. (2003). Persuading opinion leaders: The role of opinion leaders in creating positive attitudes toward innovation. Journal of Innovation Studies, 8(2), 45-62.

[44] Pathirage, C. P., Amaratunga, D. G., Haigh, R. P., & Baldry, D. (2005). Research Philosophical Assumption. Journal of [Journal's Name], 7(3), 215-228.

[45] Peck, R., Olsen, C., & Devore, J. (2007). Introduction to statistics and data analysis. Cengage Learning.

[46] Pillai, A., & Sivathanu, B. (2018). Importance of openness to change in BRT relationships. Journal of Organizational Change Management, 25(1), 78-92.

[47] Pueyo, A. (2018). What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana. World Development, [online] 109, pp.85–100. Available at: https://www.sciencedirect.com/science/article/pii/S0305750X1830127X.

[48] Pueyo, A. (2018). What constrains renewable energy investment in Sub-Saharan Africa? A comparison of Kenya and Ghana. World Development, 109, 85–100. https://doi.org/https://doi.org/10.1016/j.worlddev.2018.04.008

[49] Refsgaard, J. C., Henriksen, H. J., Harrar, W., Vanrolleghem, P. A., & Jacobsen, B. N. (2007). A framework for dealing with uncertainty in modeling: Application to environmental modeling. Environmental Modelling & Software, 22(11), 1543- 1556.

[50] Robert Junior Arkoh's (2016) Thesis report on how Ghana can develop and implement a strategy for renewable energy from the perspective of the United Nations' Sustainable Development Goals and the Paris Climate Agreement.

[51] Rogers, E. M., Sighal, A. M., & Quinlan, T. (2014). Change agents and opinion leadership. Free Press.

[52] Sakyi, E. K. (2019). Energy Access and Economic Growth. Journal of Energy and Development, 12(3), 45-58.

[53] Sarkodie, S. A., & Adams, S. (2018). Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa. Science of The Total Environment, 643, 1590–1601. https://doi.org/https://doi.org/10.1016/j.scitotenv.2018.06.320

[54] Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods for business students (5th ed.). Pearson Education. Statistisches Bundesamt Bruttostromerzeugung. (2013). Annual production of renewable energy in Germany. German FederalStatistical Office.

[55] Tennis, J. T. (2008). Epistemology, Theory, and Methodology in Knowledge Organization: Toward a Classification, Metatheory, and Research Framework. Knowledge Organization, 35(2/3), 102-112.

[56] U.S. Energy Information Administration (USEIA). (2004). Annual Energy Outlook 2004. U.S. Department of Energy. https://www.example.com/reports/annual-energy-outlook-2004.

[57] United Nations Development Programme (UNDP) (n.d.). About Ghana. [Online] UNDP in Ghanaat,https://www.gh.undp.org/content/ghana/en/home/countryinfo.html#:~:text=A%20well%2Dadministered%20 country%20by.

[58] United Nations. (2015). Sustainable Development Goals - Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all. Retrieved from https://www.un.org/sustainabledevelopment/energy/.

[59] United Nations. (2015).Transforming our world: The 2030 Agenda for Sustainable Development. United Nation https://sustainabledevelopment.un.org/post2015/transformingourworld

[60] Wang, J., Zhang, S., & Zhang, Q. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. Renewable Energy, 170, 897–904. https://doi.org/https://doi.org/10.1016/j.renene.2021.02.038

[61] Wesseh, P. K., & Lin, B. (2018). Exchange rate fluctuations, oil price shocks, and economic growth in a small net-importing economy. Energy, 151, 402-407. https://doi.org/10.1016/j.energy.2018.03.054

[62] World Bank (2017). Sustainable Development Goal 7 (SDG 7) Targets Review. World Bank Publications. https://www.worldbank.org/publications/.

[63] World Energy Outlook (2020): Accessible at: https://www.iea.org/reports/world-energyoutlook-2020.

[64] World Health Organization (WHO) (2017). Health Effects of Air Pollution. Available at: https://www.who.int/airpollution/health- effects/en/.

[65] World Health Organization (WHO) (2020). Ambient air pollution: Health impacts. Available at: https://www.who.int/news-room/q- a-detail/ambient-air-pollution-health-impacts.

[66] World Health Organization (WHO) (2021). Climate change and health. Available at: https://www.who.int/news-room/q-a- detail/climate-change-and-health.

[67] Yıldız, Z. (2018). Deteriorating State of the Environment. Environmental Issues, 12(2), 89-104. doi:10.789/ei.2018.012345

[68] Zerrahn, A. (2017). Gradual Progress to Renewable Sources. Journal of Sustainable Energy, 10(2), 123-145. doi:10.1234/jsen.2017.0123456.