INSTITUTE OF DEVELOPMENT AND TECHNOLOGY

MANAGEMENT (IDTM)

CLEAN ENERGY FINANCING AND SUSTAINABLE DEVELOPMENT: EVIDENCE FROM THE ELECTRICITY MARKET OF GHANA

JEFFREY KENNETH BAIDEN

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JEFFREY KENNETH BAIDEN

(IDTM/PHD/2021/002)

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2023

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this institute and that this thesis is towards the award of a Doctor of Philosophy (PhD) which contains no material previously published by another person nor material which has been accepted for the award of any other degree of another university, except where due acknowledgment has been made in the text.

CANDIDATE'S SIGNATURE…………….. DATE……………….

NAME: JEFFREY KENNETH BAIDEN

Supervisor's Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of those laid down by the Institute of Development and Technology Management.

PRINCIPAL SUPERVISOR'S SIGNATURE…………… DATE………….

NAME: PROF. JOHN A. MICAH

CO - SUPERVISOR'S SIGNATURE……………… DATE………...…

NAME: PROF. SAMUEL KOBINA ANNIM

ABSTRACT

This thesis examines four related objectives on clean energy financing and sustainable development: (1) describe the state of clean energy financing and sustainable development; (2) assess the determinants of clean energy financing; (3) estimate an optimal level of integrating clean energy in the electricity market; and (4) synthesize an improved system of clean energy financing.

Data was obtained through questionnaire, information request fact sheet, and interviews. The research used descriptive statistics, correlation, linear regression, binary logistics, optimization, and system improvement as the main analytical procedures.

The findings revealed evidence of clean energy financing valued at US$ 221 Million. Market factors and enabling infrastructure are significant predictors of clean energy financing. The electricity market has the potential of integrating 1,358.8 MW of clean energy. The electricity generated from clean energy sources influenced the price of electricity negatively. Weak off-taker credit worthiness can be mitigated by a payment mechanism that prioritizes payment of clean energy.

For an improved system, this thesis suggests the following: adopting and integrating an enhanced market surveillance system to guide policy and regulatory decisions and reviews; providing technical assistance in structuring bankable projects; undertaking periodic economic and financial analysis of system planning; and prioritising the payment of clean energy.

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LIST OF ABBREVIATIONS

AFD	Agence Française de Développement
AFOLU	Agriculture, Forestry and Other Land Use
ASM	Ancillary Services Market
AUM	Asset Under Management
BAU	Business as Usual
BCM	Bilateral Contracts Market
BNDES	Brazilian National Development Bank
BoG	Bank of Ghana
BPA	Bui Power Authority
BRICS	Brazil, Russia, India, China, South Africa
CAGR	Cumulative Average Growth Rate
CCUS	Carbon Capture, Utilization, and Storage
CERC	Central Electricity Regulatory Commission
CIE	Compagnie Ivoirienne d'Électricité
CLEER	Clean Energy Emission Reduction
CM	Capacity Market
CO_2	Carbon dioxide
COD	Commercial Operations Date
COP	Conference of the Parties
CRR	Congestion Revenue Rights
CSD	Commission on Sustainable Development
CWM	Cash Waterfall Mechanism
DAC	Development Assistance Committee
DAM	Day-Ahead Market

DFI	Development Finance Institution
DISCOMS	Distribution Companies
EBITDA	Earning Before Interest, Taxes, Depreciation and Amortization
EC	Energy Commission
ECG	Electricity Company of Ghana
EIB	European Investment Bank
EISD	Energy Indicators for Sustainable Development
EMOP	Electricity Market Oversight Panel
EPL	Enclave Power Limited
ESI	Electricity Supply Industry
ESG	Environmental, Social and Governance
ESRP	Energy Sector Recovery Program
FC	Financial Close
FDI	Foreign Development Investment
FiTs	Feed in Tariffs
FPSA	First-price Sealed-bid Auction
GCF	Green Climate Fund
GCSA	Government Consent Support Agreements
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Green House Gases
GoG	Government of Ghana
GPRS	Ghana Poverty Reduction Strategy
GRA	Ghana Revenue Authority
GRIDCo	Grid Company of Ghana

GSF	Ghana Stock Exchange
GSGDA	Ghana Shared Growth Development Agenda
GW	Giga Watts
GWEM	Ghana Wholesale Electricity Market
GWh	Giga Watt hour
IAM	Integrated Assessment Modelling
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPPU	Industry Processes and Product Use
IPSMP	Integrated Power Sector Master Plan
IRENA	International Renewable Energy Agency
ISO	Independent System Operator
KfW	Kreditanstalt für Wiederaufbau
kVA	Kilo Volt Amperes
KW	Kilo Watts
kWh	Kilo Watt hour
kWp	Kilo Watt Peak
LCOE	levelized cost of energy
LEAP	Long-range Energy Alternatives Planning
MDAs	Ministry Department & Assembly's
MDG	Millennium Development Goals
MoEn	Ministry of Energy
MoF	Ministry of Finance
MtCO2e	Metric tons of carbon dioxide equivalent

MW	Mega Watts
MWp	Mega Watt Peak
MYTO	Multi Year Tariff Order
NASA	National Aeronautics and Space Administration
NDC	Nationally Determined Contribution
NDPC	National Development Planning Commission
NEDCo	Northern Electricity Distribution Company
NEFCO	Nordic Environment Finance Corporation
NEP	National Energy Policy
NETF	National Energy Transition Framework
NGO	Non-Governmental Organizations
NITS	National Interconnected Transmission System
OCTP	Offshore Cape Three Points'
ODA	Official Development Assistance
PACE	Property Assessed Clean Energy
PCOA	Put Call Option Agreements
PPAs	Power Purchase Agreements
PSPA	Power Supply and Purchase Agreement
PSRP	Power Sector Reform Programme
PURC	Public Utilities Regulatory Commission
PV	Photovoltaic
RE	Renewable Energy
REDP	Renewable Energy Development and Management Programme
REIPPP	Renewable Energy Independent Power Producer Procurement
REMP	Renewable Energy Master Plan

RTM	Real-Time Market
SCF	Stabding Cmmittee on Finance
SDGs	Sustainable Development Goals
SHS	Solar Home Systems
SOEs	State Owned Enterprises
SSA	Sub-Saharan Africa
TEN	Tweneboa Enyenra Ntomme
TWh	Terawatt hour
UN	United Nations
UNCCC	United Nations Conference on Climate Change
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VRA	Volta River Authority
Wp	Peak Watts
WAPP	West Africa Power Pool
WB	World Bank
WCED	World Commission on the Environment and Development

CHAPTER ONE: INTRODUCTION

1.1 Rationale of the Study

Climate change is gradually redefining the course of development as it is one of the major challenges affecting livelihoods globally. The world's average temperature is quickly rising because of human activity over the last 200 years. According to Zhongming et al. (2021), it is evident that human activities form a significant contributing factor to the increasing average temperature of the earth resulting in warming of the atmosphere, land, and ocean. Predating the industrial revolution, it is also a fact, according to Zhongming et al. (2021), that the increases in well-mixed GHG concentrations since 1750 are attributed to human activities (Pörtner et al., 2021).

Moreover, according to the 2021 Intergovernmental Panel on Climate Change (IPCC) report, an incremental change in 1°C of the earth's average temperature will suggest a warmer earth (Masson-Delmotte et al., 2021). Observing the average earth's temperature from 1850, it is worth noting that it began increasing abnormally during the period of the industrial revolution, where the temperature inched up from 1.1°C to 1.3°C.

As the world's temperature increases and global warming becomes a more inescapable issue, nations are making promises to limit global warming to 1.5°C by the turn of the century (King, 2017). According to Bardan (2023), global temperature for 2022 was estimated at 0.89°C (1.6 degrees Fahrenheit); this tends to exceed the average baseline period (1951 to 1980) for National Aeronautics and Space Administration (NASA). To keep global warming under control, countries have committed to lowering carbon emissions and, in certain circumstances, aim to attain net-zero emissions by the middle of the century.

Adopting clean energy solutions is one of the most important goals in achieving net-zero emissions. According to the GHG emissions taken from an energy report by the IEA in 2021, electricity generations remained the largest driver of emissions. In 2019, the global growth in emissions relative to 2010 was attributed to electricity generation and transport, which account for over two thirds of total emissions. The industry and buildings sectors accounted for the remaining one third of emissions. There exist three predominant variables that affect the CO_2 emissions from fuel combustion (Ritchie & Roser, 2020). These are population growth, GDP, and energy supply. With reference to International Energy Agency (2021) report, electricity generation accounts for over 40 percent of the total CO_2 and this can be validated by the electricity output, generation efficiency, and the share and carbon intensity of fossil fuel generation.

As of the end of 2019, Ghana's Fifth National Greenhouse Gas Inventory Report (2022) reveals that the energy sector accounted for the highest GHG emissions. This sector surpassed emissions from IPPU, AFOLU, as well as waste in terms of GHG contribution.

The change in emissions from the energy sector increased from 2.9 MtCO2e in 1990 to 27.36 MtCO2e in 2019 over the 29-year period. Similarly, AFOLU increased from 19 MtCO2e in 1990 to 26.64 MtCO2e in 2019.

The high emissions recorded by energy in 2019 as shown in Figure 1.1b was underpinned by the increasing shift to natural gas as the least cost fuel option for electricity generation mix and the growth in the population in Ghana using vehicles. Figure 1.1 explains GHG emissions from the various sectors of Ghana (UNFCCC).

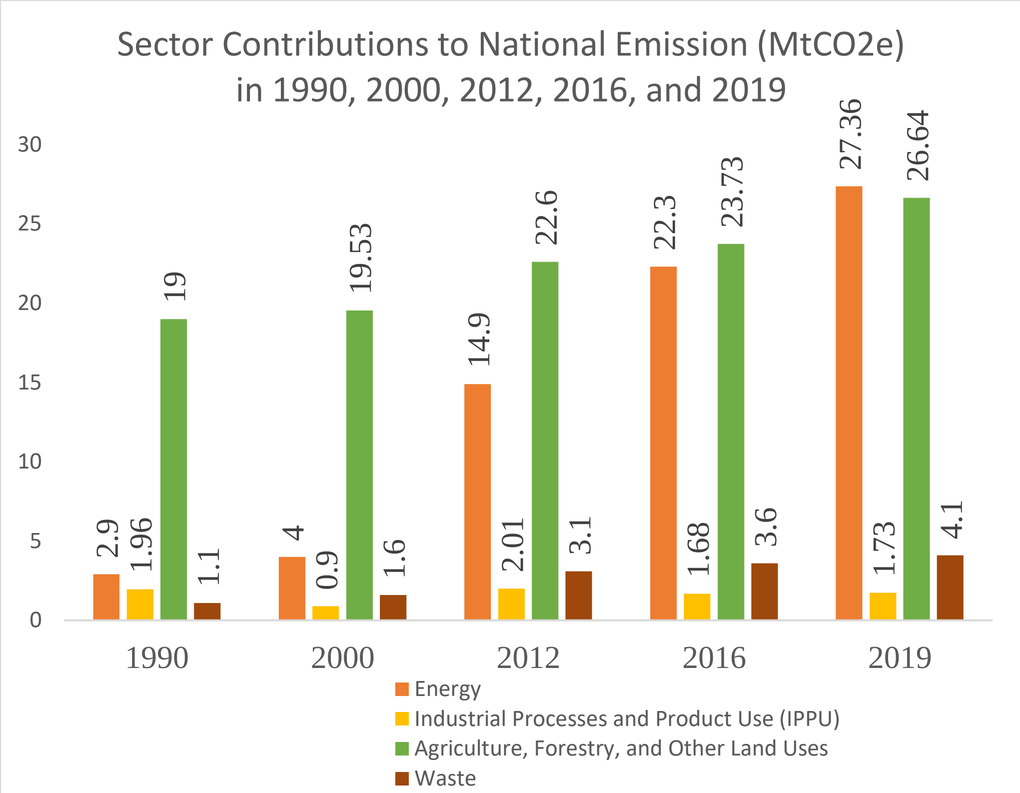


Figure 1.1: Ghana GHG Emissions by Sector (2019)

Source: Ghana's Fifth National Greenhouse Gas Inventory Report (2022)

The contribution of electricity generation to GHG emissions in Ghana is largely attributed to the composition of generation mix, which emanates from the thermal power plants that increased from 48 percent in 2012 to about 68 percent of the installed capacity as of 2019.

Mitigation actions are required to cure the adverse impact of climate change by tackling the causes of the emission of GHG into the atmosphere. On the contrary, there exist adaptation actions that seek to adjust and make provision for the future impact of climate change. In the case of the electricity sector, the use of fossil fuel to generate electricity is a cause of the emissions; hence, its mitigation will call for the use of a clean energy source. To this end, it is worth noting that the immediate shift from fossil fuel to a clean energy source may pose a consequential effect on the development approach of a nation. Hence, it is important to consider the risk posed on development by the immediate transition from fossil fuel to clean energy by exploring alternative options of mitigation where the shift in energy source for electricity is implemented over a period of time. The process of gradually shifting from the use of fossil fuel to a clean energy source by way of mitigation can be deemed as energy transition. The study will assess how the transition from fossil fuel to clean energy sources in the electricity sector will affect sustainable development.

The use of clean and renewable energy, such as solar, instead of fossil fuels is projected as a potential concern to avoid harmful emissions and an energy deficit, according to Li and Xu (2013). The development and optimization of various energy storages, transformation technologies and materials are targeted at utilizing diverse clean energy sources, which is critical and urgent. To comprehend the actual effect of renewable energy sources, the emission cost of setting up plants, raw materials, and more should be evaluated, and the same should be done for fossil-fuel power plants to provide a level playing field.

By 2030, globally yearly investments in clean energy would need to expand dramatically, to the tune of almost $4 trillion, if the goal of attaining net-zero emissions by 2050 is to be realised (IEA, 2021). The IEA predicted that by the end of the decade, a worldwide increase in investments in clean energy would have created millions of new jobs, significantly boosted global economic growth, and ensured that everyone had access to electricity and clean cooking everywhere in the world.

This implies that governments all around the globe must speed up their transitions to sustainable or clean energy. This is essential if we are to avoid the worst consequences of climate change and construct a healthier, economic, and secure future in which everyone has access to adequate and affordable energy (Zhongming et al., 2021). However, countries are not all beginning from the same point – and the negative impacts of the COVID-19 crisis are lingering in many areas of the developing world: the economic recession is deeper, and the ability to drive a long-term recovery is constrained. Financing the energy transitions and renewable energy investments in emerging and developing nations are essential to combat climate change and develop nations in a sustainable way. This is because as emerging and developing economies grow, industrialize, and urbanize, they will account for the majority of global emissions growth in the coming decades. There is a great opportunity to build a low-emissions development model for developing countries by harnessing lower-cost clean energy technologies led by solar and wind. There exist increasing funding opportunities targeted to accomplish such a goal on a global scale. The funding required to achieve the energy transition in developing countries is a challenge. However, private investors express concern regarding a balanced risk-reward ratio for renewable energy projects. One of today's defining issues is to offer financial assistance for the rapid adoption of sustainable energy technologies in emerging and developing economies. However, the global problem of climate change necessitates global solutions, and the international community must guarantee that all countries receive the assistance they require to progress in this crucial endeavour.

Ghana signed on to the Paris Agreement following COP 21, and subsequently affirmed its commitment to reduce CO_2 and other greenhouse gas emissions by issuing its policy directive called the Nationally Determined Contribution (NDC). It is unequivocal that the electricity sector of Ghana forms an integral part of the actions under the NDC and is a major sector for Ghana to achieve her climate goals. While the electricity sector is an engine of growth for industrialization, it is material to note that the sector significantly contributes to the sustainability of development. According to the 2019 Energy Sector Recovery Programme[1] (ESRP) report, the financial sustainability of the energy sector of Ghana is challenged due to excess capacity (electricity generation, gas supply); misalignment of the electricity tariffs and actual sector costs (electricity and gas); non-payment of MDAs electricity bills; high IPP charges; high cost of liquid fossil fuel for electricity generation; high losses (collection, technical and commercial); and estimation of street lighting consumption and payment for street lighting. The underpinnings of these issues are coordination among the stakeholders in the electricity market and the procurement methodology employed. These issues, as enumerated in the ESRP, threaten the macroeconomic environment as well as some indices used to measure sustainable development. More essentially, the adverse effect of climate change resulted in the erratic supply of water to the Volta Lake to ensure reliable power supply as Ghana was dependent on hydroelectric power generation from Akosombo Dam. Energy transition in Ghana is not a new phenomenon: Ghana has transited from Phase One, where 100 percent of hydroelectric power was used for the partial integration of hydrocarbon and thermal energy sources, to Phase Two. It is currently under Phase Three where blending of other renewable energy sources such as waste to energy, solar, mini grid, and micro hydro plants are further integrated to the existing hydro and thermal power plants. The procurement of these hydrocarbons has embedded contractual obligations on

[1] https://energycom.gov.gh/files/2019%201111%20ESRP%20ESTF_Clean_v3.0redacted%20final.pdf

Ghana amidst the fact that there is an over-supply of contracted energy relative to the demand capacity of the country. Baiden (2021) identified the prevalence of the utilization of renewable energy technologies in the off-grid electricity market of Ghana. The findings of the research further observed an increasing trend that has resulted in the displacement of electricity from the main grid. This poses the risk of widening the revenue gap for the electricity distribution, especially with respect to the ECG. From the above, it is imperative to undertake this research in the context of assessing the fiscal impact of the optimal level of integrating clean energy technologies into the electricity market of Ghana.

Since the time of pre-independence till the present, Ghana's energy market has developed through a variety of market models. Previously, Ghana's energy market was vertically integrated and monopolistic, with the VRA, an integrated power utility, owning and managing all of the assets for generation, transmission, and distribution. The government eventually decoupled the monopoly activities of VRA by separating the transmission and generation of power. In the southern part of Ghana, the ECG is responsible for electricity distribution and retail sales, whereas the NEDCo (a subsidiary of VRA) is responsible for these tasks in the northern half of Ghana.

In recent times, the market structures of electricity generation and its distribution has evolved from the traditional vertical integration systems, which allows for competition. The private sector has been allowed to invest in certain areas of the electricity supply chain. However, it is worth noting that there exist different forms of electricity market structures in Ghana.

The arguments are: What is the quantum of clean energy technologies that can be integrated into the electricity market? How does clean energy financing affect sustainable development? How will financing energy transition affect the levels of GHG emissions? How do we leverage the cost of integration while we ensure that there is a base load of energy to drive sustainable development? Battery storage may also need to be installed or added in order to fully complement the end user consumption following the integration of renewable energy into the grid network. The transmission system's strategy is suitable for integrated development and demonstrations to address technical, financial, regulatory, and institutional barriers to the deployment of renewable and distributed systems. In addition to addressing all operational issues, the integration offers workable business models for incorporating these technologies into capacity planning, grid operations, and demand-side management.

What happens to the electricity market structures now that the world is advocating for clean energy sources, despite the financial constraints of financing clean energy technology in underdeveloped countries? The relevance, constraints and strength of effective market design may be seen in today's reformed electricity markets. Electricity markets have developed over the last 25 years to solve complex financial and engineering constraints.

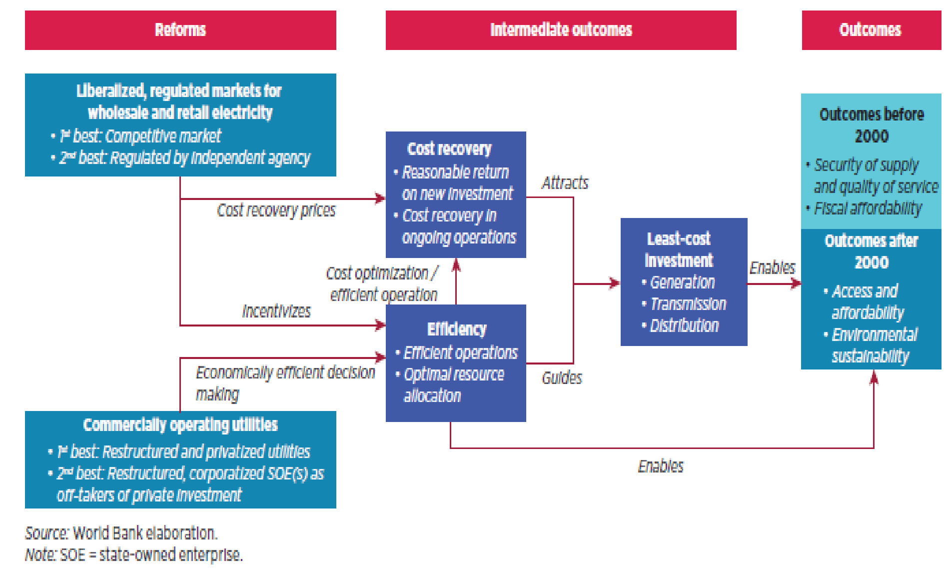


Figure 1.2: Electricity Market Reform

Source: International Bank for Reconstruction and Development / The World Bank (2020)

The Ghanaian government began reforming the electricity industry in the early 1990s. Among other things, the PSRP sought to bring in private sector engagement to the electricity supply industry (ESI) (Opam & Turkson, 2000). Through the PSRP, Ghana adopted a framework for a competitive wholesale electricity market and established structures and regulations to end monopolies and market dominance in the industry. Because of this, the ESI was unbundled, which led to the foundation of the regulatory organizations (Public Utilities Regulatory Commission and Energy Commission) and the establishment of an independent Grid Transmission Utility (GRIDCo) in 2006. The technical regulator is the EC, mandated through the Energy Commission Act 1997 (Act 541), while the economic regulator is the PURC mandated through the PURC Act 1997 (Act 538).

The NITS was established by the passage of the Electricity Transmission (Technical, Operational and Standards of Performance) Rules, 2008, L.I.1934, which also established the legal framework for market participants in GWEM to have open, equitable, and non-discriminatory access to the country's electricity transmission infrastructure. The 2008 Electricity Regulations helped pave the way for a competitive electricity market (L.I.1937). In order to allow wholesale energy trading and the supply of ancillary services in the NITS, the L.I.1937 creates the GWEM (Energy Commission, 2008).

Despite rare hiccups, the markets have mostly fulfilled their aim of delivering consumers with steady power at a moderate cost, according to Cramton (2017). Additionally, the market has to send the right pricing signals to promote long-term resource investment and development that is effective (Cramton, 2017). However, the structure of the electrical market is far from static. With the continual evolution of the electricity sector, new issues emerge. Renewable energy production, demand response, distributed generation, smart homes, and battery storage are the forces driving change, according to Cramton (2017). According to Borenstein (2002), the main source of carbon emissions into the atmosphere is the creation of electricity.

The consequences of climate change will shift the generation of energy away from fossil fuels and toward non-emitting choices like wind, solar, and nuclear. The architecture of the electrical market needs to account for this change. Since the main renewable resources, wind and solar, are erratic sources of supply with no inertia and no minimal cost of production, the endeavour is challenging. The markets of today are perfectly capable of absorbing a little quantity of renewable energy, but what if renewables make up the majority of generation? Does the market design need to be altered to account for such big changes in the producing mix?

The spot market serves to meet additional electricity demand by consumers above contracted capacity from the BCM to make up for shortfalls and imbalances, whereas the BCM is a forward market where wholesale suppliers and other market participants agree on the terms and conditions for the supply of electricity. The Electricity Regulations, 2008, which are overseen by the Electricity Transmission Utility, provide for the creation of market regulations to serve as the fundamental guidelines for controlling activities in the GWEM. Trading in electricity takes place on the spot market. The most cost-effective and efficient power plants are sent here.

A consumer operating in the deregulated market, such as the bulk customers, has the flexibility to contract electricity from a power generator based on a bilateral trading agreement. Bulk consumers procure power directly from generators at negotiated prices, which is reflected in their contracts (PSPA or PPAs).

The study is of the view that advocating for clean energy and its financing is essential to the extent that the electricity market is able to ensure full recovery of costs associated with energy generated, transmitted and distributed. Additionally, it must meet the demands of global sustainable development. With respect to the electricity market in the context of this study, liquidity is key and central to the sustainability of the sector. Liquidity is required to undertake planned maintenance, and to improve the performance of the sector, such as improving power reliability, limiting losses (both technical and commercial), as well as make the sector viable for investments (Ottens et al., 2006).

Climate change is projected to be addressed similarly to how the eradication of poverty resulted in certain important advancements through improvements in the standard of health, education, and water supply. Practically all of the goals of sustainable development have depended on energy. Sections of the energy industry are already undergoing changes that will increase sustainability, considering the problem of ensuring access to cheap, dependable, sustainable, and contemporary energy for all.

Electricity is steadily replacing conventional petroleum fuels in services and applications like automobiles. Additionally, a number of European countries are transitioning to more renewable energy sources and uses. These massive difficulties caused by all of these energy transitions are typically substantially resolved by technical means (Nerini et al., 2018). It is oversimplified, according to Bolton and Foxon's (2015) argument, to compare renewable and sustainable energy. Both advantages and disadvantages can be associated with renewable energy. Due to their low energy density, renewables consume a lot of space that could be used for other purposes, like farming. Furthermore, using renewable energy could conflict with other environmental conservation efforts. Therefore, analysing the highs and lows of funding clean energy and sustainable growth within the Ghanaian power market is commendable.

Assessing clean energy funding and sustainable development in Ghana within the context of the electricity market is the study's principal objective. Is there enough financial room for Ghana's government to sustainably finance increased energy capacity from low-carbon emission technologies? Is it economically feasible for the Ghanaian government to raise the price of energy so as to transfer the extra expense of procuring low-carbon emission technology on to the public? Are there any other finance possibilities the administration should take into account? Will the government's fiscal space allow for such a large number of subsidies? How far can Ghana integrate low carbon emission technologies into the country's regulated and unregulated electricity markets, considering the following factors: the nation's energy security; the achievement of the nation's climate emission goals as stated in the NDC; and the least expensive energy supply and fuel? What effects would the speed of Ghana's transition to a low-carbon economy have on its socioeconomic climate? What are the risks associated with funding green investment possibilities, risks brought on by climate change, such as income shortfalls, that affect businesses, financial sectors, or the financial industry, and what are the solutions to manage them, including investment strategies?

1.2 Problem Statement

Climate change and environmental sustainability are challenges that can no longer be ignored on a global scale. The need for clean, sustainable energy sources has never been greater than it is now, as the globe is confronted by the effects of decades of industrialization and dependence on fossil fuels (Zhongming et al., 2021). Developing nations like Ghana have the same difficulties and are looking for ways to strike a better energy and environmental balance. Some measures have been considered to address the threat resulting from the world's sole reliance on fossil fuels for energy and electricity (IEA, 2021). For instance, the UNCCC on clean energy funding, COP21, which was held in December 2015, and the Paris Agreement were some of the measures meant to address the issues of climate change. The Paris Agreement's aim of limiting the rise in the global average temperature to well below 2°C over pre-industrial levels and promoting efforts to keep it below 1.5°C was restated during the United Nations Conference on Climate Change (COP26), which was held in December 2021.

According to Mulugetta et al. (2022), the integration of sustainable development and climate change objectives necessitates the preponderance of clean energy technology in Africa's future energy systems. However, the ways in which this may be accomplished are not yet clear and vary widely among nations. The study further argued that clean energy financing is one of the challenges. However, Mulugetta et al. (2022) were unable to support their findings with empirical data to demonstrate why there is no route for Africa to obtain clean energy financing instruments meant to support sustainable development. Other studies, like the UNFCCC (2022), Bird et al. (2017), Venugopal and Patel (2013), and Corfee-Morlot et al. (2009), have talked about clean energy at the conceptual level with little empirical evidence within the area of clean energy and clean energy technologies, as well as measures to support clean energy financing. Klein (2019), the G20 Group (2016), Böhnke et al. (2015), and Zadek Flynn (2013) have contributed to clean energy and climate financing. Sawin et al. (2016), in their study, focused on the adoption and expansion of renewable energy to boost economic growth in Africa.

Clean energy was shown to play a crucial role in all scenarios studied by the IEA in 2021. To keep up with ever-increasing demand for energy, clean sources like solar and wind power are increasingly preferred. At the same time, spending on infrastructure like networks and flexibility sources like battery storage is expected to increase dramatically. On the other hand, it is widely expected that investments in electricity generation using fossil fuels will decrease. In addition, the IEA noted that more funding for access to sustainable energy is planned to meet the SDG 2030 goals. In EMDEs, where millions of people live in darkness and use unsafe cooking methods, ensuring that everyone has access to electricity and clean cooking options must be a top concern. While the study stresses the significance of these expenditures, it also notes that they constitute a very small portion of the overall expenditures needed. Investments in clean energy financing, electrification, and energy efficiency are all growing, and the IEA investigates these trends. The direct use of clean energy in different industries, together with the increasing popularity of electric cars, is expected to result in a significant rise in financing for these areas. The clean energy transition is also expected to greatly benefit from increased investments in energy efficiency throughout the construction, transportation, and industrial sectors. Despite these changes, the IEA (2012) noted that certain economies have relied on fossil fuel income for a long time and that the industrial progress of others has depended on coal usage. It is still very difficult to manage the switch to cleaner energy sources while funding capital-intensive initiatives in electricity, energy efficiency, and electrification.

Greater awareness of the economic and social benefits associated with using clean energy technologies could stimulate demand for such products, especially in emerging and developing economies. In turn, this could determine the level of financing for clean energy projects. Awareness and demand are not enough to access greater clean energy finance. Rather, the type and quality of technology developed, and the management and experience of clean energy firms tend to be very important determinants of clean energy financing from the financial institutions' perspective. As alluded to earlier, clean energy technologies (like wind, solar, etc.) are the major preoccupation when discussing clean energy (see

SDG Report, 2019; 2022). And innovation in clean energy is often geared towards electrification, which is a golden thread for achieving other interconnected goals such as poverty alleviation, climate action, public health, and the environment and strongly aligns with the UN SDG 7: access to affordable, reliable, and modern energy.

Considering recent concerns about the availability of funds for clean energy, it is crucial to consider consumer and producer concerns about long-term sustainability. To satisfy the energy demands of its people while protecting the environment for future generations, Ghana's electricity sector has demonstrated some commitment towards a transition towards cleaner, more sustainable energy sources, as have other developing countries. This transformation calls for heavy funding of clean energy infrastructure, new forms of finance, and a receptive policy climate. There are several obstacles to overcome when trying to fund the transition to sustainable energy. Funding mechanisms that have been around for a while tend to benefit fossil fuel projects because of their proven track record and the perceived reduced risks associated with them. But if Ghana is intentional about sustainable development, a balanced strategy is necessary. Financing projects that use clean energy sources, such as wind, solar, and hydropower, is what we mean when we talk about clean energy. The high initial costs of clean energy projects are a major obstacle to their funding.

The high initial costs associated with solar panels, wind turbines, and hydroelectric projects may deter investors. The funding situation is further complicated by the possibility that financial institutions would see these initiatives as riskier than more conventional fossil fuel enterprises. Ghana's sustainable energy finance issues can only be overcome with the help of international alliances. To open pathways to funding for clean energy projects in Ghana, organisations like the UN, the WB, and the International Finance Corporation (IFC) might be useful partners. These collaborations provide not just monetary aid but also technical assistance and increased capability. Ghana's clean energy funding approach relies heavily on foreign collaborations, but indigenous investment and entrepreneurship are also essential. Job creation and knowledge transfer are two benefits that might result from encouraging local investors and entrepreneurs to enter the clean energy industry.

The country's economic progress and independence from foreign aid may benefit from this. The demand for electricity may be lowered by implementing energy efficiency and conservation programmes, which in turn reduce the strain on the power infrastructure and lead to a more sustainable energy environment. The UN' SDGs are the ultimate yardstick against which to evaluate Ghana's clean energy finance initiatives. These objectives span a wide spectrum of social, economic, and ecological aims that are intrinsically linked. Financing for clean energy helps achieve multiple SDGs, including those related to decent employment and economic development (SDG 8), and reducing GHG emissions (SDG 13). Ghana can monitor its continued progress towards sustainable, inclusive, and ecologically responsible growth by linking its clean energy projects to the SDGs. The electrical market in Ghana's quest for clean energy and sustainable development is a tale of perseverance and teamwork. While the obstacles are formidable, the benefits of lower carbon emissions, better access to energy, and increased economic development are substantial. Financing for clean energy, via both international collaboration and local efforts, is an essential aspect of this revolutionary shift. Over the years, the electricity market for clean energy has been evolving rapidly due to it being more efficient[2], environmentally friendly and inexhaustible.

IRENA reported that the generation of clean energy capacity at the end of 2021 was 3,064 GW, with hydropower accounting for 40 percent (1,230 GW), followed by solar (28 percent, 849 GW), wind (27 percent, 825 GW), and other cleans, including geothermal, marine, and bioenergy (5 percent, 160 GW) (IRENA & OECD, 2022). However, this growth has been disproportionate across regions in developing countries. East and Southern-East Asia experienced the highest capacity increase of 243.28 percent, from 134 GW in 2010 to 460 GW in 2020 (Figure 1.3). The region was closely followed by developing countries, with a growth of 141.18 percent around 246 GW in 2020 compared to 102 in 2010. In sharp contrast, the lowest clean energy capacity was reported in SSA in 2010 (24 GW) and 2020 (38 GW), but its growth was 58.33 percent, which was the 5th.

[2] According to IRENA (2021), around 60% of the installed clean energy capacity in 2019 cost less than the most economical fossil fuel in 2020.

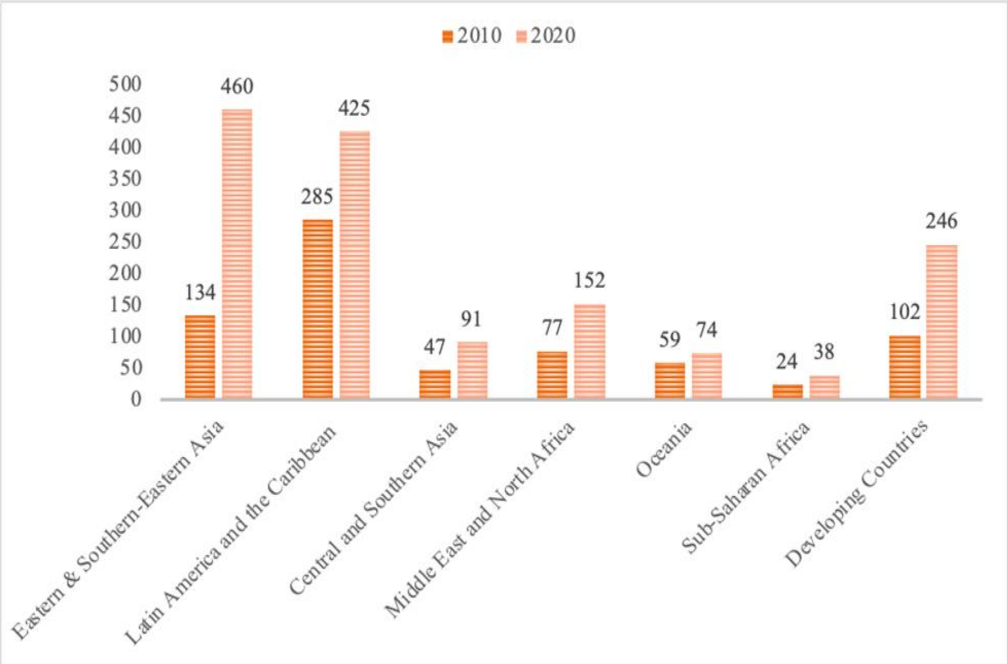


Figure 1.3: Growth in Clean Energy Capacity in GW across Regions in Developing Countries (2010 and 2020).

Source: IRENA (2021)

Traditionally, the structure of the electricity market was characterised by monopoly, where the government totally controlled the provision of electricity at all stages—generation, transmission, and distribution. However, in recent times, greater space for private sector participation has been created, especially in the sectors of generation and distribution. The main concern is that the energy-efficient market in developing countries is only emerging; hence, it is less developed or known. This can make it difficult for clean energy investing firms to access credit because financial institutions lack knowledge of the technologies involved or the formulation of a contracting structure for assessing clean energy loans (Ablaza et al., 2021), thus creating some form of hesitation when it comes to clean energy efficient projects. Aside from that, given that financial institutions are profit-driven, they might be more comfortable approving capital loans to core clients over non-core clients or new entrants such as the players in the clean energy market. That notwithstanding, this form of financing could be more reliable and sustainable given that donor funds are volatile (see SDG Report, 2022) and commitments are rarely met in full.

Therefore, understanding the area of clean energy financing is critical to achieving sustainable development. Up to this point, empirical knowledge in this regard has been scarce, in part due to the novelty of the concept. Most of the literature on this concept is focused on assessing clean energy and economic growth (Zhang, 2014; Sawin et al., 2016; Batini et al., 2021). Karim and Naeem (2021), however, investigated the interconnectedness between clean energy, electricity markets, and information transmission in Australia. While the contributions of these studies to clean energy are laudable, none fully or partially examined clean energy financing in the context of the electricity market. Understanding the electricity market structure from the perspective of clean energy financing is essential for enhancing sustainable development. In line with this, it is the preoccupation of the researcher to provide a comprehensive analysis of clean energy financing and sustainable development to synthesise an improved system of clean energy financing.

In brief, Ghana is one of the developing countries making efforts towards transitioning away from fossil fuels to low-carbon emission technologies such as wind, solar, and nuclear, as well as other non-emitting options in the energy sector. According to the 2021 Electricity Supply Plan published by GRIDCo, there is a trend towards idle electricity power plants that have the potential to generate power beyond the estimated demand capacity within the regulated market. This presents an opportunity to contract for additional energy in the deregulated market. However, the financing options associated with low carbon emission technology utilisation will have a material impact on electricity pricing and the fiscal environment of the GoG. In the 2018 and 2019 annual budget statements of Ghana, the government had to mitigate the risk of most of the IPP by providing them with government consent support agreements (GCSA), put call option agreements (PCOA), and WB guarantees to ensure that these projects attain FC and COD, as well as an agreed minimum off-take of energy, which is otherwise termed take or pay obligations. The servicing of these contractual obligations and the risk of the guarantees, present a risk of the sovereign rating of the country being downgraded, which is reflected by the increasing trend of the debt-to-GDP ratio. The primary gap discovered from the studies that have been done in the space of clean energy financing and sustainable development is that none look at it from the perspective of the electricity market, which this study sought to do. Also, empirical analysis on the relationship between clean energy financing and sustainable development from the perspective of the electricity market was lacking, as empirical studies have yet to be done on clean energy from that perspective. Furthermore, the lack of a comprehensive clean energy financing framework in the electricity market constitutes a major challenge for the integration of clean energy technologies into the market. In view of this, the study seeks to fill this secondary gap by synthesising an improved system of clean energy financing to help enhance sustainable development in Ghana. Another important gap the study seeks to fill involves estimating the optimal energy mix required for sustainable development. Against this background, the study evaluates the readiness of the Ghanaian electricity markets for a switch to clean energy, including risk management and improved disclosure, as well as current and planned changes in risk management systems, accounting, reporting, and other areas in banks and other financial institutions to address issues with the Ghanaian clean energy industry.

1.3 Objectives of the Study

1.3.1 General Objective

The primary objective of this study is to analyse clean energy financing and sustainable development to synthesize an improved system of clean energy financing for an enhanced sustainable development in Ghana.

1.3.2 Specific Objectives

The study sought to achieve the following objectives:

1. To describe the state of clean energy financing and sustainable development in Ghana.
2. To assess the determinants of clean energy financing in Ghana.
3. To estimate an optimal level of integrating clean energy in the electricity market of Ghana.
4. To synthesize an improved system of clean energy financing for enhanced sustainable development in Ghana.

1.4 Research Questions

1. What is the state of clean energy financing and sustainable development in Ghana?
2. What are the determinants of clean energy financing in Ghana?
3. What is the optimal level of integrating clean energy in the electricity market of Ghana?
4. What is the improved system of clean energy financing for sustainable development in Ghana?

1.5 Definition of Terms

Operational definitions used in the study are described in the below sub-sections.

1.5.1 Clean Energy

The term "clean energy" refers to both energy that is preserved through energy efficiency methods, and energy that is generated from renewable, low-emission sources that do not affect the environment when used. Clean energy will only be defined in the context of the following technologies for the purposes of this study.

a. **Photo-Voltaic (PV) Technology:** Using modules made of several PV cells, PV devices convert the energy in sunshine directly into electricity. There are two main types of PV devices: concentrator and flat-plate. While flat-plate solar panels make use of all incident solar energy, including diffuse (scattered) and direct insolation, concentrator systems use lenses to concentrate radiation onto a small number of highly effective PV cells.

b. **The Wind Technology:** The energy of moving air masses at the earth's surface is turned by wind technologies into rotating shaft power, which may then be utilized for mechanical energy requirements (such as water pumping or milling) or transformed into electric power in a generator. Based on the direction of rotation of the blades, there are two main categories of turbines: horizontal-axis turbines (which now rule commercial markets) and vertical-axis turbines.

c. **The Biomass Technology:** The sources of biomass are numerous, and there are several techniques to process it. Bio-mass is derived from several conventional crops, including corn (maize) and sugar. The bio-mass left behind after the creation of other goods can be made into an energy source. For industrial purposes or to generate steam for power production, biomass can be burnt directly to create heat energy.

d. **Hydropower Technologies:** In order to produce electricity, hydropower plants use the kinetic energy of falling or flowing water. Conventional hydropower plants continuously generate electricity using water from a river, stream, canal, or reservoir. The amount of water released from reservoirs that are only used for power generation may be swiftly modified to meet electricity demand.

e. **Waste-to-Energy and Biogas Technology:** Waste's organic makeup is utilized in the creation of energy. This makes it feasible to generate biogas or syngas, which may be used to run generators to generate energy, using digesters and sophisticated biomass gasification.

1.5.2 Clean Energy Financing

Clean energy financing refers to the process of providing financial support, investment, or funding to projects, initiatives, and technologies that promote the development, deployment, and adoption of clean and renewable energy sources, energy efficiency measures, and sustainable energy practices. The primary goal of clean energy financing is to accelerate the transition from fossil fuel-based energy systems to environmentally friendly and sustainable alternatives.

1.5.3 Electricity

Electricity is a secondary energy source produced from various primary energy sources such as fossil fuels (coal, natural gas, and oil), nuclear energy, renewable sources (solar, wind, hydropower, biomass), and others.

1.5.4 Electricity Market

Electricity market is an avenue for buying and selling of electricity between generators and consumers (off-takers).

1.5.5 Sustainable Development

Development that satisfies current demands without jeopardizing the ability of future generations to fulfil their own needs is referred to as sustainable development.

1.6 Scope of the Study

The research was designed to comprehensively examine the financial aspects of clean energy within the Ghanaian electricity market and its impact on sustainable development. This study specifically delves into the accessibility of clean energy financing and sustainable development within the Ghanaian electricity market, considering contributions from the private sector, public sector, and international perspectives.

1.7 Limitations of the Study

Many renewable energy technologies are being used in different parts of West Africa. Consequently, the research should have included other West African countries but was limited to Ghana due to travel restrictions emanating from COVID-19 and security threats in the region. The study was restricted to the renewable energy industry and a few selected institutions in Ghana. Clean energy finance is a relatively new concept in Ghana, which is why there is a scarcity of literature on the subject. Furthermore, because most of the analysis was conducted using primary data to undertake the quantitative technique and qualitative responses, it was important to limit geographical location. It is very challenging comparing electricity market structures and legal regimes in multiple countries along their respective priorities; hence, it was important to focus on Ghana and then compare the lessons learned with other successful or failed market structures as part of future studies. As an emerging area of interest where participation in the sector is restricted by licencing by the EC to safeguard the quality of the technology used and service in the sector, there is a limitation in the number of participants operating in the space. Additionally, clean energy financing requires longer-dated funding options at affordable rates; however, there are few institutions in that regard. These factors influenced the sample size used for the study.

This study also examined the effects of clean energy financing on sustainable development, but due to data constraints, its findings were excluded. The researcher is still monitoring for more data points as the sector is still growing. Despite the omission of the effects of the impact of clean energy financing on sustainable development, the study findings reflected the demands of the study objectives and the gaps it should fill; and market factors were significant in establishing the determinants of clean energy financing. Although each of the specific variables could have a different level of significance when it comes to influencing clean energy financing, together they explained the market factors.

1.8 Study Organization

By outlining the problem statement, study objectives, research questions, and study rationale in the first chapter, the study was introduced. The chapter also examines the study's structural organization and limitations as well as its scope. The issues related to climate change, funding renewable energy, and sustainable development are covered in considerably greater detail in the second chapter. It looks at the causes and history of climate change, the dependence theory of growth, and the idea of energy value. It also establishes a connection between climate change, clean energy funding, and sustainable development.

The study's research techniques are presented in Chapter 3. The chapter describes the research design and the researcher's role, and how they affect the way data is collected and the study's results. The chapter describes the study's techniques for gathering data, analysing it, and presenting it, as well as its difficulties and restrictions. The backdrop of the research region and study institutions was then given. The study's findings are provided in Chapters 4 through 7. Chapter 4: the state of clean energy financing and sustainable development in Ghana; Chapter 5: analysis on the determinants of clean energy financing in Ghana; Chapter 6: the optimal level of integrating clean energy in the electricity market of Ghana; Chapter 7: an improved system of clean energy financing for sustainable development in Ghana; and Chapter 8: summary, conclusion, recommendation, and policy actions. Key results and debates from the literature are used to support the study's conclusions. The last chapter addresses the results' consequences and offers several suggestions for dealing with the problems and difficulties found. Finally, the report suggests more research to fill in the gaps that were found.

CHAPTER TWO: REVIEW OF LITERATURE

The focus in this chapter was a review of the study's primary concepts; that is, theme review, geographical review with pertinent empirical data backing these concepts, and assessment of the conceptual framework for the research. The study also explores the fundamental ideas of the study in subsection 2.1, and in subsection 2.2 it looks at the interdependencies of significant concepts as well as an empirical review. In subsection 2.3, the study summarizes the conceptual basis for the research.

2.1 Review of Major Concepts of the Thesis

2.1.1 Clean Energy Financing

2.1.1.1 Clean Energy

Based on their research, Smith et al. (2021) found that the worldwide consumption of clean energy increased by 3 percent in 2020 compared to a decline in the use of all other fuels. Despite declining energy demand, problems with the supply chain, and construction delays in many parts of the world, the rise of renewables was aided by long-term contracts, priority grid access, and continued plant deployment. As a result, the share of renewable energy sources in total power generation rose from 27 percent in 2019 to 29 percent in 2020 (Smith et al., 2021). The authors also claimed that the use of biomass energy climbed by 3 percent globally, albeit this was somewhat offset by a decline in the use of biofuels as a result of the drop in demand for oil. In 2021, it was projected that the output of clean energy will climb by more than 8 percent, reaching 8,300 TWh, the largest annual increase since the 1970s. Two-thirds of the predicted growth in renewable energy will come from solar PV and wind power. About half of the increase in renewable energy globally in 2021 came from China alone.

According to the IRENA, with the right laws, regulations, governance, and access to financing markets, Sub-Saharan Africa may meet up to 67 percent of its energy demands by 2030 (Obonyo, 2021). Native, clean, renewable energy might provide around a fifth of those needs if the right policies and financial resources were put in place. Less than 2 percent of global emissions originate from Africa, which has historically contributed little to global emissions. Likewise, Vaissier et al. (2021) said that it is predicted that African countries would agree to cut the continent's contribution to greenhouse gas emissions by 32 percent by 2030 through a plan that was to be submitted to the UNFCCC before COP26 in November 2021.

Africa has seen exceptionally severe climate change effects compared to its emissions contribution, and it is anticipated that the continent will pay a significant portion of the price of climate change, especially if efforts to limit future increases in average temperatures are unsuccessful. The study's main focus is on the current possibilities for investments in renewable energy in Africa (Vaissier et al., 2021).

The effects of climate change on Africa have been unusually severe compared to its emissions contribution, and it is anticipated that the continent will bear a significant portion of the burden of climate change, especially if the world fails to put limits on future increases in average temperatures. Key to this study's findings are the current investment opportunities in renewable energy in Africa (Vaissier et al., 2021).

The private sector is now in charge of the majority of Africa's renewable energy programmes. These investments might, however, occasionally be difficult due to legal frameworks and the "business climate". SOEs are not adopting renewable energy technology at the same rate as the private sector, and this trend is likely to continue unless more African nations reform their SOEs and energy sectors in general. For instance, a competitive electricity procurement process might lower power costs while offering African institutions and markets access to renewable energy options. The cost of solar energy has decreased to as little as US$ 0.05 per kilowatt-hour thanks to the Scaling Solar Program of the World Bank and the International Finance Corporation, the REIPPP program of South Africa, and other initiatives (Okonjo-Iweala, 2020).

Despite having more than one-sixth of the world's population, Africa only generates 4 percent of the world's electricity (IEA, 2021). Additionally, three-quarters of the energy used on the continent is used by South Africa and the nations north of the Sahara. According to the IEA (2021), 780 million Africans rely on solid biomass for cooking; primarily fuelwood and agricultural waste, while over 600 million do not have access to electricity. According to the International Energy Agency (2021), in SSA, 80 percent of the population lacks access to electricity. One of Africa's problems, and one of the most significant barriers to socioeconomic advancement, is the lack of access to power. There are challenges involved in switching from energy produced using fossil fuels to energy produced using renewable resources. The COVID-19 pandemic has caused African governments' debt levels to reach all-time highs, and more funding is required to use renewable energy to make up for the country's lacking energy infrastructure.

2.1.1.2 Clean Energy Financing

The adoption of renewable energy technologies, including solar energy (photovoltaic), among others, must be financially supported. Owners of residential, commercial, and industrial property can use clean energy financing to pay for upgrades to their properties' energy efficiency, disaster preparedness, water management, or renewable energy installations (Speer, 2010). For residential developments, installing more batteries is akin to installing rooftop solar panels; for commercial projects, installing chillers, boilers, LED lighting, and roofing are examples of energy efficiency and renewable energy upgrades. An inventive method for funding upgrades to private property's energy efficiency and renewable energy sources is the PACE concept. In the United States of America (USA), in areas where PACE Financing of Renewables and Efficiency legislation is in force, the government issues a specific bond to investors or, in the case of the open-market approach, private lenders provide funding to building owners to put toward an energy retrofit. A yearly assessment on their property tax bill is used to pay off the loans during the allotted time frame (often between 5 and 25 years). PACE bonds may be issued by municipal financing districts, state agencies, and finance corporations, and the money raised can be used to modernize both commercial and residential buildings. One of the most distinctive aspects of PACE programs is the loan's connection to the property rather than an individual.

According to Buchner et al. (2011), renewable energy funding consists of money transfers from wealthy countries to developing ones. Domestic climate financing flows in both developed and developing nations might originate from developed-to-developed countries (North-North).

Although this notion has a wide range, these definitions are somewhat limited. In this study, "clean energy financing" refers to the funding of long-term infrastructure, commercial projects, and private and public services that support the production and distribution of energy derived from renewable, low-carbon emission sources that are less harmful to the environment when used, as well as energy saved through energy efficiency techniques (IEA, 2021b). The financing might be accomplished by the issuance of debt or stock or through self-financing, as opposed to being restricted to capital transfers from the Global North to the Global South. The idea is global and does not apply to only one country or economy, to reiterate.

2.1.1.3 Sources of Clean Energy Financing

To address the consequences of climate change, a variety of clean energy finance initiatives are being carried out throughout the globe. The architecture of clean energy financing is complex and constantly evolving. Both inside and outside the UNFCCC financial framework, funds are channelled through a multilateral channel, which includes the GEF and GCF, or a bilateral channel, which includes regional and national climate change channels and funds. It is difficult to track the flows of clean energy funds since there is no consensus on what constitutes clean energy finance or common accounting standards. Due to the wide range of financing choices for climate-friendly energy, coordination still presents a challenge. However, efforts to increase access, extend inclusiveness, and offer complementing options continue.

a) **Bilateral Source of Clean Energy Financing**

Bilateral climate money is obtained through direct government collaboration, is carried out by direct payments from industrialized to poor nations, and is typically managed by already-established development organizations. Bilateral sources have a lot more scope flexibility, which might mean more opportunities to establish connections between climate and development results. However, governments' self-classification and self-reporting of climate-relevant financial flows without a standard reporting format or outside verification appears to be limiting openness and consistency in reporting of certain bilateral money for climate activities. In addition to the money spent on climate funds and development financing institutions in 2014, the Climate and Policy Initiative projected that those governments, ministries, and bilateral agency also spent between US$12 and US$19 billion on climate-related activities (IEA, 2021c). But it is important to remember that for many years, the bilateral institutions have been crucial in supplying aid and capital to poor nations. As a result of their increasing integration of clean energy funding into development efforts, they are now a prominent player in providing money for climate change.

b) Multilateral Climate Funds of Clean Energy Financing

A significant source of climate money flowing from foreign donors to projects in poor nations is through multilateral climate funds, which are frequently used as part of multibillion-dollar national investment programs run by multilateral development banks (Buchner et al., 2011). To finance and carry out initiatives in host countries, funds are channelled through multilateral agencies, development banks, other organizations, and UN organizations. There are several of them, including the World Bank, regional development banks like the Asian Development Bank, the African Development Bank, and the Inter-

American Development Bank, as well as two organizations taking part in this mapping exercise, namely the European Investment Bank (EIB) and Nordic Environment Finance Corporation (NEFCO). These organizations are essential to achieving local investment in developing nations through the use of worldwide public backing. Additionally, they specifically want to include the business sector and use its funding for investments related to climate change (Buchner et al., 2011).

A crucial conduit for the ODA of Development Assistance Committee (DAC) member nations is the multilateral system. They have the benefit of allowing for the mobilization of sizable amounts of funding and the expansion of development goals, especially for smaller contributors. The profits of significant borrowing programs, gross revenue from loans, investments, and shareholdings, and direct donations from donor countries to particular distribution programs are also sources of funding for these intermediaries. Additionally, according to Buchner et al. (2011), these actors raise money on the capital markets from a combination of public and private investors.

In comparison to global climate finance flows, which averaged US$ 714 billion per year in the same time (Standing Committee on Finance (SCF), 2016), multilateral climate funds provided developing countries with an average of US$ 2.2 billion annually in 2013–2014 (UNFCCC, 2018). To reach agreement on the necessity of taking action in response to climate change, effective use of international climate funding and the delivery of successful results are essential. Together with developing and developed nations, multilateral funding help identify the optimal strategy for resolving this global issue. They have established new standards for public financial governance by establishing a framework where new ideas may be developed via collaborative discourse among scientific, commercial sector, and civil society players.

This offers the government of a developing nation more influence and representation in decision-making. A role for non-governmental stakeholders as observers at fund meetings has been established, with varied degrees of chances for active involvement, as part of efforts to promote inclusiveness and accountability in multilateral fund governance.

c) National Climate Change Funds for Clean Energy Financing

It is crucial for nations to consider various routes and methods to attract and harness all forms of climate change investment, including that from private sources, due to the growth in climate change financing prospects. One of the resources that may be utilized to address this situation is national and regional funding. Developing nations have expanded their investment on climate change-related initiatives through their own national budgets (Buchner et al., 2011). A number of developing nations have created regional and national funds and channels with a range of structures and purposes that are financed by domestic budgetary and private sector resources as well as international money (Nakhooda et al., 2016).

Of these organizations, the Indonesian Climate Change Trust Fund was founded first. The largest national climate fund is Brazil's Amazon Fund, managed by the BNDES, which has received a promise of more than US$ 1 billion from Norway (GIZ, 2016). Additionally, Bangladesh, Benin, Cambodia, Ethiopia, Guyana, the Maldives, Mali, Mexico, the Philippines, Rwanda, South Africa, and the United States have national climate change funds. An increasing number of developing countries are calling for more decentralized decision-making and, in some cases, direct access to funds rather than through the mediation of international or other institutions. This trend toward the establishment of national funding entities and institutions in charge of allocating and managing climate change finance is in line with this demand. As a result of this new development, national institutions will be required to function in accordance with accepted standards of good governance, creating a demand for funds for capacity building. The task of bolstering these national institutions will be ongoing and probably take a while (Gomez-Echeverri, 2010). It will require time and money to develop the capacity of many of these national institutions.

d) Private Clean Energy Financing Source

It is unlikely that private financing arrangements alone will be sufficient to deliver the necessary adaptation or mitigating actions in many countries, particularly emerging economies. Private financing arrangements already play a crucial role in the global climate change financing architecture. Private investments prioritize financial gain over mitigation as a tool for boosting energy availability and facilitating the elimination of poverty. As a result, financial flows are extremely challenging (Atteridge, 2011). The primary motivation behind private climate funding is economic gain; as a result, investments are made in projects and regions where capital returns are greatest and most predictable, but not always where they are most needed.

e) International and Multilateral Sources of Clean Energy Finance

The United Nations Framework Convention on Climate Change has set aside international money specifically for tackling climate change. These funds, like the Special Climate Change Fund, Least Developed Countries Fund, and Global Environment Facility, focus on both adaptation and mitigation. In order to help the least developed nations combat the consequences of climate change, the Global Environment Facility was formed by the Conference of the Parties' seventh session in 2001 and manages these sources. Thirty-five of the 49 least developed nations in the world—or almost 70 percent—are in Africa.

f) Adaptation Fund

The Adaptation Fund was formed in 2007 under the Kyoto Protocol signatories to the United Nations Framework Convention on Climate Change. It is primarily funded by a 2 percent tax on the money made from the sale of certified emission reduction (CER) credits, and it uses a project-based model in which implementing organizations submit project ideas to a central board.

2.1.1.4 Instruments for Clean Energy Financing

Adequate capital investment in clean energy transitions is necessary to meet the sustainable development goals. In the energy sector, debt and equity play a significant role in the financing of capital investment. These financial tools are thought to be easy and dependable for generating cash (Ablaza et al., 2021). The renewable energy market can obtain funding through these routes from both domestic and foreign sources.

a. Debt

A climate-driven scenario created by the IEA suggests that debt would serve as the capital structure for funding half of the world's need for investments in efficient energy (2021). In addition, borrowing money to transition to renewable energy has always been most likely to be done through debt. For instance, in India, debt financing makes up 70 percent of the finance for green energy while equity financing makes up 30 percent (Sarangi, 2018).

Although debt finance is often used, obtaining it to pursue projects that improve energy efficiency is still a difficult task. It is considerably harder to finance renewable energy investments through loans in developing economies than it is in wealthy countries with sound and stable financial systems. This is especially true at a time when the market for energy-efficient products is still developing: as a result, there is less momentum in this region of the world. Financial institutions often view energy-efficient projects as risky, primarily because of a lack of understanding regarding the technology involved or the complex contractual structures required for loan assessment (Ablaza et al., 2021). In addition, banking institutions have trouble sanctioning sizable capital loans to new or non-core clients — a situation that nearly typifies the green energy sector. Other issues include the fragile, constrained, and immature financial systems (IEA, 2021).

Improving access is crucial given the significance of debt finance in realizing a green energy economy. Therefore, it is necessary for both providers and receivers to adopt plans for reducing the risks connected with loan providing. By obtaining loan guarantees from government-owned financial institutions and export credit organizations, Justice (2009) recommended using structural financing options. In addition, implementing sustainable finance laws at the national level may boost and promote investment as well as supplementary aid from financial institutions and overseas investors. It is anticipated that doing this will raise the chances of loan approvals while lowering the project's related risk to an acceptable level.

b. Equity

Equity finance will inevitably play a substantial role in capital investment at some time. For example, this type of financing is anticipated to be essential in the early stages of the transition to clean energy, such as the exploration phase of geothermal, carbon capture, and low-carbon hydrogen (IEA, 2021). However, employing this strategy necessitates a solid financial foundation for the company or project developer, and efficient energy measures must be a mainstay of operations (Ablaza et al., 2021).

Equity was traditionally only offered by the organization or project creator (Sarangi, 2018). Today, the idea has changed and is no longer exclusive because it is now attainable from other sources. Private equity and venture capital are viewed by IEA (2021) and Sarangi (2018) as typical third-party equity financing mechanisms.

These modes, nevertheless, are more probable at certain phases of a project's development. While private equity funding is concentrated on the later stages of a project or the mature technological stage, venture capital is likely the focus of suppliers or the organization during the early stages of the clean energy transition (Justice, 2009).

2.1.1.5 Determinants of Clean Energy Financing

The market demand (off-takers) for a company's goods determines the clean energy finance. The process of obtaining finance in the clean energy sector is made easier when a clean energy company can meet the financial requirements demanded by lending institutions. Donors are more inclined to provide the financial requirements of the clean energy company with government permission or support. Most financial institutions need government involvement to finance renewable energy projects (Speer, 2010).

The kind of clean technology that the clean energy company uses is also a deciding element in clean energy funding. The financing mechanism is based on the type of technology. The type of renewable energy technology to be employed, for instance, influences the company.

The level of management and experience at the clean energy company is another aspect of clean energy financing. A financial institution, a donor, or an investor would think about the company's track record and the technical proficiency of key individuals before making an investment decision in corporate finance. How the money is spent is a very important consideration for investors when choosing an investment.

The kind or sophistication of technology used by the company or with which it is affiliated is another factor. The organisation has a higher chance of obtaining financing when the technology is high-quality and in high demand than when it is of lower quality.

Additionally, investors in renewable energy are more willing to put their money and resources into projects in a nation where they may get tax advantages like tax relief packages (Azarova & Jun, 2021). On the other side, investors find it challenging to employ sustainable energy technology when there are no tax advantages or incentives.

A robust legislative framework and policies that support clean energy initiatives, such as feed-in tariffs, in the host nation are other important factors in determining clean energy investment (Azarova & Jun, 2021). Additionally, Ragosa and Warren (2019) found that the availability of foreign public funding, regulatory support measures, and feed-in tariffs, along with a favourable political environment, significantly influence the level of clean energy investment in developing nations.

Foreign exchange is one factor that affects financing for renewable energy sources (International Energy Agency, 2021b). Foreign exchange, or the price of one currency relative to another, has an impact on the financial decisions made in the clean energy sector. Investors are willing to put their money into nations where they will receive a fair return in the form of foreign cash. In situations where foreign exchange returns are unfavourable, there is a financial hardship.

According to Kutan et al. (2017), impoverished countries must scale up more swiftly to meet climate and sustainable development objectives, even though spending on renewable energy has risen significantly over the previous ten years. According to Kutan et al. (2017), renewable energy projects, particularly in developing countries, encounter a few challenges, ranging from institutional, governmental, and regulatory concerns to market and project-level issues that may impede their expansion and acceptability. Lack of proper knowledge of regulations, markets, and resource availability are among the latter, as well as a lack of finance, project development expertise, and market openness (Hudson et al., 2019). This has led to a dearth of banking options, making it more difficult for investors to locate projects they are interested in funding and, as a result, reducing the amount of money available for those who are.

Kutan et al. (2017) used a range of robust panel econometric techniques using annual data from 1990 to 2012. The empirical results confirmed the long-run equilibrium relationship between the variables. The research also showed that important emerging market countries' stock market indices and FDI inflows both significantly influence how much renewable energy is promoted there. The use of renewable energy contributes significantly to the reduction of CO_2 emissions while promoting economic growth.

2.1.1.6 Electricity Market and Clean Energy Financing

2.1.1.6.1 The Global Electricity Sector

Global power usage fell by around 1 percent in 2020, falling most dramatically in the first half of the year as lockdowns hindered business and industrial activity.

Demand dropped by 20–30 percent from what it had been before to the lockdowns. After accounting for weather variations, China's demand decreased in February 2022 by more than 10 percent compared to the same month in 2021. In May, when stay-at-home orders were at their peak, the United States, the second-largest power consumer in the world after China, saw a decline of almost the same amount (Newell & Raimi, 2020; IEA, 2021). In the months of March and April, weekly consumption in Germany, France, and the United Kingdom decreased by more than 15 percent, while it decreased by more than 25 percent in Spain and Italy. The same is true for India, where demand decreased by more than 20 percent between mid-March and the end of April (IEA, 2021). Where COVID-19 instances were fewer than in Europe and the US, including Japan and Korea, demand declined by around 8 percent in May. Despite a little improvement in the second half of 2020, the advanced economies mostly remained below their levels from the previous year. China and India, which showed year-over-year growth of more than 8 percent and 6 percent, respectively, in the fourth quarter of 2020, are two examples of rising economies and developing regions that experienced substantial growth towards the end of the year (IEA, 2021). A stronger economy and rapid development in important emerging countries like China, according to the IEA's forecast (2021), was anticipated to increase electricity. Due to the economic boost and the milder weather in the first few months of 2021, it was expected that demand would increase by around 2 percent in the United States. Due to this increase, demand should have been within 1.6 percent of 2019 levels. Germany, France, Italy, and Spain, the top four consumer nations in the EU, were predicted to maintain their 2019 levels, with a rise of just under 3 percent forecast in 2021 failing to fully make up for declines of 4 percent to 6 percent in 2020. The situation was the same in Japan, where it was predicted that demand would only increase by 1 percent from 2020 levels, which was far from sufficient to reverse the nation's 4 percent decline. The demand trend in emerging and developing countries, which started in the second half of 2020, kept increasing due to the economic recovery experienced. This tendency has been accelerated by the strong economic recovery that China and India were predicted to have.

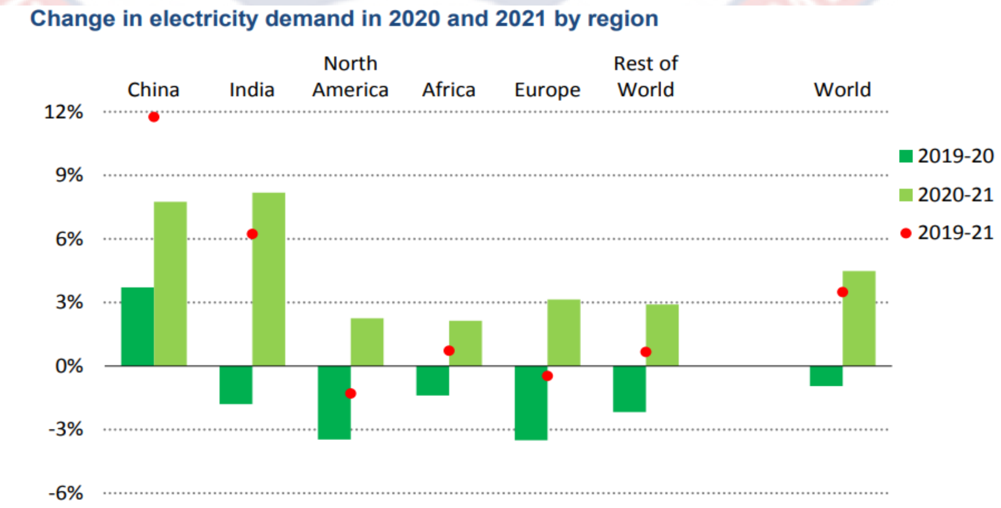


Figure 2.1: Change in Electricity Demand between 2020 and 2021
Source: International Energy Agency (2021)

Recent developments predicted that for the 20th consecutive year, renewable-based electricity output will increase in 2021. The rise in the supply of power in 2021 is expected to be mostly driven by the expansion of renewable energy sources. Nuclear capacity was expected to increase by around 2 percent, while the remaining energy demand growth was met by coal and natural gas power plants.

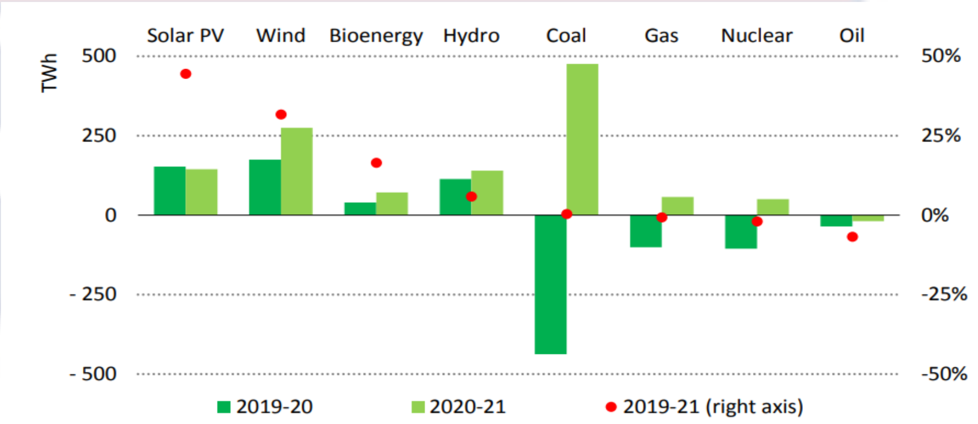


Figure 2.2: Change in Electricity Supply between 2020 and 2021
Source: International Energy Agency (2021)

Most of the increase in energy production from fossil fuels was expected to come from coal-fired power plants, whose output was forecast to increase by 480 TWh. A little amount (+1 percent) of the increase in gas prices is offset by natural gas. According to the analysis, when coal-to-gas switching was to be reversed in different parts of the nation in 2021, about half of the decline in coal-fired electricity in the United States was to be stopped. By 2021, gas-fired electricity in the US should have decreased by more than 80 TWh as a result (International Energy Agency, 2021). More than half of the growth in coal-fired energy output in 2021 is anticipated to come from China (IEA, 2021). Fossil fuels will contribute about half of China's 8 percent growth in power production in 2021, increasing coal generation by 330 TWh (or 7 percent) over 2019. IEA (2021) argued that despite making up nearly 45 percent of the additional global renewable energy, coal generation was to increase by 7 percent over 2019. In 2021, thermal generating in India, which is expected to have the second-largest absolute market growth after China, would almost exclusively rely on coal to meet the increased energy demand.

2.1.1.6.2 Electricity Market Structures

The 2020 World Bank Power Sector Reform Report claims that the electrical reform resulted from a comprehensive set of actions that were carried out in a logical order. Power sectors throughout the world may be divided into several sorts of structures based on the breadth of the changes implemented in recent decades. It is clear that the structures of the electrical market have changed from a monopoly, where it was formerly governed by governments of nations, to being disaggregated for operational clarity between generation, transmission, and distribution. At both the generation and distribution stages of the electrical value chain, the transformation produced an environment that was favourable for private sector engagement. The structure of the power market becomes a crucial component of this study.

Figure 2.3: Electricity Sector Reform

Source: International Bank for Reconstruction and Development / The World Bank (2020)

Regulated Electricity Market

The Public Regulator has complete authority over the utility, which owns the infrastructure for generating and delivering power to end customers. Electricity generated, sent to the grid, and distributed to customers are all taken care of by the utility. Energy users are compelled to identify the source of the electricity-generating power plant or corporation since they have no other choice in terms of alternative electricity supply. There are two regulatory bodies in Ghana: the EC, which oversees technical matters, and the PURC, which oversees the economy. Moreover, the PURC is in charge of deciding on tariffs, while the EC is in charge of approving technical licenses. The energy market in Ghana was the epitome of a controlled market up until 2008.

Deregulated Electricity Market

The deregulated energy market encourages competition, especially in the generating and transmission utility infrastructure. The generation, transmission, distribution, operation, and maintenance of electricity from the point of grid hook-up to the meter, as well as the billing of consumers, cannot be owned by a single business. Deregulated markets—also known as "choice markets"—often benefit large commercial and industrial clients. Businesses might be able to negotiate lower costs and more precisely predict annual energy costs if they have the freedom to compare electricity prices and sign contracts for certain rates. Consumers who shop at home frequently fail to notice significant distinctions between markets that are regulated and those that are not.

Vertically Integrated Utility

The vertically integrated utility receives an exclusive franchise within its service area in return for taking on the responsibility to provide for all of the territory's consumers and putting its prices, investments, and other business activities to governmental regulation. The regulator, usually a state public utility commission or a state public service commission, has the responsibility of making sure that the utility provides reliable service at fair and reasonable prices. In this capacity, the regulator sets the utility's rates, manages complaints, upholds consumer protections, and offers expert oversight regarding the wisdom of investments to ensure a proper balance between consumer interests and the need for a utility to recover its proposed investments and expenses, as well as an opportunity to earn a reasonable profit. Since production, transmission, and distribution decisions all fall under the purview of the state, lawmakers may influence utility behaviour and performance through regulatory mechanisms while still holding decision-making authority. As an instance, a state may require a vertically owned utility to create or buy particular types of preferred generation to meet its policy objectives, and it can ask the state commission to help carry out this order using the rate-setting and planning procedures it already has in place. Under the vertically integrated monopoly utility model, a single monopoly corporation or a group of monopolies with strong ties to one another own and run the generation, transmission, distribution, retail sales, and system operations activities and assets as a single integrated whole (Du et al., 2021).

Vertically integrated electric utilities in Ghana saw modifications as a result of this market. Three distinct firms made up the vertically integrated electric utility: one for generating (VRA and Independent Power Producers IPPs); one for transmitting (GRIDCo); and one for distribution (NEDCo and ECG). All three businesses were often owned by the same parent company as independent subsidiaries. The restriction on power generation prices has been eliminated or greatly eased. Electricity providers may impose whatever prices the market will bear in place of imposing set prices. These new power markets would be under the control of the Energy Commission, not the state. The majority of the regulated pricing for electricity transmission would remain in place, but the Energy Commission and PURC were given a lot of the state's control over transmission price setting. IPPs can now depreciate new equipment more quickly in their accounting since several power plant financing procedures have been relaxed. As part of the vertically integrated electric utility, Ghana deployed this after 2008.

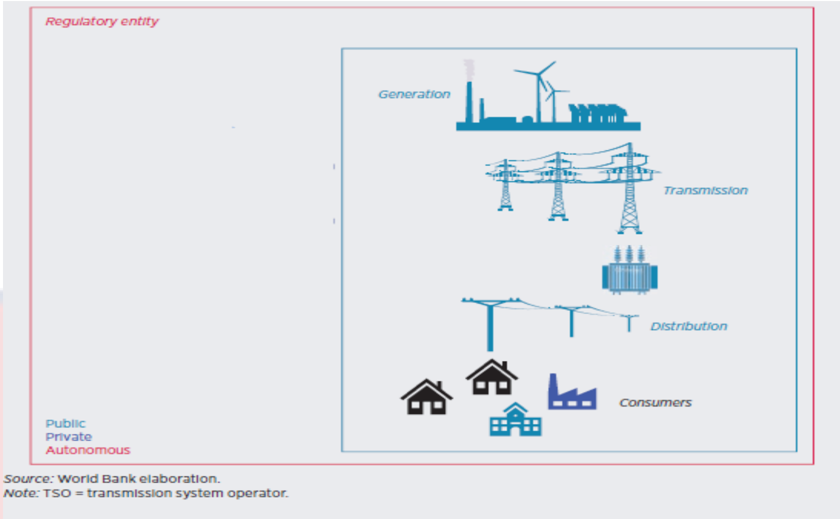


Figure 2.4: Vertically Integrated Utility

Source: International Bank for Reconstruction and Development / The World Bank (2020)

Disaggregated Utility

Energy industry participants oversee the breakdown of energy signals from a structure or residence to ascertain the amount of power utilized by certain gadgets like a TV or washing machine. It is a technique that makes better predictions about the amount of energy that consumers will use and how to prevent energy waste. Customers may have a clearer understanding of their bills as well as more in-depth advice on how to reduce their energy and utility costs. Energy disaggregation has advantages for both customers and providers. Although the Ghanaian electrical market structure has features in common with this market structure, it is not the country's primary market structure.

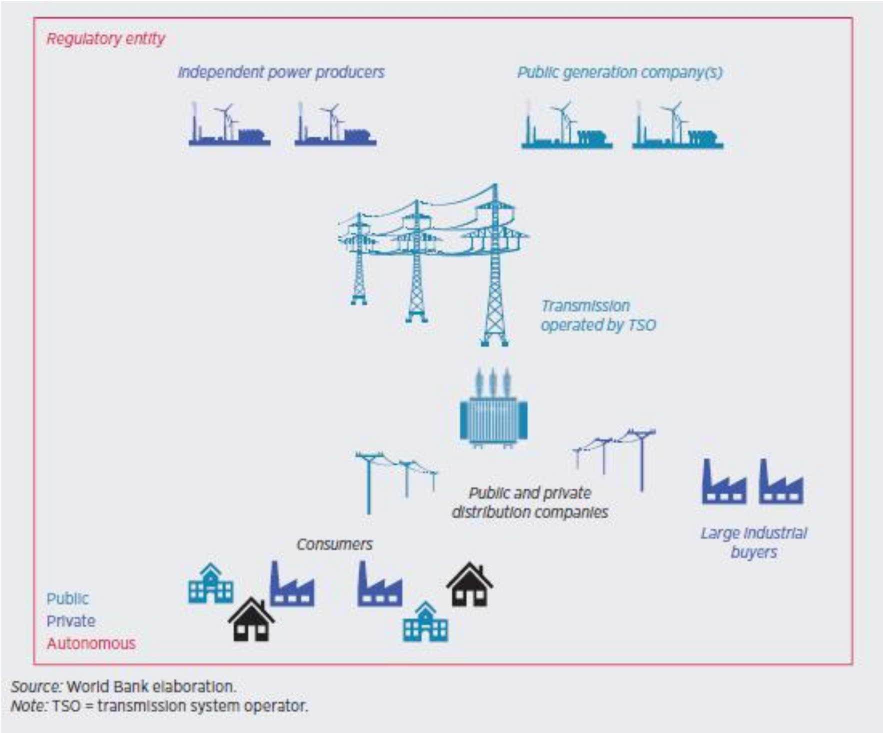


Figure 2.5: Disaggregated Utility

Source: International Bank for Reconstruction and Development / The World Bank (2020)

Wholesale Market

Under this market, electricity is traded (bought and sold) in the wholesale market before it is delivered to end users (individuals, households, or businesses) via the grid. Ghana operates this market structure. The GWEM is designed in accordance with industry standards used in many nations across the globe. The GWEM offers a capacity market, forward energy markets (including a day-ahead market), and a RTM. All the suggested markets provide market participants enough leeway to satisfy their responsibilities, whether via self-supply, bilateral transactions, or procurement through centralized marketplaces. Market players, for example, may either self-schedule energy and/or supplementary services or acquire them from the market. Similarly, Load Serving Entities (LSEs) and Bulk Power Customers (BPCs) may satisfy their capacity obligations through self-supply and bilateral contracts, market-operated capacity auctions, or both. The number of market participants, as well as the volume and value of transactions, determines a market's success. As a result, the approach to this evaluation was not just from the perspective of a consultant, but also from the perspective of a market participant.

Furthermore, the evaluation focused on the comparatively modest size of Ghana's power system, the minimal equipment and facilities required to make it operational, and the cost. The market architecture allows for price discovery, offers a forward pricing curve to allow for economic market entrance (particularly in the capacity market), assures dependability, competition, renewable integration, and simulates regional planning and integration via the WAPP. The concept also suggests energy and capacity pricing based on geography. The pricing structure distributes costs to entities that create expenses and benefits to entities that give benefits in an effective manner. The GWEM will considerably reduce the danger of catastrophic failure by adopting the industry-standard market design provided. From design to implementation, one must simply solve pre-existing circumstances and transitional concerns, as well as integrate lessons acquired from previous markets.

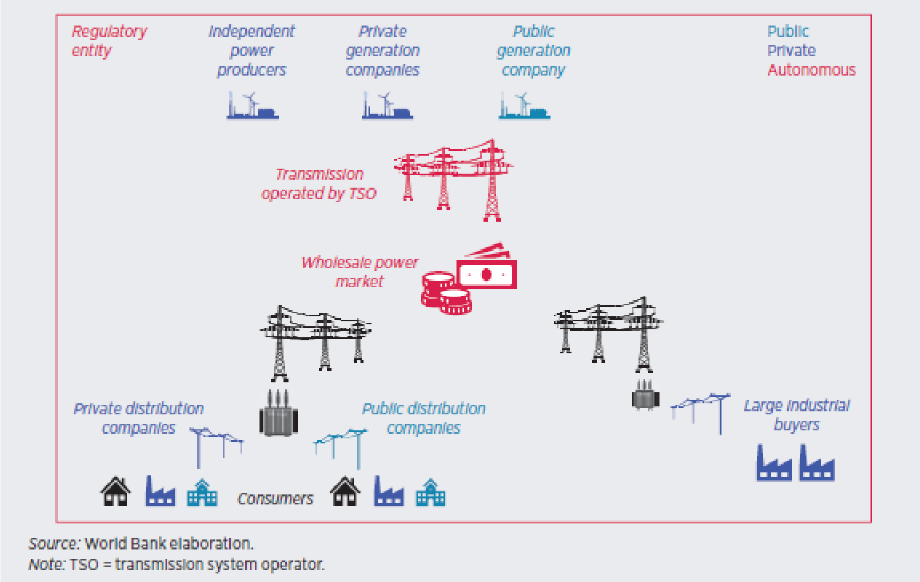


Figure 2.6: Wholesale Electricity Market

Source: International Bank for Reconstruction and Development / The World Bank (2020)

Wholesale Market and Retail Competition

The market offers the opportunity to buy, sell, and exchange electricity as a commodity. A system known as an electrical market enables short-term trading, offers to buy and sell, and purchases through bids to buy. A wholesale energy market develops when rival producers sell their output to retailers. The power is subsequently resold, and its price is changed by the merchants. The system operator receives bids from owners of energy resources to sell power, and in a competitive wholesale electricity market, the system operator then distributes that power to utilities and other significant consumers of electricity. These markets, like all markets, respond to supply and demand and provide price signals that allow power providers to choose which resources to maintain, grow, or retire, based on their ability to compete with all other sources of supply. Electricity is typically distributed and consumed as it is generated since it can be produced but cannot be stored in large quantities.

In order to meet these objectives, a variety of markets are available, such as those that guarantee future power supply or take care of system operating requirements unrelated to the selling of electricity to end users. While capacity markets negotiate contracts with power producers to create electricity later, energy markets, for instance, purchase and sell energy for immediate or day-ahead usage. The availability of resources at a previously agreed-upon price, dependability, and protection from price spikes are all features of the capacity market that contribute to guarantee power availability.

The Ghanaian Electricity Sector

The developments in the energy sector have been summarized in figure 2.6 below.

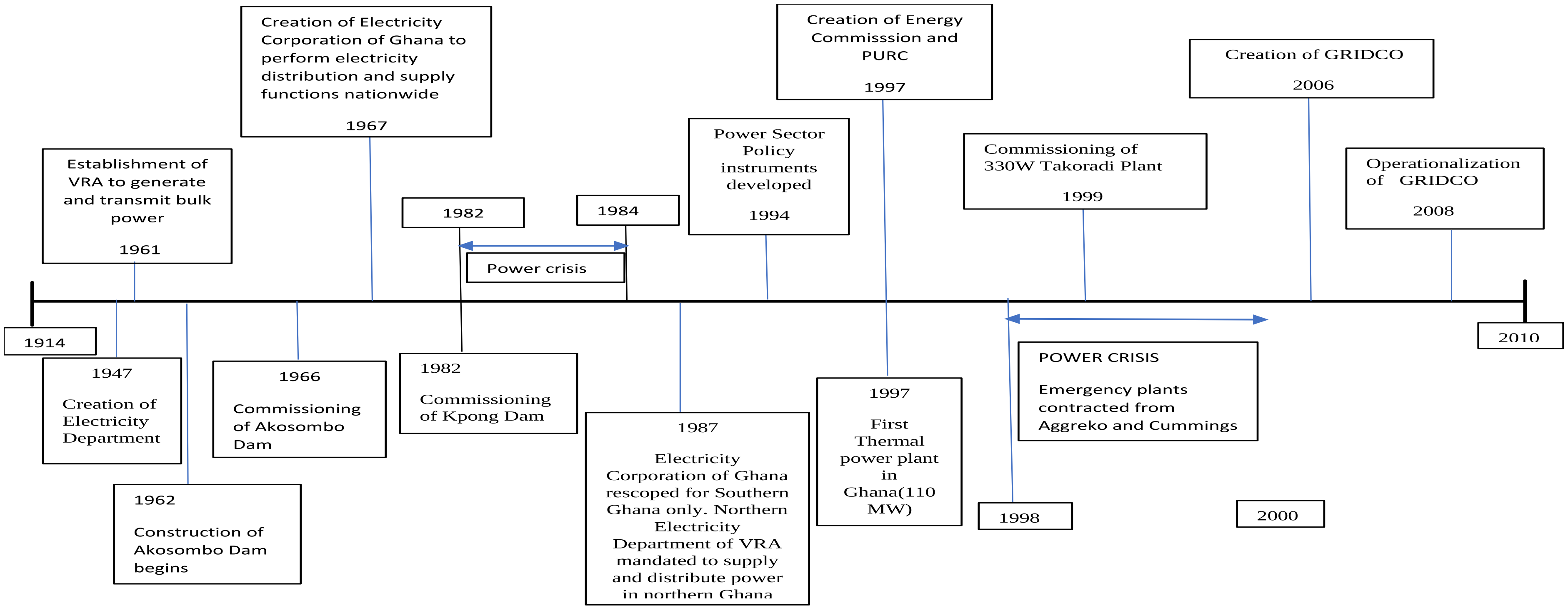


Figure 2.7: Developments in the Energy Sector of Ghana

Source: Author's Construct

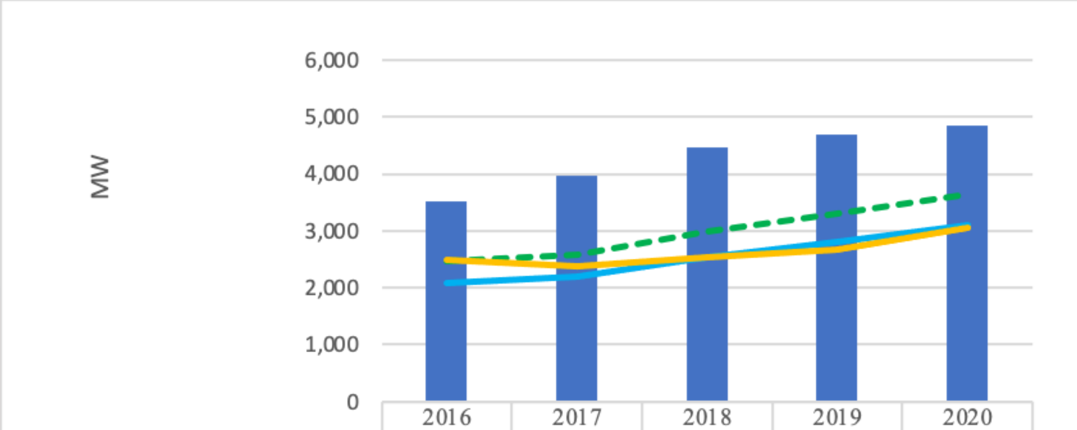
The energy sector in Ghana has evolved during the last 20 years. This is because stability and continuing reforms have encouraged private enterprises to increase their investment, notably in the energy subsector. Additionally, the country's energy industry advanced thanks to the 2007 commercial oil and gas finding and the subsequent 2010 oil discovery. The three oil-producing fields in the country, which started production in 2010 with just one field, are Jubilee, Tweneboa Enyenra Ntomme (TEN), and the Offshore Cape Three Points' (OCTP) Sankofa and Gye Nyame. The year 2020 turned out to be challenging despite significant advancement in the energy sector. Ghana's energy sector had modest growth in 2020 despite the negative consequences of COVID-19. The GoG has taken several energy-related measures to assist lessen the effects. Notable is the absorption of electricity costs (total for lifeline clients and 50 percent for non-lifeline users).

The energy business is still being affected by COVID-19's knock-on effects. The Ghana 2021 Energy Outlook, however, is the outcome of an attempt to anticipate Ghana's energy sector for the coming year (Energy Commission, 2022). The research provided an evaluation of the actual performance of the energy sector, particularly the electricity and petroleum industries, as well as the wood fuel subsector, for the prior year by comparing actuals to predicted values (2020). It kept projecting energy supply and demand into 2022, with a focus on the economic issues that would greatly affect both. At the moment, there are around 21 power plants in Ghana, with a total installed capacity of about 5,488 MW (Energy Commission, Energy Statistics Report, 2021). The VRA, which controls more than 80 percent of the total capacity, has historically controlled the ESI, which is dominated by hydro from run-of-river plants on the

Volta Lake. By the end of 2010, Ghana's total installed generation capacity was almost equally split between these two power sources thanks to significant investments in traditional thermal production capacity. According to the Energy Statistics Report of the Energy Commission, the system peak demand for 2019 was predicted to be 2,665.68 MW (2021). However, with an 18 percent reserve margin, it is anticipated that demand would exceed 5000MW by 2024.

Due to its vast gas reserves and use of renewable energy to produce power, Ghana is well-positioned to handle these issues; nonetheless, there are a number of issues that need to be resolved. Since 2010, Ghana has experienced significant development, in part due to the growth of the oil and gas industries as well as the expansion of the services sector, which is now responsible for over half of the country's overall GDP growth. Data from the Ghana Energy Commission show that since 2010, the rate of growth in power consumption has increased at an average rate of 7–10 percent annually. Peak demand in Ghana increased from 2,525 megawatts (MW) in 2018 to 3,246 MW in 2021 according to Energy Commission (2021), a higher than 10 percent annual average increase (Energy Commission, 2021). In Ghana, dependable electricity access remains a significant problem, which has a negative influence for both businesses and consumer goods. The country lost almost 6 percent of its GDP annually as a result of inadequate wholesale power supply during the power crisis from 2006 to 2016, according to reports from the Ghana Energy Commission. In 2020, the system peak increased to 3,090 MW from 2,804 MW in 2019 (Energy Commission, 2021). This implies an increase of 10.2 percent over the system peak demand for 2019 and an increase of 0.9 percent over the system high of 3,061 MW predicted for 2020 (Energy Commission, 2021). In some SSA nations, it is estimated that the cost of delivering power can represent more than 30 percent of all business production expenses, while regular losses from electrical outages may represent up to 16 percent of total yearly sales. This element could be substantially more relevant in the case of micro, small, and medium-sized businesses, which account for more than two thirds of all employment. Numerous industries have been forced to reduce output and employment as a result of cost-cutting efforts due to the detrimental impact that energy shortages have on corporate operations. High rates of youth unemployment, rising crime rates, and a general feeling of helplessness among the public are additional negative effects of a power outage that might result in anti-government demonstrations.

Ghana's ability to compete in the West African area may be hampered, which would make it less desirable as a place to invest, particularly as a manufacturing powerhouse. There will be significant change in a number of industries by the year 2020, including Ghana's energy sector. This was mostly a result of COVID-19 breaking out in 2020 and the shocks it brought to the economic and work plans of significant industrial organizations. The energy industry enjoyed a prosperous year, but it might have been much better. Peak demand increased by 10.2 percent in 2020 over 2019 (Energy Commission, 2021). 2019 had an 11.0 percent rise in peak load over 2018.



	2016	2017	2018	2019	2020
Dependable Capacity	3,521	3,966	4,472	4,695	4,842
Actual System Peak	2,087	2,192	2,525	2,804	3,090
Actual System Peak +18% RM	2,463	2,587	2,980	3,308	3,646
Projected System Peak	2,477	2,386	2,525	2,666	3,061

Figure 2.8: Trend in Peak Demand from 2016-2020

Source: Energy Commission- Energy Outlook for Ghana (2021)

The Energy Commission Report (2021) indicates that energy usage has been rising gradually. The entire quantity of energy used increased by 9.5 percent annually, from 13,700 GWh in 2016 to 19,717 GWh in 2020.

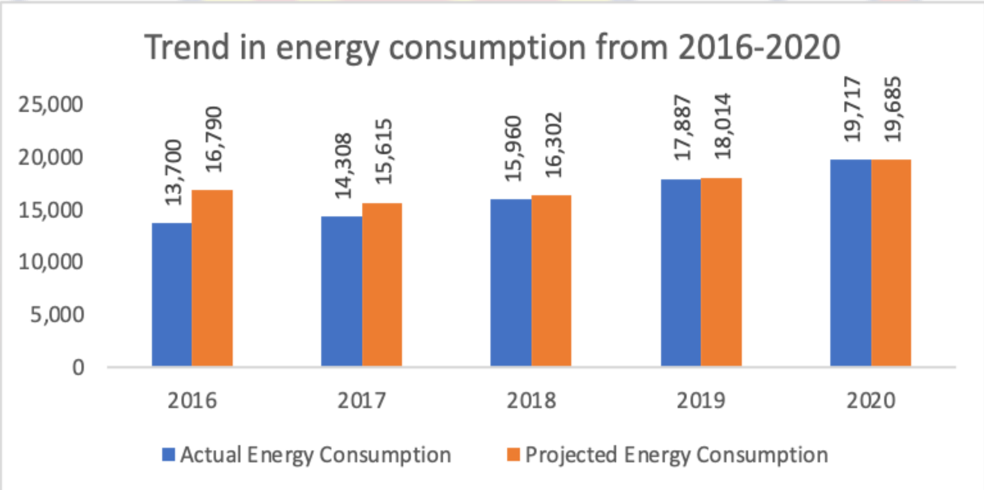


Figure 2.9: Trend in Energy Consumption from 2016-2020

Source: Energy Commission- Energy Outlook for Ghana (2021)

When losses are taken into account, overall energy consumption in 2020 increased by 10.2 percent from 2019 to 19,717 GWh (17,887 GWh). Actual energy use in 2020 was 0.2 percent higher than the predicted 19,685 GWh (Energy Commission, 2020).

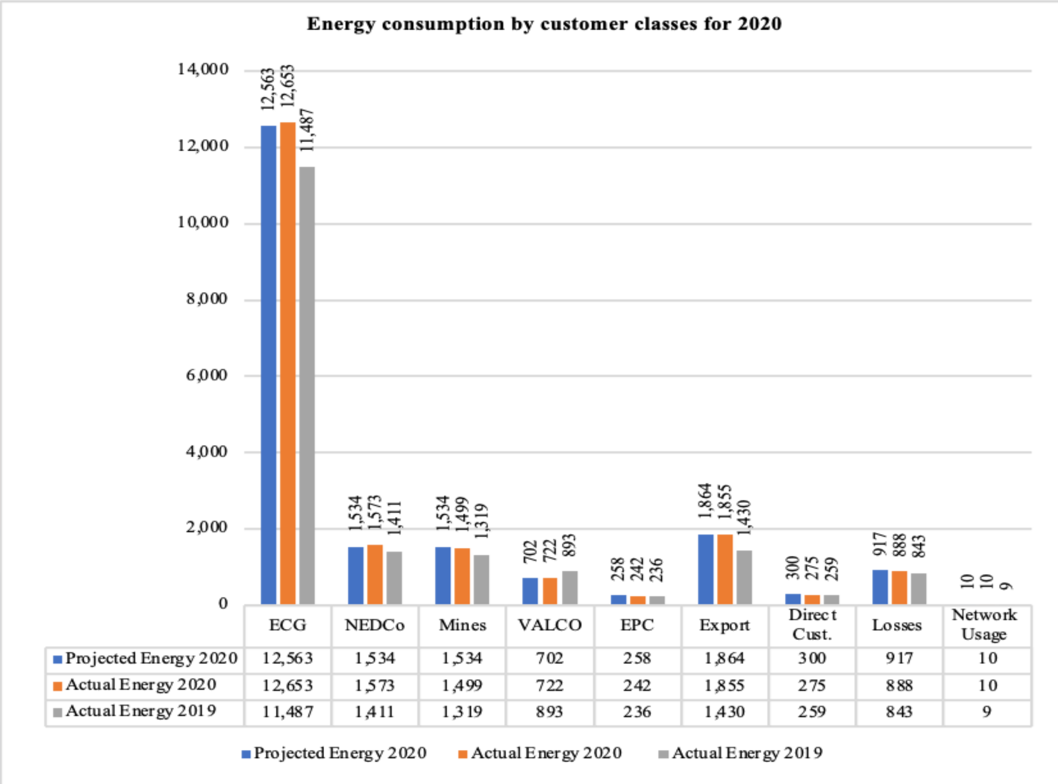


Figure 2.10: Energy Consumption by Customer Classes for 2020

Source: Energy Commission- Energy Outlook for Ghana (2021)

The amount of energy consumed by ECG in 2020 grew by 10.2 percent over the level of the prior year and was 0.7 percent more than expected. An 11.5 percent yearly growth was expected for NEDCo in 2020; and up 16.3 percent, from 1,319 GWh in 2019 to 1,499 GWh in 2020, was the mining load. On the other side, VALCO's energy usage dropped from 893 GWh in 2019 to 722 GWh in 2020, a 19.2 percent decline. The cut occurred as a result of VALCO's inability to concurrently operate two pot lines as planned. The anticipated increase in consumption from direct clients in 2020 was 5.9 percent on average. 2020 saw a 29.7 percent increase in export consumption as a result of greater supply to Burkina Faso and Compagnie Ivoirienne d'Électricité (CIE) in the fourth quarter.

2.1.1.6.3 Types of Electricity Market

There are four major markets for energy, depending on the kind of market a nation conducts. The type of market might significantly affect the financing strategy. Financing for sustainable energy is no exception to this rule. A country's market structure is depicted in Figure 2.10.

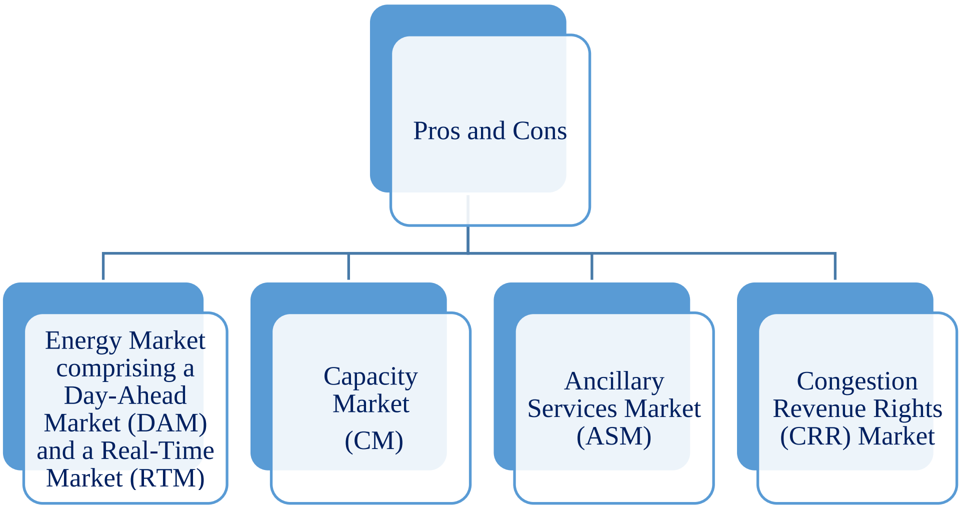


Figure 2.11: Type of Electricity Market a Country can Operate

Source: Author's Construct

Day-Ahead Market (DAM)

You can sell and buy electric energy on the day-ahead market; that is one day before delivery. Buyers and sellers submit their bids to a market operator, who acts as the central counterpart. An energy offer describes the quantity and cost of the energy that a market player is prepared to contract. According to the pricing, the seller or buyer is prepared to supply or consume energy in the case of offers or bids, respectively, at a minimum or maximum price. All sell bids are arranged in ascending price order to produce a cumulative selling curve.

Similar to how the cumulative purchasing curve is constructed, the purchase offers are arranged in decreasing price order. The intersection of the two curves yields the market-clearing price and volume (Asija & Viral, 2021).

Pros

- Allows suppliers to better arrange slower-starting units in order to fulfil predicted demand.
- Increases system dependability by allowing enough time for plants to be planned.
- Over time and in competitive market, market clearing price incentives power plant operators to operate more efficiently and invest in more efficient units.

Cons

- Because pre-dispatch already predicts market outcomes, any scheduling benefit may be restricted.
- If the amount of fast-start generation grows, market signals promoting slower-start generation may become less effective.
- Can be prone to market swings and gaming by market participants if not effectively regulated, especially in the case of unplanned fuel disruptions and technical outages.

Real-Time Market (RTM)

The RTM is a commonly utilized platform all over the globe. In India, the Central Electricity Regulatory Commission (CERC) is attempting to make the power market more dynamic by allowing half-hourly auctions for electricity trading. The RTM is set up as a half-hourly market, with 48 auction sessions lasting 15 minutes each. The auction sessions take place on the hour in even time blocks, with delivery starting one hour after the trading session ended. As a result of the real-time market, buyers and sellers can buy or sell power from anywhere in the nation with only one hour's notice. The double-sided closed auction underpins RTM, ensuring transparency and competitive price discovery. RTM makes it easier for utilities to lessen their reliance on deviation frameworks and avoid paying large fines. Furthermore, a RTM assists grid operators in improving the grid's overall safety and security. The real-time market assists DISCOMS to effectively forecast and schedule green energy, thereby supporting national green energy goals. India has set a goal of increasing renewable energy capacity by 175 GW by 2022 (Rajiv, 2021).

Pros

The RTM modifies projected demand in the day-ahead market based on real-time demand, enabling market participants to make hourly bids for energy and related services at least 15 minutes before each operational hour.

Cons

Given the presence of different marketplaces with varying degrees of complexity, the major problems for electric generators are their energy placement on the market. These are intended to be exchanged based on final user demand estimations — from long to short term — enabling users to plan their consumption more efficiently and secure rates to make their predicted spending more predictable. This market requires a minimum level of technical sophistication by grid operators and power plants to operate on such short intervals.

Capacity Market (CM)

One of the core initiatives of the electricity market reform program is the CM. The CM strives to assure future power supply security at the lowest possible cost to customers. Customers continue to have access to dependable electricity at a fair price thanks to the capacity market, which serves as a safety net against upcoming blackouts, such as during periods of low and high demand. By providing incentives to encourage new capacity investment or to maintain existing capacity, the capacity market aims to ensure that there is adequate reliable capacity available. The agreements that confirm the CM responsibility and the quantity of capacity payments are based on the auction clearing price (EMR Settlement Limited (EMRS), 2014).

Pros

Implementing a capacity market may increase supply sufficiency while also lowering consumer prices. It mostly results in increased investment in low-cost peak generating units. If the administratively defined reserve margin is large enough, uncertainty or demand shocks have no effect on supply security. For assuring dependability, a capacity market has been determined to be more successful than a strategic reserve.

Cons

It is notoriously difficult for any power system to strike the optimum balance between keeping enough electricity producing capacity to satisfy peak demand while not paying for an excess of idle power plants. Over-capacity incurs additional costs, while under-capacity causes blackouts. Excess capacity has generally been considered an acceptable expenditure in industrialized nations, because power outages may have considerably bigger economic effects than paying a little too much for a steady supply. That is no longer true. Generators and suppliers in liberalized economies must conform to market efficiency.

Ancillary Services Market (ASM)

The term "ancillary services" refers to a group of services needed to maintain the security of the power system, assure power supply, and meet criteria for voltage, frequency quality, and other factors. Ancillary services primarily consist of: (1) frequency stability services like speed regulation control, automatic generation control, and reserve services (spinning reserve and non-spinning reserve); (2) voltage stability services like reactive power support and voltage control; (3) transient stability services like load shedding, automatic islanding, and PSS stability control; and (4) other ancillary services like blackout protection (Asija & Viral, 2021).

Transmission bottlenecks and frequency fluctuations in the national grid are intended to be relieved by ancillary services. These services are frequently provided by primary reserves, secondary reserves, quick tertiary reserves, and slow tertiary reserves (response times of greater than 15 to 60 minutes).

Cons

The restricted size and character of the market are the main obstacles to the effective operation of the ancillary service market when DISCOMs use these services primarily to fulfil their energy needs during peak hours rather than to address unexpected changes in supply and demand for power.

Congestion Revenue Rights (CRR) Market

The owner of a CRR receives a charge or payment as a result of the financial instrument (DAM). In the energy sector, CRRs can be utilized as an investment vehicle or as a financial hedge. Congestion Revenue Rights are available and entitle owners of such instruments to a stream of hourly payments or fees linked to income the Electricity Transmission Utility (ETU) collects or pays from the hourly Day-Ahead Locational Marginal Price's (LMPs) Marginal Cost of Congestion component.

Characteristics of Ghana’s Electrical Energy Market

Ghana's electricity market, which is mostly divided into the regulated and unregulated sectors, is where electrical energy produced there is traded. The electricity market can be divided into the following sub-markets based on the geographical regions of electricity consumers and their corresponding energy suppliers: the mines, the export market (Burkina Faso, Cote d'Ivoire, Togo, and Benin), and the bulk consumers. These sub-markets are: EPL, NEDCo, and ECG. The Power Planning Technical Committee (PPTC), which is jointly directed by the GRIDCo and EC with assistance from MoEn, conducts assessments on a regular basis to determine the existing and projected demand for the power sector. In Ghana's electricity industry, the regulated market, which consists of ECG, NEDCo, and EPL, accounts for the majority of demand at roughly 80 percent. The Volta River Authority is primarily responsible for providing electricity to mining, the export market, and large customers (VRA). Hydroelectricity, Ghana's main energy source, is produced by the Volta River Authority. While the NEDCo is in charge of distribution in Ghana's northern area, the ECG distributes electricity mostly inside the southern portion of the country.

Hydroelectricity is the main source of power in the country, which is produced exclusively by the VRA and Bui Power Authority. A portion of electricity is generated by thermal energy. Population expansion, rural electrification, and industry expansion have all led to a rise in thermal power. The Takoradi thermal plant, built by the Ghanaian government in collaboration with a private company to fill this requirement, now supplies the VRA with about 650 MW of power. Energy prices in Ghana are governed by the PURC. Ghana has an agreement with Côte d'Ivoire that allows it to import or export power as needed. Ghana also exports energy to Togo.

The general structure of Ghana's energy sector is shown below.

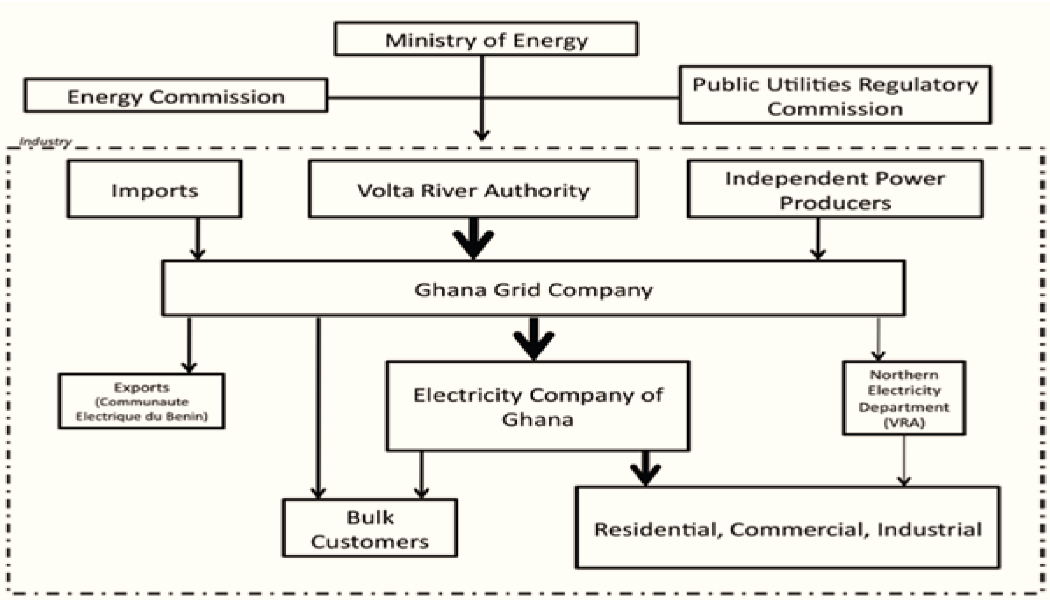


Figure 2.12: General Structure of Ghana's Energy Sector

Source: Author's Construct

The Ministry of Works and Housing's Public Works Department's Electrical Department formalized the electricity sector in the beginning of the 1960s. The electricity industry then turned into a public monopoly. The Volta Development

Act, which was passed in 1961, created the VRA Act 46. VRA built the Akosombo Generating Station (GS) in 1965 (first power plant). A transmission grid was constructed with VRA's oversight. Production and transmission of power were vertically integrated by VRA. The Ghana Power Department became the entirely state-owned ECG in 1963, changing its name from the Ghana Power Department. In order to take over the duty of electricity distribution in Ghana's northern area from ECG, the Northern Electricity Business (NEDCo) was founded as a semi-autonomous distribution company under VRA in 1987.

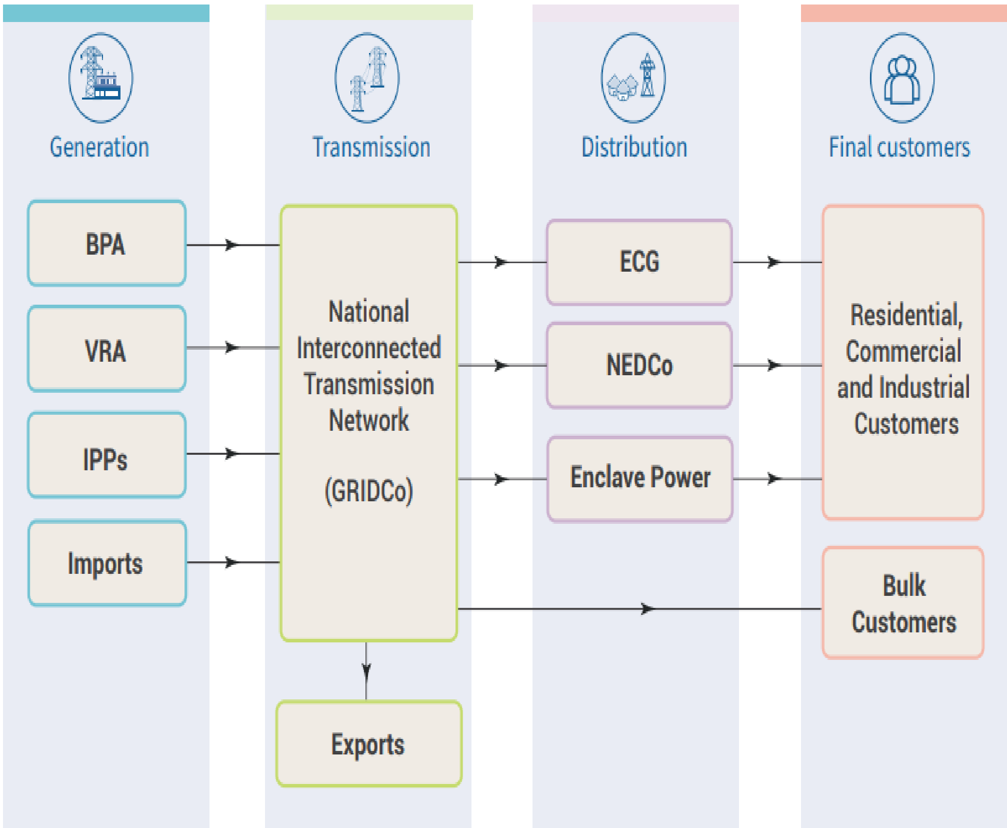


Figure 2.13: Electricity Supply Structure in the Electricity Market

Source: United Nations Economic Commission for Africa (2021)

Reforms in the Ghanaian Energy Space

The purpose of Ghana's power sector reforms, which started in the 1990s, was to introduce competition, open up the system to private investment, and increase the effectiveness of the delivery of energy services. The reforms included extensive institutional and policy adjustments to support the sector's transition to meet worldwide standards. The VRA, the primary power utility, owned and managed all of the assets used in the production, transmission, and distribution of electricity prior to the reform. This structure was vertically integrated and monopolistic. The changes led to the division of the services for generation, transmission, and distribution, which are currently under the administration of distinct independent utilities. The National Interconnected Transmission System, which is owned and run by the National Grid Company, or GRIDCo, is at the centre of the updated power market.

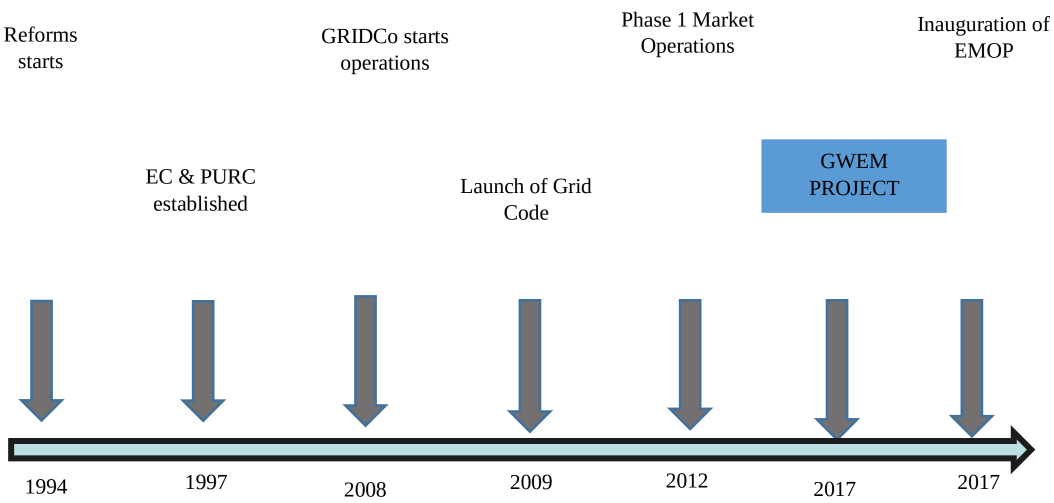


Figure 2.14: Energy Reforms in Ghana

Source: Author’s Construct

The worldwide electricity market is organized into many market structures. The United States, for example, operates under a number of market systems, depending on the states in which it operates. Similarly, depending on the distribution under consideration, Ghana's electricity market has a varied market structure in operation.

2.1.2 Sustainable Development

The concept of sustainable development has grown in popularity across the world over time. Therefore, according to the Brundtland Report's definition of sustainable development in Our Common Future, "Sustainable development is development that satisfies the requirements of the present without compromising the ability of future generations to satisfy their own needs" (Brundtland, 1987), it is now outdated. The report's main goal was to encourage economic growth without endangering the environment or obstructing prospects for further economic progress. In general, it was an idea related to the environment. The three pillars of sustainable development (environmental, economic, and social) were, however, articulated more extensively as time passed. This strategy is described in modern times to suggest that choices must support inclusive economic growth, justice, and fairness in social development, as well as protecting and restoring the planet's environmental quality (IISD, 2019). There are other environmental issues and threats to world development in addition to climate change. But given its size and the significant hazards it presents; climate change is exceptional. It puts at risk the advancements made in development over the previous few decades and is a powerful danger multiplier for other pressing issues including habitat loss, disease, and global security (Fankhausera & Sterna, 2016). If left uncontrolled, climate change may radically alter where and how humans and other animals may survive on Earth. As long as natural systems continue to be able to supply the natural resources and ecosystem services that are essential to the economy and society, sustainable development will be the organizing principle for achieving human development goals. A civilization that continues to fulfil human needs while maintaining the stability and integrity of the natural system is the intended outcome. This is achieved through using resources and living circumstances in this way. The ability of future generations to fulfil their own requirements must not be compromised for growth to be sustainable (Shaker, 2015). Based on indicators or other criteria, sustainable development may be evaluated. Although additional measures, such as the Millennium Development Goals, exist, the study in this section focused on four fundamental indicators of sustainable development. According to studies, when these signs are common, a nation has achieved sustainable development. Globally, people are becoming more conscious of the need for sustainable development. Regarding culture, values, and expectations, quality of life examines how individuals see their place in the world. It becomes clear that there is a positive association between self-reported well-being and total life satisfaction when using indicators like the UNDP's human development index and life satisfaction rating.

A similar environmental performance indicator that the UNDP offers correlates with happiness. These relationships are visible at both the national and local levels. Sustainable development calls for meticulous planning that is site-and culture-specific and incorporates community and citizen engagement in order to improve quality of life, especially at the city level. Sustainable development will increase the possibility of being able to satisfy the demands of future generations by enhancing the quality of life and addressing existing needs. Therefore, a measure of sustainable development is quality of life. The degree of health care, education and literacy levels, life expectancy, the number of physicians per person, daily calorie intake per person, infant mortality, and access are all measured using human development as a sustainable development indicator (Robert et al., 2005). The availability of doctors' services and healthcare is a crucial sign of sustainable growth. Numerous additional metrics, including infant mortality and life expectancy, might be impacted by this.

There must be better health care, high-quality education, and reduced infant mortality rates, among other things, for sustainable development to be fulfilled. Similarly, this indication has been used to gauge access to good drinking water. The fulfilment of fundamental human needs is one of the key elements of sustainable development, and human welfare is a key indicator of sustainable development (Department of Economic and Social Affairs Social Inclusion, 2022). In fact, the notion of sustainable development includes the idea of needs. The government's or other organizations' financial support is frequently linked to human wellbeing. But it goes farther than that. Human or social welfare, in its most basic definition, attempts to reduce poverty and suffering among the suffering people within a community. It is not always equivalent to offering financial support. The United Nations defines human welfare development as providing individuals access to necessities including information, comforts, and resources. All of these things are necessary for people to live long, healthy lives and be able to contribute to their communities.

Standard of living, which is typically ascribed to a community or area rather than a person, gauges the amount of accessible money and amenities. The standard of living matters because it affects a person's quality of life (Britannica, 2018). Britannica (2018) further argued that standard of living is often concerned with impersonal, objective measures such as economic, sociological, political, and environmental issues. These are the kinds of elements that a person could take into account when deciding where to live in the world or how well an economic program is working.

The quality and accessibility of employment, class disparity, poverty rate, quality and affordability of housing, hours of work required to purchase necessities, inflation rate, amount of free time, access to and quality of healthcare, quality and availability of education, literacy rates, life expectancy, occurrence of diseases, price of goods and services, infrastructure, access to, quality and affordability of housing, hours of work required to purchase necessities, gross domestic product etc. It is typically compared throughout time or across groups identified by social, economic, or geographic criteria for economics and policy objectives. Standard of living is used to gauge sustainability.

2.1.2.1 Indices for Sustainable Development in the Energy Sector

Using the same conceptual framework as the United Nations Commission on Sustainable Development, this section divides the variables in the EISD core set into dimensions, subjects, and sub-themes. The indices are separated into three groups (social, economic and environmental). The most significant issues at the ninth session of the Commission on Sustainable Development (CSD-9) were pushing for less wasteful use of energy resources by the rich and increasing the cost and accessibility of modern energy services for the rural and urban poor. In order to provide energy for long-term growth, good practices such as the dissemination of knowledge about clean and efficient technologies and proper legislation were viewed as essential. The worldwide community came to the conclusion that useful information might aid in the selection of suitable policy and energy supply options, and that energy indices could be used to monitor the effects of those choices (The World Bank, 2021). Among the judgments taken at CSD-9 that were pertinent to the refinement of the EISD was the identification of the key energy challenges of accessibility, energy efficiency, renewable energy, advanced fossil fuel technologies, nuclear energy technologies, rural energy, and energy and transportation.

Additionally, as external expenditures can be challenging to quantify, using indices may help in finding solutions. Through more or less effective responses to more or less appropriate legal and financial incentives, energy markets may and do accept the internalization of some of energy's "external costs". However, certain external expenditures are more difficult to absorb and must therefore be covered by society. Oil refineries, electrical lines, and other energy infrastructure can have externalities that affect people's health, the environment, and the value of their homes. What does a tonne of radioactive waste produced by a nuclear power station, a tonne of nitrous oxides released by a gas or coal power plant, or a tonne of wind turbine landscape damage cost? What penalties or benefits apply to each energy technology? Indices that evaluate energy intensity, accidents per unit of energy, and environmental effects per unit of energy might help policymakers choose the best policies, like fines or subsidies, to encourage the development of efficient and sustainable energy sources. The development of indices to gauge the extent of external cost internalization might lead to their eventual incorporation into the EISD.

Sadorsky (2009) contends that between 1980 and 2005, the grid integration of renewable energy resources in the G7 countries had an impact on the economy of those nations. A positive impact was discovered on real GDP per capita and

CO_2 emissions per capita, while a negative impact was observed on oil prices. The study employed Panel cointegration techniques to arrive at these results.

Marques et al. (2010) identified the driving variables for clean energy projects using data from 1990 to 2006 on 24 European Union countries, including the adoption of Directive 2001/77/EC, EU membership, the influence of lobby pressure, energy self-sufficiency, CO_2 emissions, and income. For the same stated number of nations and research period, Marques et al. (2011) used Quantile regression and made the same findings. Using panel dynamic estimators on the same dataset, Marques et al. (2011) found that the quantity of renewable energy consumed in the previous period had a positive and highly significant impact on the level of usage in the present. Conventional energy sources hinder the use of renewable energy. Social concern for sustainability, the prevention of climate change, or CO_2 reduction targets will not be sufficient to ignite a transition to renewable energy sources. Between 1990 and 2006, market factors (income and the cost of fossil fuels) had little influence on the advancement of renewable energy.

Aguirre and Ibikunle (2014) examined the variables impacting clean energy financing for the OECD and Brazil, Russia, India, China and South Africa (BRICS) countries using fix effects vector decomposition (FEVD) and panel-corrected standard error (PCSE) estimations. For this investigation, data from the years 1990 to 2010 were used. Environmental issues take precedence over energy security (CO_2 emission levels). The study's results demonstrated a negative correlation between energy use and the utilization of renewable energy sources as well as high power costs for the industrial sector. The percentage of coal, oil, natural gas, and nuclear power in the energy mix is negatively connected with the use of renewable energy. Unacceptably high levels of uncertainty are created by the negative effects of often used political aspects (Voluntary Approaches, Fiscal and Financial Instruments), which heighten the chance that the design of clean energy deployment plans has failed.

The two primary variables impacting the financing of renewable energy, according to Omri and Nguyen (2014), are increased trade openness and a reduction in CO_2 emissions. A dynamic panel data model analysis of data from 64 countries collected between 1990 and 2011 is used to support this assertion. Lucas et al. (2016) claim that pollution does not properly encourage the expansion of RE since increased CO_2 emissions lead to less RE pledges. In contrast to prior studies, Aguirre and Ibikunle (2014) and Cadoret and Padovano (2016) support a positive correlation between CO_2 emissions and RE development.

According to Böhringer et al. (2013), Germany's subsidized power production from renewable energy implies that the chances of increasing employment and wellbeing are fairly slim and that the size of the financing mechanism and the subsidy rate are the two factors that matter most. If labour taxes are used to pay for renewable energy facility subsidies, welfare and employment effects are categorically negative across a wide range of subsidy rates. When funding renewable energy systems through an electricity tax, little gains are made at low subsidy rates, but when the subsidy rate rises beyond a certain threshold, these gains quickly turn into large losses.

According to an early study by Kammen et al. (2004), increasing the amount of renewable generation can result in the creation of jobs, but the methodology essentially involves calculating the effects on employment of switching from one unit of electricity generation from conventional technologies to renewable technologies.

To attract foreign investment in renewable-power technologies, national renewable energy policies must be established (Gambhir et al., 2014). In particular, it is projected that feed-in tariffs will be particularly successful in attracting investment in this industry (Eyraud et al., 2013). With a feed-in tariff, renewable energy producers have a set price and a long-term buying commitment. Likewise, it is believed that subsidies and fiscal incentives will have a positive effect since they cut investment costs (Romano et al., 2017).

Clean Energy Financing and Sustainable Development

The study at this point looked at how clean energy financing promotes economic growth and sustainable development. In addition, it elaborates the interconnections between clean energy financing and sustainability development in the context of the electricity market.

Not only has clean energy funding been recognized as an essential element for tackling the problems caused by climate change, but it is also an essential strategy for advancing and attaining sustainable development. According to the empirical data, clean energy finance encourages the use of renewable energy technology, energy efficiency, access to clean energy, and innovation in clean energy technologies, which all contribute to sustainable development. Wang et al. (2022), Zhou and Li (2022) and Zhang and Wang (2021), for instance, all discovered evidence in favor of the beneficial impact of green funding for sustainable development. On the other hand, Siemiatkowski et al. (2020) employed a method of linear ordering to analyze how the funding of renewable energy affected the evaluation of sustainable development in Polish districts.

According to the study's findings, Poland's degree of sustainable development is being impacted by finance for renewable energy in an increasingly negligible way.

The effectiveness of sustainable energy finance programs, however, depends on a variety of variables, including institutional capability, stakeholder participation, and legislative frameworks. In a research on the determinants of green financing in China, for instance, Xu et al. (2022) found that feed-in tariffs, legislative support policies, and international financial aid are the main proponents of green finance in China. The importance of green finance in attaining the SDGs was also examined by Lee (2020) through a desk-review. In further detail, the study looked at how the public and private sectors may work together to advance green financing. The research found that actions including greening the banking system, the bond market, and institutional investors are essential for green finance as well as the private sector to pursue since they may improve the performance of the SDGs. In a similar spirit, it was proposed that the public sector establish rules and capabilities, support market transparency and governance, and encourage private-public partnerships for diversified green financing resources.

The effects of financial development and FDI on renewable energy in the United Arab Emirate (UAE) were studied by Samour et al. in 2022. A Bootstrap Autoregressive Distributed Lag (BARDL) and Granger causality study for the years 1989 to 2019 showed that boosting FDI and fostering financial growth are crucial to raising the UAE's use of renewable energy. In the instance of China, Zhang and Wang (2021) emphasize that financial growth may serve as a conduit for enhancing and using green finance to support sustainable development. Therefore, the financial system needs to be reinforced in order to prevent the financial risks that come with inadequate financial systems, which frequently threaten the stability of the financial markets and have an impact on the use of renewable energy. In order to help the endeavor to achieve sustainable energy development, policies that promote green financing and stimulate investments in green energy projects must be promoted.

The research found that clean energy finance encouraged the use of renewable energy technologies, which have a smaller carbon footprint than fossil fuels. This lowers greenhouse gas emissions and aids in reducing the impact of climate change, which poses a significant obstacle to sustainable development. Using primary survey data from 220 respondents in Indonesia, Ronaldo and Suryanto (2022) investigated the impact of green energy funding on sustainable development (with an emphasis on environmental and economic sustainability). It was discovered that green finance is crucial for supporting both environmental and economic sustainability by using smart-Partial Least Squares to identify the relationship and test the hypothesis. According to the finding, expanding green financing can improve economic and environmental sustainability by encouraging the creation and growth of green microenterprises and green technological innovation.

According to research by Sachs et al. (2019), financial institutions find it easier to deal with fossil fuel projects than with green projects, mostly because of the dangers attached to some of these new technologies. The authors went on to point out that in order for countries to meet the sustainable development goals, they must make a concerted effort to open a new file for green projects and scale up the financing of investments that provide environmental benefits, through new financial instruments and new policies, such as green bonds, green banks, carbon market instruments, fiscal policy, green central banking, financial technologies, community-based green funds, etc. Clean energy finance might increase access to and affordability of clean energy by encouraging innovation in clean energy technology, which can result in additional increases in efficiency and cost-effectiveness. This would assist sustainable development even more.

Once more, it was shown that finance for clean energy may support policies that cut energy usage and hence lower greenhouse gas emissions. This is crucial in developing nations where there are many opportunities to increase energy efficiency. Rasoulinezhad and Taghizadeh-Hesary (2022) looked at how green funding might help with developing renewable energy sources and energy efficiency in Iran. The release of green bonds may considerably increase the promotion of green energy projects and the reduction of CO_2 emissions, according to research done using panel data and a stochastic regression model. According to the findings, green energy investment projects must be supported by policies if sustainable development is to be achieved.

In light of government spending and investments in renewable energy, Wu and Song (2022) examined whether green finance and Information and Communication Technologies (ICT) are relevant for sustainable development. The study used the Augmented Mean Group (AMG) for analysis using panel data. According to a study, variables, including economic expansion, government spending on health care and R&D, and FDI, tend to boost the development of green finance and renewable energy. However, the growth of green finance and renewable energy is slowed by the increase in emissions and environmental damage.

All in all, access to clean energy, especially in rural regions where there is frequently a lack of access to power, may be increased through clean energy finance. This can thus raise living standards and lower poverty, which are crucial elements of sustainable development.

Using panel cointegration and panel vector error correction modeling techniques, Zhang (2014) investigated the causal link between power consumption, economic development, and CO_2 emissions for a set of 14 SSA nations from 1980 to 2009. The study's findings show that using electricity has a long-term, statistically significant beneficial effect on CO_2 emissions. The findings also show that the SSA nations' example fits the inverted U-shaped Environmental Kuznets Curve (EKC) theory. According to the panel causality tests, there is a short-run unidirectional causal relationship between economic growth and CO_2 emissions as well as energy use. Likewise, there is a long-term bidirectional causal relationship between power use and GDP, electricity use and CO_2 emissions, and GDP and CO_2 emissions.

2.2 Review of Major Theories

The preference theory, life-span theory, positive signalling theory, dependence theory of development, and modernization theory of development are some of the clean energy finance ideas that have been examined.

2.2.1 The Preference Theory

The central argument put forward by this theory is that the amount of effort economic agents are willing to give for achieving sustainable finance goals can be reflected adequately by the level of priority given to the sustainable financing agenda (Wilson, 2010). The level of coordination and collaboration together with the speed at which consensus is achieved, and action taken is important for assessing the priority level of economic agents in this regard. Therefore, if sustainability issues are given utmost priority, economic agents are more likely to support clean energy financing.

Importantly, the theory recognizes that priorities of economic agents can be many and different; hence, the need for them to be ranked in order of preference. Again, agents' priorities or order are not fixed, and is liable to a change in response to the current reality of a time (Ozili, 2022). This assumption provides hope for the investors pursuing the emerging area of clean energy transition. Therefore, with the right promotion and education on the need for a green and sustainable economy, over time, economic agents' perception might become more positive and eventually become a top priority on the development agenda. Subsequently, this would attract both technical and financial support in clean energy projects. However, there is an element of trade-off embedded in this theory since prioritising clean energy financing requires deserting another goal. If the trade-off is very costly, economic agents might decline the idea of prioritising clean energy financing at a particular time.

One advantage of this theory is that it allows economic agents to assess and effectively determine the importance to give a particular goal. Another is based on the assumption that the scale of priority preference can change. In this regard, if a country, at a point in time, experiences a low priority for clean energy financing among economic agents, more knowledge about the general welfare benefits and the potential consequences for not supporting clean energy products might change perceptions, consequentially improving the priority placed on sustainable financing. For instance, this would encourage the country's financial institutions to adopt and incorporate, as part of their business model, sustainable financing policies that can easily support green economy projects (Cunha et al., 2021; Setyowati, 2020).

2.2.2 The Life-Span Theory

According to Ozili (2022), this theory asserts that, like any marketable product, economic agents are aware that clean energy financing products, services, instruments, schemes, policies or activities have a cycle that begins with sustainable finance being introduced as a new concept and ends with its growth, maturation, and eventual decline. This theory is similar to Vernon's Product Life Cycle Hypothesis (Vernon, 1979). According to this theory, it is essential for economic agents to be aware of the present state of a clean energy project or product since this information will help them make an informed decision about whether to make a short-term, medium-term, long-term, or no commitment at all.

Therefore, with full disclosure and economic agents' articulation of the project based on the available information, a decision could be made. Short term commitment is likely if the project is perceived to be short-lived. On the other hand, the commitment will be long-term if the clean energy financing project is expected to last long and become the new mode of operation. According to Ozili (2022), the recognition placed on information and prediction in this theory provides a plausible explanation as to why there might be an increase (or decrease) in support for certain clean energy financing instruments (like green bonds). Thus, if the green bond market is expected to grow and flourish, economic agents are likely to make long term investment; otherwise, they will completely abstain or make short-term investments. However, a possible limitation of this theory is the likelihood that the predictions of the life cycle stages of sustainable financing projects might be inaccurate or not even be available.

2.2.3 Positive Signalling Theory

Since energy efficient markets are emerging, potential investors or financial institutions might require more information about the market before making a decision to invest in green projects or provide capital loans to such projects. In this regard, the positive signalling theory comes in handy. The main argument of the theory is that as a signal of good news to potential investors, there is an incentive by economic agents to disclose positive information about their intentions to pursue any sustainable finance goal (Quatrini, 2021). Signalling channels can be through direct public media announcements or via annual published financial and non-financial reports (Ozili, 2022).

This makes it simple to acquire funding for green initiatives. For example, if a private company regularly publishes information about their sustainable financing products or instruments (such as green bonds), or if the government declares its intention to implement a national green financing policy, this could have the tendency to draw investors who are interested in clean energy or energy efficiency. Additionally, releasing a national policy intent will improve the nation's image for sustainability and show that it is prepared to welcome outside help and investment for green project-related initiatives (Ozili, 2022).

However, as much as the disclosure might eliminate the possibility of information asymmetry that may exist between the firm and the investor, this might subsequently go against the fundamental principles of symmetric information. Besides, information about green projects is often limited to potential investors and financial institutions (Yodpradit, 2021); thus, making the assessment of the project in terms of valuation, risk construction and appraisal of investment difficult.

2.2.4 Dependency Theory of Development

The underlying premise of the dependency theory postulates that underdevelopment is primarily caused by the unequal relationship that exist between the poor countries (identified to be on the periphery) and developed countries (identified as the core) - the relationship being one of subservience, pillage and exploitation (Deng & Zhang, 2021). Putting this theory into perspective, Rodney (1972) focused on the socio-historic context of European and American expansion through the system of colonization – a system that allowed them to not only exploit but also shrewdly repatriate the profits made in their various colonies. From the dependency theory perspective, it can be argued that the development of the Western world was mainly derived from systematically expatriating the excess values created by African labour using African resources. Hence, the subordination of the continent plausibly explains its retarded economic development.

Sadly, this form of relationship between Africa and the West continues to exist even today, although in the form of economic and political dominance (Matunhu, 2011). In fact, unnecessarily, the developed nations (centre) wield pressure against developing nations (periphery), which inhibit their growth to a certain extent. Hence, it is plain from the basic message of the dependency theory that for the development of the centre, there must be an underdevelopment in the periphery.

The structure of the international economy is very much indicative of the dependence theory, with certain countries being favoured over others and restricting the possibilities of the development of dependent economies, despite the expansion in globalization, cooperation, and dependency links across states (Deng & Zhang, 2021). However, even though clean energy technologies are manufactured by developed countries, clean energy financing will result in the flow of funds to developed countries as proceeds creating technologies that will address the global challenge but not exploit developing countries. With this background, the theory of dependence theory provides an understanding that can address apprehension by developing countries towards clean energy financing.

According to the Keynesian economic theory, in order to strengthen national development conditions and raise national standards of living, the relationship should be driven by the desire to "increase worker income as a way of generating more aggregate demand in national market conditions" and "promote a more effective government role" (Reyes, 2001). This is because some global issues call for the pooling of resources from all countries. For instance, climate change, sometimes known as global warming, is a problem that affects everyone and is now the largest danger to progress. Without shared effort, the reversal of countries progress could be predestined. To avoid this, a reversal of the relationship is crucial if developing countries are to generate and mobilize resources to meet clean-energy infrastructure needs, and ultimately achieve sustainable development.

2.2.5 Modernization Theory of Development

The argument brought forward for the theory of modernity is that it explains the process of development: how society advances, the factors responsible or influencing such progress, as well as the response mechanisms to such progress. Hussain et al. (1981) claim that the theory's statement covers all phases of the transition and radical change that traditional cultures need to make in order to become contemporary. The stages of modernisation are frequently described using Rostow's growth model. According to Rostow's theory, development proceeds in a straight line from a traditional or primitive society through the pre-requisite for take-off, the take-off stage, the drive to maturity, and finally a time of intense mass consumption. According to Willis (2005), the age of high mass consumption is the time when the general public can spend a lot of money on consumer goods and the economy is heavily industrialized, urban, and less reliant on agriculture. The phases were a good fit for the concept of modernity theory (Mutunhu, 2011; Reyes, 2001).

The norms established in Europe and America via industrialization, urbanization, and the expanding usage and application of technology across all sectors of the economy today define what is meant by "modern" (Willis, 2005). Reyes (2001) said that contemporary civilizations "...are more productive, children are better educated, and the destitute receive more welfare...a clear description of functions and political tasks from national institutions". This is characteristic in the global North. But it is important to note that the term "modern" is dynamic. Since what was originally deemed contemporary in the 1950s is different from what is deemed modern today: it is more of a dynamic idea that changes with new advancements.

The modernity theory was initially built on the idea of mobilizing technology to use resources more efficiently for production (Matunhu, 2011; Willis, 2005), and the idea that development was limited to economic indicators like GDP, GNP and GNI, ignoring non-economic indicators. According to Willis (2005), natural resources were merely seen as inputs into a human-devised system, and the long-term sustainability of this approach was largely discarded. While some of these technologies led to some positive growth results for countries like India and Indonesia to name but a few, they were environmentally inappropriate (Willis, 2005). Some of the negative consequences on the environment from using such technologies included loss of diversity, increased demand for water, and pollution (Barrow, 1995).

Huber (1982; 1984; 1985) made the argument that ecological modernization is inexorably a stage in the growth of industrial society by the 1980s, as referenced by Andersen and Massa (2000). The effects of human activities on the environment are brought into balance at this stage. The underlying principle of this concept is that environmental issues might be resolved by changing the way things are produced by creating and utilizing more advanced technology. As civilizations got more advanced, the need for environmental sustainability and efforts to use technical innovation to separate environmental effect from economic growth became more and more important. In this process, however, Huber considered economic actors and entrepreneurs as the most important players in achieving the transformation to ecological modernization. Nevertheless, the role of the state must not be underestimated. Their role in regulating the market and ensuring that the market operates efficiently are essential.

2.2.6 Behavioural Choice Theories

A decision's fundamental rationale is often focused on how those decisions would be seen to have an impact. Under this general heading, the study discusses related theories that aim to offer a framework for understanding and projecting their behaviours in order to provide insight into the complex decision-making processes of the various stakeholders (end user, project developer, utility, government, policy, financiers, and entrepreneurs of clean energy) of clean energy financing. However, there is some dispute on how decisions about the funding of sustainable energy are made.

2.2.6.1 Theory of Consumer Behaviour

Consumer theory is predicated on individuals' decision to spend or make choices on a bundle of goods based on their preferences and budget constraints. While the theory is firmly based on the proposition about rationality and dependence of expenditure on income, consumption behaviour is explained by three main factors: income, prices and tastes. Any fluctuation in demand that cannot be simply traced to changes in real income and relative prices is tied to changes in tastes, according to Michael and Becker (1973).

In an attempt to expand its applicability, the theory of consumer behaviour is often modified by economists. But in doing so, the fundamental framework of the theory remains essentially unaltered. Despite this, the theory has come under fire for missing a usable or sophisticated framework to assess tastes, raising doubts about the extent to which changes in tastes may account for behaviour change since it is unable to explain how tastes are produced and how to forecast their consequences (Michael & Becker, 1973). Furthermore, by suggesting that the utility derived from goods and services is only acquired from the market, the theory has come under fire for omitting behavioural choices that are typically not made in the market sector and are largely immeasurable, such as religion, family size, political party, or way of life (Michael & Becker, 1973).

It was against this backdrop that Michael and Becker (1973) proposed a relatively new behavioural theory. Unlike the traditional approach, in explaining the behaviour of consumers, this approach placed greater emphasis on income and price effects over that of tastes. The rationale for this, the authors suggested, is primarily due to the lack of a well-developed theory to explain the behavioural responses as a result of tastes. Another important contribution in the theory is the consideration given to the environment in which non-market production occurs. The amount of technology included into the manufacturing procedure in this case reflects the environmental variable. Accordingly, Michael and Becker (1973) proposed that if families can influence the environment in which they reside, they would substitute toward those elements that promote productivity. They may result in increased political stability, improved health, higher levels of education, and ideal weather. Even though this theory is a significant advancement in the literature on consumer behaviour, its consequences have not been fully investigated.

Similarly, Katona (1968) forwarded the adaptive behaviour theory of consumers. This theory has the advantage of being applicable to the decision making of households in general. The central proposition of this theory suggests that, "success makes for the arousal of new wants and an improvement in the standard of living" (Katona, 1974). From this, one can infer that as per capita income rises in a country, demand for a sustainable environment increases in line with the Environmental Kuznet Curve (EKC). The theory is based on four key principles, namely:

i. Changes in the environment (stimuli) and the individual have an impact on how people react: $R=f(E, P)$. The stimuli elicit the response according to the motives and attitudes of the person responding.

ii. People work as members of larger organizations that they identify with. The influencing factors frequently vary amongst groups, yet they are often comparable among group members.

iii. Desires are not constant. Aspirational levels do not exist in a static form. Success raises them, while failure lowers them. Success and failure are viewed as subjective terms that reflect how an individual feels about his successes and setbacks.

iv. Most of the time, neither success nor failure is felt. Habitual behaviour predominates in the absence of considerable information about overall economic trends or significant personal financial pressures. Genuine decisions are formed when powerful stimuli are present because of inertia, the perceived incapacity to handle the numerous changes in the environment, and the effort needed to make a decision. To make individuals aware of a situation that requires a new choice, stimuli must be powerful. People continue to act in the same way they have in the past under similar situations in the absence of such stimuli; habits then govern behaviour.

In as much as the decision to spend and consume solely rests with the customer, it is important for them to consume in a socially responsible manner. Because responsible behaviour varies from person to person, it might be difficult to understand how far they go. Some customers are unwilling to make ecologically responsible choices. Because they lack the resources to support it or believe it to be less successful, they become reluctant to buy green items (Luchs et al., 2010). However, cultures that value the environment, are well educated (concerned with the literature and conversation around environmental concerns), and have better incomes are more inclined to support environmental causes and buy ecologically friendly goods and services (Diamantopoulos et al., 2003; Straughan & Roberts, 1999). Such actions are more frequent in industrialized nations than in emerging nations, as is to be expected.

2.2.6.2 Theory of a Firm

The theory of a firm, which provides insights into the operations of firms, is a microeconomic concept that is focused on determining the goods, output, and distribution of income in the market through the forces of demand and supply. While the theory has been progressed significantly, the dynamic process of growth and development has made understanding the behaviour and organization of firms a challenge for economists in contemporary times. Nevertheless, firms have always been an indispensable part of the economy, and subsequently, the process of development. Their role in the economy is core not only to the growth and prosperity of nations but also for the progress in technological innovation, which has greatly enhanced welfare and fostered the idea of globalization.

Typically, managers of firms act in the interest of their superiors (shareholders); thus, working as agents rather than for themselves. Therefore, the process of decision-making significantly differs from the kind made by individuals in the economy. In point of fact, the behaviour of firms emanates from a process of complex joint decisions within a network of agent relationships (Holstrom & Tirole, 1989). It goes beyond just the black-box concept of a production function to include contractual deigns, since firms nowadays are a form of contract between a multitude of parties (ibid).

An important aspect in a firm's decision mix is how capital is raised. As alluded to earlier, debt and equity are the two main instruments used to finance capital investment. Jensen and Meckling (1976) argued that since firms are controlled by self-interested agents, resulting in high agency cost due to the separation of ownership and control. According to the authors, some of these agency costs are associated with debt and equity financing. However, it was cautioned that if a firm raises its capital through equity, there is a likelihood of slacks, especially if the equity is held by third parties without direct management control. Instead, the firm will pursue activities that equate private benefits and costs. Therefore, to avoid the firm collapsing, management of the firm should have absolute ownership or capital should be raised through debt. However, debt financing incurs agency costs as well; while 100 percent ownership might lead to firm inefficiency (Jensen & Meckling, 1976). The optimal capital structure to minimize total agency cost is achieved by pitting agency cost of debt against the agency cost of equity (ibid). Other capital structure arguments include the signalling arguments and the capital irrelevance proposition by Modigliani and Miller (1963).

Increasingly today, firms are encouraged to consider integrating in their operational guidelines looking not only from the economic lens but also social and environmental. This is critical to achieving sustainable development. Normally, governments set sustainable development policies and enforce regulation where necessary while management systems are often applied voluntarily by the firm (Steurer et al., 2005). As such, the firm's decision would not only be influenced by the interest of profit but also government sustainable-related policies. And if the country is sustainability-conscious, the firm might submit and make decisions in line with the needs of society. Such a situation can cause a massive shift in the operations of a firm, if it was not closely aligned with the state's developmental policy.

2.2.7 Theory of Change

An explanation of how a certain intervention, or set of therapies, is likely to result in a specific development change is known as a theory of change. This explanation is based on a causal analysis of the data that has already been collected. A change theory aids in identifying solutions to effectively address the root causes of problems that impede progress and in guiding decisions about which approach should be used, taking into account UN comparative advantages, effectiveness, feasibility, and the uncertainties that are inherent in any change process. A theory of change may also help in identifying the underlying presumptions and dangers that must be recognized and examined throughout the procedure to guarantee that the approach leads to the desired transformation (Davies, 2018). This theory was used in the research to describe how the adoption and integration of clean energy technology can enable sustainable growth in Ghana's power market. Please see the framework in figure 2.15 for an understanding of the theory of change.

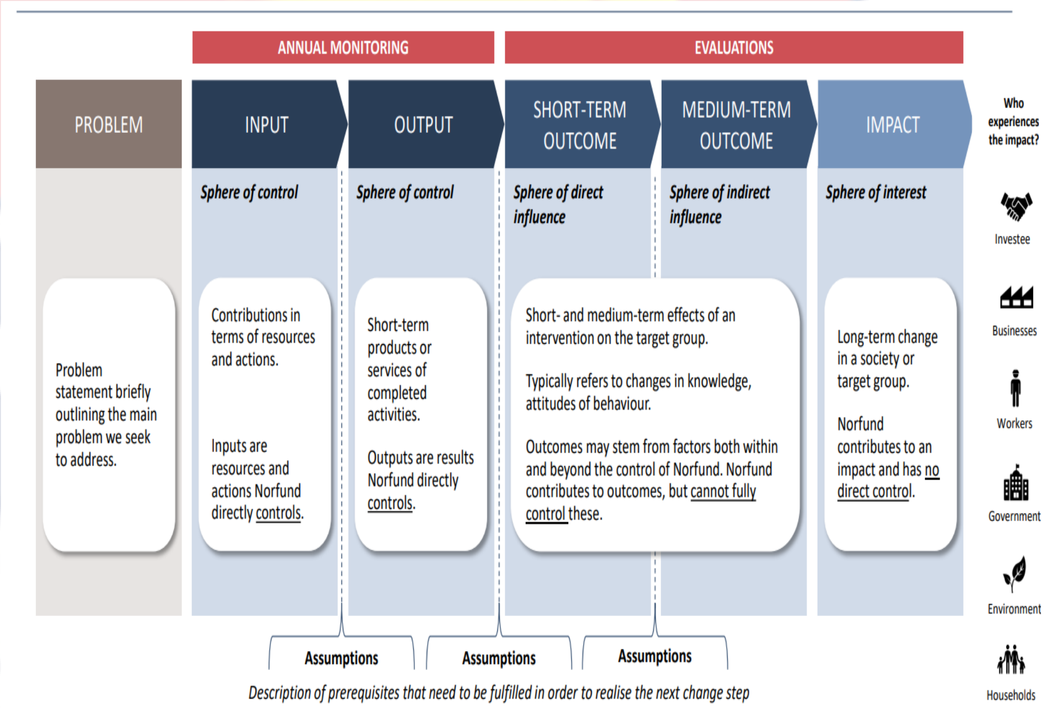


Figure 2.15: Theory of Change Framework

Source: Hilleren (2020)

In comparison to Spain, a country with a population of 47 million, the 48 SSA countries developed less generating capacity in 2017 (103 GW). Since installed capacity is insufficient to meet current demand, power shortages are inhibiting economic growth and the creation of jobs. In SSA, 79 percent of businesses experience power outages, and 53 percent of them rely on generators to supply their energy requirements. Forty percent of businesses consider energy access to be a major operational constraint. Many utilities rely on expensive peak power sources, such as diesel plants, to solve the problem. The need for significant expansions in power generation capacity is clear, particularly in view of the continent's vigorous economic progress, which has been the main factor driving energy consumption during the preceding ten years. To meet the anticipated demand in 2040, SSA would need to build 300 GW of capacity during the following several years. According to this, an increase in power generation capacity of more than US$ 490 billion would be needed by 2040. But in high-risk, capital-constrained locations, the generation of new clean electricity is not rising rapidly enough in the absence of Development Finance Institution (DFI) financing. Lack of well-prepared, "bankable" projects available to investors like Norfund is one of the main obstacles to the broad deployment and diffusion of clean and renewable energy. Although energy consumption and production stimulate economic growth, they also have a significant negative impact on the environment.

In SSA, the share of renewable energy in the electrical sector is still under 50 percent, and new coal-fired power plants are being built across the continent. The increased capacity required to tackle climate change should mostly come from renewable energy sources. Power outages and lost income are decreased because to the electricity produced by the larger production capacity. As a result, businesses rely less on pricey backup solutions. A higher level of electrical reliability enables businesses to make goods in a shorter time and at lower costs, which boosts corporate output and raises tax revenues. Lower energy costs may occur from a reduction in the need for pricey peak power supply due to the greater production capacity. The output from such sources helps to reduce GHG emissions since its GHG emissions are lower than those from fossil fuel-powered facilities. As a result, there has to be reform in Ghana's electrical market.

2.3 Conceptual Framework of the Study

In the schema below, marked as Figure 2.16, the conceptual framework for the study is shown.

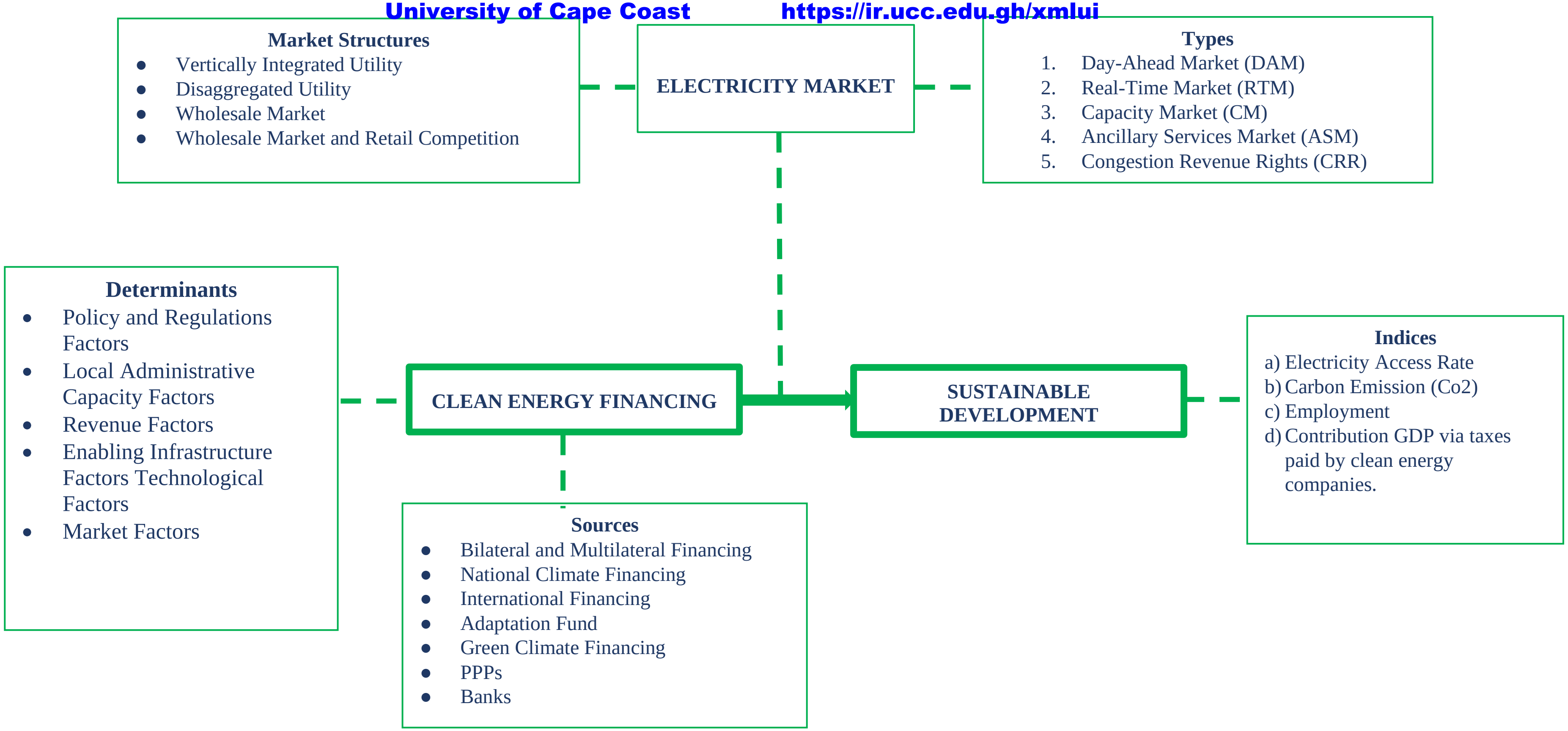


Figure 2.16: Conceptual Framework

Source: United Nations Economic Commission for Africa (2014) and Baiden (2022)

As a result of the effects, which included unpredictable rainfall patterns, acid rain, floods, and food poverty, among others, the onset of climate change was recognized as a problem by the international community. The adoption and use of energy production technologies that rely on solar, wind, biomass, biogas, and hydro as fuel sources are necessary in this respect to lessen the effects of climate change. Clean energy finance is necessary since these technologies need funding on both the supply side and the demand side. Mitigating climate change and advancing sustainable development are the two fundamental goals of climate energy funding. Alternatively stated, "clean energy financing aims at lowering emissions and strengthening sinks of greenhouse gases as well as goal at reducing vulnerability, preserving, and increasing the resilience of human and biological systems to negative climate change impacts" (United Nations Economic Commission for Africa, 2014).

Sustainable development is essential if we want to reduce the consequences of climate change with the help of clean energy finance. The growth of renewable energy in the electrical market is one of the best strategies to combat climate change and implement sustainable development. According to assessments from the United Nations Economic Commission for Africa (2014) and the United States Environmental Protection Agency (2010), Africa has difficulties in reacting financially to climate change. Financing for clean energy becomes important at this point.

It is believed that access to clean energy funding is a significant barrier to the use of renewable energy technology. On the basis of this assumption, the study suggested the framework in figure 2.16 to depict the connection between funding clean energy and sustainable development in the context of the electrical market and its applicability. In order to do this, a lot of nations are including finance for clean energy and climate change into their national planning procedures, which is reflected in the objectives, targets, and indices that make up their national policies and plans. Over the next years, there has been a significant rise in the amount of money promised to fight climate change. The factors influencing clean energy finance serve as a foundation for decision-making in order to be able to obtain the necessary investment. Investors and financiers evaluate government policies and laws, the macroeconomic climate, electricity market performance, demand (off-takers) creditworthiness, and technical competence to run and maintain clean energy technology in order for clean energy financing to take place. Investors place a premium on commercial viability, which is why it is important for the study to examine the factors affecting clean energy finance.

Already developing nations are utilizing renewable energy funding as a chance to radically alter the direction and scope of their economic growth plans. A rising number of national projects show how clean energy finance may lead to more resilient, inclusive, and equitable development models, despite the fact that the field is still in its infancy (Kaur & Geoghegan, 2013).

Financial investments are needed to finance renewable energy technology. Clean energy finance takes into account the situation of the electricity market with a particular emphasis on the structures of the electricity market. The main factor influencing clean energy finance decisions is the creditworthiness of the electricity consumer. Any of the following kinds of funding—bilateral financing, multilateral financing, national climate financing, international climate financing, adaptation fund, green climate financing, and PPPs—can be used to finance clean energy projects.

If funds for clean energy are raised and wisely invested, they will have a significant impact on both the resilience and general economic growth of developing nations as well as climate change adaptation and low-carbon development. The effects of clean energy finance include increased adoption of renewable energy, a reduction in greenhouse gas emissions, the creation of jobs, an improvement in public health, and an increase in energy security. These effects also result from tax payments that contribute to the GDP. In the end, this results in sustainable development.

There are a number of variables that affect the availability of funds for clean energy financing and energy efficiency projects in Ghana, all of which contribute to the clean energy finance environment. Government rules and laws play a crucial role in luring investors and creating a favourable setting for funding sustainable energy projects. Policies and incentives, as well as a clear and stable regulatory framework, encourage investments in the clean energy sector, but regulatory ambiguity and policy changes deter them.

The ability of local governments to oversee sustainable energy projects is another important factor. It is crucial that governments have the capacity to manage and roll out sustainable energy initiatives effectively. Increased funding from regional and global investors is possible because of competent project management that keeps costs down and deadlines met.

Finance choices for clean energy must take revenue into account. The income that investors might anticipate from ventures like selling power or earning money from carbon credits has a significant impact on their interest in clean energy projects. Investors care most about how likely it is that the business will continue to make money in the future.

There must be a solid grid system and transportation networks in place for renewable energy projects to be realised. Due to the potential for operational difficulties and additional expenses, inadequate infrastructure might slow down or even halt project development and finance.

There is also the issue of technology. Changes in how money is allocated may be influenced by developments in clean energy technology. Projects that use cutting-edge, efficient technology tend to get more financial backing from backers because of the higher returns on investment they promise. The need for sustainable energy options is intrinsically linked to market dynamics. Financing is more likely to be offered to a developing market that is rapidly adopting renewable energy sources. Investors are becoming more interested in the sustainable energy market as demand increases.

Increased access to clean energy, fewer CO_2 emissions, and new job possibilities are just a few of the many important goals that benefit from clean energy funding. Clean energy finance helps bring out innovations that lessen the impacts of climate change and provide cleaner energy sources by supporting renewable energy projects. This helps lessen the release of greenhouse gases and boost environmental sustainability generally. In addition, the production, installation, maintenance, and operation of sustainable energy installations provide many employment possibilities. This not only generates cash and stimulates local economies, but it also helps combat unemployment. In addition, the GDP benefits from the taxes and royalties collected by sustainable energy initiatives. This additional funding might be used to improve public services and expand infrastructure, contributing to long-term economic growth and development.

In conclusion, accomplishing environmental and socioeconomic objectives is dependent on a complex process that includes clean energy finance. As a result, it promotes the use of renewable energy, lessens carbon emissions, helps the economy grow as well as promote access to clean power.

CHAPTER THREE: METHOD OF RESEARCH

3.0 Introduction

This chapter of the study discussed the methods and strategies that were used over the course of the research. The study sought to analyse clean energy financing and sustainable development to synthesise an improved system of clean energy financing for enhanced sustainable development in Ghana. Specifically, describe the state of clean energy financing and sustainable development in Ghana and assess the determinants of clean energy financing in Ghana. In addition, to estimate an optimal level of integrating clean energy into the electricity market as well as synthesise an improved system of clean energy financing for enhanced sustainable development in Ghana. In view of this, the chapter concerns itself with the research design, research philosophy, study population, sample size, its justification, and sampling technique. In addition, the data collection techniques, data sources, data processing processes, model specifications, and statistical analyses used are all laid out in detail in this chapter.

3.1 Research Philosophy

The pragmatic philosophy principle is based on the idea that ideas are useful only if they lead to practical results (Dudovskiy, 2012). Because no single viewpoint can grasp the complexity of the universe and because various realities may coexist, pragmatic scholars recognise the possibility of diverse views and interpretations (Dudovskiy, 2012). On the other hand, positivism and interpretivism are two separate and incompatible worldviews that diverge in their assumptions about where and how knowledge is derived. Within the pragmatist paradigm, the research question plays a pivotal role in determining the research philosophy used. Researchers with a pragmatic mindset can draw from positivist and interpretivist perspectives in their work, choosing the methodology that will provide the most useful results for a given inquiry (Dudovskiy, 2012; Saunders et al., 2016).

This study analyses the effects of clean energy financing on sustainable development in Ghana; hence, a pragmatic approach to research is a good fit for the study's objectives and design. As a philosophical outlook, pragmatism places a focus on real-world problem-solving, creative thinking, and the direct application of knowledge. The focus of pragmatic philosophy is on finding workable solutions to issues. Pragmatism's emphasis on practical answers to tangible difficulties is in perfect harmony with the main aim of this research, which is to synthesise a better system of clean energy funding to improve sustainable development in Ghana. A pragmatic worldview that considers the sector's potential contributions to GDP growth, ecological sustainability, and social progress informs this research on clean energy financing.

In addition, pragmatism stresses the value of understanding the current landscape of renewable energy finance in Ghana and the factors that shape it. This helped the researcher place a high value on findings supported by empirical data because they are essential for developing wise decisions and policy recommendations. The other hallmark of pragmatism is its openness to change. Given the fluid nature of renewable energy technology and sustainable development goals, a pragmatic approach provides wiggle room to account for these factors. Finally, pragmatism's emphasis on the practical makes it well-suited for turning research findings into policy recommendations. In essence, the problem-solving mentality, propensity for interdisciplinary inquiry, dedication to empirical analysis, adaptability to change, and emphasis on practical application that characterise a pragmatic research philosophy make it an excellent fit for this research.

3.2 Study Method

Pragmatism, as a research philosophy, agrees with the ideas that research concepts should have an application and that several points of view are helpful in making sense of complicated occurrences. This research acknowledges that there is no one research paradigm that can answer all questions and stresses that the research topic should determine the research philosophy used.

The use of a mixed-methods design method was justified in this study because it is consistent with pragmatism in the context of clean energy funding and sustainable development in Ghana. By using both quantitative and qualitative strategies, mixed-methods studies provide the researcher with more options for achieving their goals. Given the complexity of the relationship between clean energy financing and sustainable development in Ghana, an approach using mixed methods is deemed acceptable for this research. It has allowed for an in-depth investigation of the subject at hand by including both quantitative data analysis and qualitative perspectives from the appropriate stakeholders. The study's validity and reliability have improved because of the method's capacity to triangulate its results. In the end, a pragmatic research philosophy that emphasises practicality and informs meaningful actions and choices is consistent with a mixed-methods strategy.

In the context of clean energy finance and sustainable development in Ghana, pragmatism and mixed methods research found common ground in their respective commitments to the practical, to problem solving, and to the generation of information that supported informed actions and choices.

3.3 Research Design

This study was based on an input-output design, which is an experimental design. A quasi-experimental design is like an experimental design in that it investigates the relationship between two factors (the independent and dependent variables). While actual experimental studies randomly assign participants to treatment and control groups, quasi-experiments do not. Instead of randomly assigning participants to groups, we use an input-output research design due to the non-experimental nature of the study objectives. Thomas (2020) argued that in cases where real trials cannot be done for ethical or practical reasons, a quasi-experimental design is a great alternative.

In addition, the input-output design is useful for examining the determinants of clean energy financing in Ghana. It is crucial in the field of clean energy finance and sustainable development to have a firm grasp on how shifts in funding techniques influence the results of such endeavours. Within the constraints of quasi-experimental approaches, this study design allows for the investigation of such causal relationships.

Furthermore, studies done in natural, uncontrolled environments lend themselves well to quasi-experimental approaches. It is essential to investigate study variables in their natural environment because of several contextual elements on clean energy funding and sustainable development. The input-output architecture takes this complexity into account and allows for a more ecologically sound study of it. Quasi-experimental designs also have the benefit of being relatively easy to implement. There are substantial obstacles to conducting real experimental research in this setting, where random allocation of clean energy finance options may not be possible or ethical. Practicality without sacrificing the ability to draw conclusions about cause and effect is what quasi-experimental designs provide in this research.

Finally, the input-output approach allows for the evaluation of specific policies or interventions on sustainable development outcomes, which is particularly useful given the policy-oriented character of clean energy finance. This is crucial in assisting decision-makers in the pursuit of sustainable development objectives by providing them with evidence-based recommendations.

As a quasi-experimental research tool, the input-output design provides a realistic and moral way to probe the complex connection between clean energy funding and sustainable development in the Ghanaian electricity market. It considers ethical concerns and the limitations inherent to this kind of study without sacrificing the capacity to draw causal inferences or conduct practical applications.

3.2 Data Types and Sources

3.2.1 Primary Data Types and Sources

The success of this study was predicated heavily on collecting primary data. The study benefited greatly from the researcher's ability to observe and record quantifiable data from project developers and funders. The study's overall objectives were met, and a lot of new information was uncovered because of the research endeavour. Different kinds of data were carefully observed and recorded within the area of primary data sources. This study's main data was obtained in a careful manner by use of a detailed questionnaire.

3.2.2 Secondary Types and Sources

The researcher encountered situations where using just primary sources of information was impractical. The researcher thus looked for and included secondary data sources to supplement the primary source data. Nominal data, ordinal data, and quantitative scale data were all included in the study's design. The WB, the European Commission, GRIDCo, the MoEn, PURC, ESRP, the Ghana Renewable Energy Association, and the United States Energy Information Administration all played important roles in providing essential secondary data for the research. Most of the variables were data on clean energy financing, among other relevant data, in determining the current state of clean energy financing in Ghana.

3.3 Choice of Sample

The remaining subsections in this chapter's section examined the study population, sampling frame, sample size, and sampling strategies used throughout the research's execution.

3.3.1 Population

The researcher considered all clean energy developers and clean energy financiers in Ghana as the study population. The researcher considered these actors under the clean energy sector as they are the main stakeholders of the clean energy sector in Ghana and had the requisite resources for the study.

3.3.2 Sampling Frame

The researcher used an extensive database consisting of authorised renewable energy companies, clean energy finance institutions, renewable energy policy and regulatory authorities, development partners, donor organisations, and other recognised energy specialists in Ghana to generate the sample frame. These various parties agreed to keep all information about the sample frame list, including the names, localities, and addresses of the intended responders, strictly secret. The researcher then reached out to these energy stakeholders, using the provided contact information to begin dialogue with the intended respondents. The researcher faced several obstacles while trying to reach their target audience in Ghana, but with the help of this sample frame produced from the firm's database, this research was conducted.

3.3.3 Sample Size Determination

In this research, respondents were selected to represent Ghana in the energy space. The country was considered for the study as there is an increasing trend of renewable energy businesses compared to the other sub-regions in West Africa. The minimal sample size necessary for the study was calculated using Cochrane's formula since the population size was unknown. The formula has been presented in equation 3.1.

$$Sample\,size\,(n) = \frac{Z^2(\theta)(1-\theta)}{\omega^2} \qquad 3.1$$

Where n= sample size used, θ=estimate response rate, *Z*=level of confidence 1.96 for 95 percent confidence level, 1-θ = is the population's projected response rate from which the sample was taken and ω =level of precision or margin of error. The study considered as sample size 150 key stakeholders for the quantitative responses. The sample size has been justified based on a response rate of 50 percent, level of confidence 1.96 for 95 percent and margin of error to be 8 percent. A representative sample of 150 clean energy developers, key players from Ghana's PURC, ECG, GRIDCo, VRA, EC and clean energy financiers was taken from across the entire nation of Ghana.

By substitution we have

$$Sample\,size\,(n) = \frac{1.96^2(0.50)(0.50)}{0.08^2} \approx 150 \qquad 3.2$$

The researcher interviewed 45 consultants and professionals in renewable energy companies to acquire qualitative insights, in addition to polling 150 respondents to collect quantitative data. The research objectives were better explored using this combined strategy. Comparatively, the qualitative interviews gave in-depth opinions and context, while the quantitative survey supplied organised, measurable data. By using a variety of research techniques, this study found more accurate results and provided a more complete picture of the state of clean energy financing and the determinants of clean energy financing in Ghana. The researcher was able to get a better grasp on the quantitative tendencies as well as the drivers and hurdles that players in the clean energy industry confront.

3.3.4 Sampling Techniques

The validity and reliability of a study's conclusions depend critically on the sampling method used in the investigation; thus, it is crucial that researchers choose wisely. The capacity to generate representative samples and allow for statistical inference is usually attributed to probability sampling techniques, which include the random selection of individuals from a well-defined population. The research setting and the characteristics of the population being studied might affect whether sampling methods are appropriate.

In the context of this study, the landscape of the renewable energy industry in Ghana is both unique and dynamic. Clean energy innovators, investors, policy experts, and development partners are just a few of the many players in this field. In Ghana, the clean energy industry is still in its infancy, unlike more established businesses with extensive databases. Therefore, using standard probability sampling methods like simple random sampling or stratified sampling in this setting posed substantial difficulties.

The lack of an up-to-date, all-encompassing sampling frame that adequately reflected the sector's complexity was a major obstacle. As the industry expanded and evolved at a rapid pace, it became difficult to have an accurate and comprehensive roster of all the key players. In addition, the project attempted to collect data from participants in the clean energy ecosystem who may not be included in traditional databases.

Because of these obstacles, the researcher consciously decided against using probability sampling methods. Purposive and snowball sampling were used instead because they provided more realistic, industry-specific solutions for the research. By using these strategies, the study was able to specifically reach out to those people and organisations that are driving the clean energy project sector forward.

The aims of this study and the unique peculiarities of Ghana's renewable energy market informed the sample methods used. Because it enabled the researcher to zero in on people and businesses with direct engagement and knowledge in the clean energy market, purposive sampling was an efficient method for identifying clean energy innovators. The study's focus on the relationship between clean energy funding and sustainable development meant that input from people working on such initiatives was crucial. Purposive sampling increased the chance of receiving useful and specialised information by selecting a sample that was highly relevant to the study's aims.

To reach a larger sample of people working in the field of sustainable energy technologies, the researcher used the snowball sampling method. Given that standard sample approaches would exclude important players in Ghana's renewable energy industry, such as bankers, policy experts, and development partners, snowball sampling provided a workable alternative. With this method, existing participants might suggest others who could fit the study's parameters. It was successful in reaching respondents who would not have been found using other sampling alone, thereby increasing the size of the sample.

In conclusion, probability sampling techniques are useful in many research settings, but the ever-changing nature of Ghana's clean energy industry required the employment of non-probability sampling methods. The research team was aware of the potential pitfalls of these approaches, but they were ultimately deemed the most practical options for meeting the study's aims by collecting the wide range of opinions and levels of expertise present in the clean energy industry.

3.4 Instrument Preparation

The main tools the researcher used to gather data for the study's purpose were a structured questionnaire and interview guide. This questionnaire was developed with input from seasoned professionals within the field of clean energy and the EC. The questionnaire's structure and questions owe a great deal to the combined knowledge of these experts.

The questionnaire was carefully prepared to meet the goals of the research, and it was sent to a wide range of participants, including those working in clean energy financing, business owners, and consultants. It included a wide variety of questions on important facets of funding clean energy in Ghana. Clean energy funding in Ghana, its motivating factors in the country, and its far-reaching ramifications on the whole spectrum of sustainable development were all explored in these investigations. Inevitably, the researcher created an interview guide vetted by experts in collecting qualitative information via interviews.

The questionnaire and the interview guides were carefully crafted to collect detailed and pertinent responses from the survey's respondents with the help of insights and comments from professionals in the subject. By working together, the researcher was able to build a questionnaire and interview guide to elicit useful information about the dynamics of clean energy funding and its influence on sustainable development in Ghana.

3.5 Instrument Refinement

Following the preparation of the questionnaire drafts, a group of financial industry specialists, the EC, and other advisors were given the chance to examine and approve the instruments. Following the acceptance of the questionnaire, a pilot was conducted to improve the validity of the findings.

3.6 Data Collection

The researcher used a wide variety of methods to gather information for this study, such as questionnaires, fact sheets for requesting information, structured interviews, and secondary data.

Distributing well-crafted questionnaires was the major technique for collecting data. Careful consideration was given to the study themes and the demographics of the target audience while developing these questionnaires for use by clean energy financing experts, individuals with clean energy sources, and consultants. The questionnaires covered a wide variety of concerns, including clean energy finance in Ghana, the factors driving clean energy financing, and the effect of clean energy financing on long-term economic growth. One-on-one interactions were used to distribute the surveys. Some survey takers preferred an online format for completing the surveys. Participants were interviewed in person by trained research assistants. Research assistants handed out questionnaires and helped respondents through the questions during in-person interviews.

Respondents and research assistants were able to communicate openly and freely because of this one-on-one format. It made sure that people were able to answer the questions completely and accurately. In addition, any questions or concerns the interviewees may have might be answered on the spot.

With fewer opportunities for misunderstandings or half-answers, this approach proved very useful in collecting accurate information. In addition, it helped the study team become more approachable to the respondents, which in turn increased the number of honest responses.

Given the complexity and significance of the study's aims, it was determined that administering the surveys one-on-one would provide the most accurate and comprehensive results.

The data was gathered using a combination of surveys and structured interviews. To maintain uniformity and applicability, interviewers used a carefully crafted interview guide. Experts in the clean energy space and the EC were among those interviewed for this research. In-depth conversations and the collection of experts' qualitative perspectives were made possible by conducting these interviews face-to-face with the chosen participants.

In addition, secondary data sources were used to supplement the original data. The EC, GRIDCo, the MoEn, and the PURC all provided year-over-year reports and information that were used in the study. The information and background on the study's subject matter came from these sources.

Both quantitative and qualitative data, in the form of questionnaires and interviews, as well as secondary data sources, were gathered for this study. By using these three steps, the researcher was able to strengthen the findings' validity and trustworthiness.

3.7 Data Processing

Several critical procedures were included in the data processing to guarantee the delivery of useful results. The first step was collecting data, which included consulting a wide range of reliable sustainable energy industry resources. To ensure the reliability and validity of the study's findings, the researcher worked hard to collect information from reputable sources.

The next stage, data preparation, followed the collection of data. In this first stage, the researcher worked to clean and organise the raw data. The raw data was examined thoroughly so that any mistakes, duplications, or inaccuracies could be found and fixed. The plan was to get rid of inaccurate data and replace it to ensure the reliability, validity, and robustness of the study findings.

Data coding was an essential part of the processing since it allowed for the standardisation and organisation of the data into useful categories. The processing and interpretation of data were simplified by using this organised coding method. After these steps were completed, the data was ready for analysis.

To derive inferences from the cleaned and corrected data, regression and other appropriate methods were employed. These analytic techniques allowed for a thorough evaluation of the data, which was crucial to successfully accomplishing the study's aims.

3.8 Data Analysis

The data analysis plan is shown in the data analysis matrix as presented below in Table 3.1.

Table 3.1: Data Analysis Matrix

Specific Objective	Framework of Analysis	Technique of Analysis
1. To describe the state of clean energy financing and sustainable development in Ghana.	Description	Descriptive Statistics
2. To assess the determinants of clean energy financing in Ghana.	Correlation	Regression Analysis
3. To estimate an optimal level of integrating clean energy in the electricity market of Ghana.	Optimization	Modelling
4. To synthesize an improved system of clean energy financing for enhanced sustainable development in Ghana.	Synthesis	System Improvement

Source: Author's Construct (2022)

In analysing the data, Table 3.1 shows the data analysis matrix for the study.

Specific Objective 1: To describe the state of clean energy financing and sustainable development in Ghana.

The framework used for the analysis is a descriptive framework and the technique used is descriptive statistics. Descriptive statistics use frequency tables and charts to summarize the study results.

Specific Objective 2: To assess the determinants of clean energy financing in Ghana.

This section of the study assessed the determinants of clean energy financing in Ghana. In assessing the determinants of clean energy financing (Y), the study used data on the number of years clean energy firms have been in operation (FirmAge), the number of employees of the firm (FirmSize), local administrative capacity factor (LocalAdmin), revenue factors (RevenueFact), infrastructure factors (InfrastructureFact), technical factor (TechnicalFact), market factors (MarketFact) and policy and regulatory factors (PolicyReg). The details about the factors are presented in Table 3.2.

Table 3.2: Details on Factors Used in the Binary Logistic Regression

Policy and regulations factors
• Regulatory uncertainty in Ghana's energy sector.
• The impact of unexpected, retroactive, or frequent changes in laws and regulations on clean energy financing.
• Risk allocation challenges and ambiguity in clean energy financing and development.
• Transparency in the contracting process for renewable energy service companies in Ghana.
Local administrative capacity factors
• The cost of procuring land for clean energy projects.
• Complications arising from overlapping permits, fragmented ownership, and unregistered land.
• The high local content requirements for clean energy project approvals in Ghana.
• Recommended local content ownership
Revenue factors
• Delays in payment for power, fuels, or energy services by counterparties, linked to the financial performance of the counterparty.
• Factors affecting the financials of a clean energy company, including load curtailment, low demand, and technology underperformance.
• Operational challenges for clean energy plants due to a lack of maintenance and meteorological variations.
• The establishment of a reliable baseline and processes for measuring, reporting, and verifying energy savings.
• The exposure of the electricity market in Ghana to variable wholesale market pricing with limited ability to manage price fluctuations using hedging instruments.
Enabling infrastructure factors
• Difficulty in connecting to the national grid or a local grid.
• The national grid's incapability to accommodate variability in electricity generation sources.
• The national grid's incapability to accommodate variability in electricity demand.
• Issues with power purchase agreements leading to unreliable dispatch or affecting the provision of electricity services.
• The existence of a secondary market through the net metering mechanism to sell excess energy to the grid in Ghana.
Technological factors
• There is uncertainty over the performance of clean energy technologies traded in Ghana without a track record and wide demonstration at a global level.
• Technicians or installs are not familiar with clean energy technologies.
• Financial institutions in Ghana understand how to structure funding instruments for clean energy technologies.
• Clean energy technologies have outputs or performance at less than rated specifications.
• Clean energy technologies have unforeseen maintenance or outages challenges.
Market factors
• There are unexpected changes in the interest rate for a loan in Ghana
• Inflation and exchange rate are very unpredictable in Ghana.
• The local capital markets in Ghana are underdeveloped.
• There are currency convertibility restrictions and restrictions to repatriate capital in Ghana.
• The end user tariff for clean energy is expensive for the consumer.

y represents the financing status

$$y = \beta_0 + \beta_1 FirmAge + \beta_2 FirmSize + \beta_3 LocalA\min + \beta_4 \operatorname{Re}venueFactors + \beta_5 InfrastructureFact + \beta_6 TechnicalFact + \beta_7 MarketFact + \beta_8 Policy\operatorname{Re}g + \varepsilon \quad 3.3$$

Where β i's are the regression coefficients to be estimated and ε is the error term of the model.

Estimation Technique

The researcher in this study used the binary logistic model. The dichotomous nature of the clean energy finance focus variable (1 representing financing and 0 representing lack of financing) served as the driving force behind this decision. To evaluate the connection between the predictor variables (policy and regulations, factors, local administrative capacity factors, revenue factors, enabling infrastructure factors, technological factors, and market factors) and the probability of the binary event happening, the binary logistic model was judged appropriate for this analysis. By using a modelling strategy well-suited for binary data, this study was able to delve into the variables impacting the presence or absence of clean energy finance, yielding important insights into the drivers of clean energy financing in the context of the research. The estimation of the model coefficients was based on the maximum likelihood estimation approach with the help of SPSS. Using the binary logistic model, the study predicts the odds ratio for each of the nine determinants of clean energy financing in equation 3.4. The odds ratio lends itself to the following interpretations: (1) odds ratio > 1 shows increased odds of the event (clean energy financing) occurring; (2) odds ratio = 1 shows neither increased nor decreased odds of an event (clean energy financing) occurring; and

(3) odds ratio < 1 shows decreased odds of the event (clean energy financing) occurring.

The functional of the logistic model for the objective is;

$$y = \ln\left(\frac{\lambda}{1-\lambda}\right) = \beta_0 + \beta_1 FirmAge + \beta_2 FirmSize + \beta_3 LocalA\min + \beta_4 \mathrm{Re}\,venueFactors + \beta_5 InfrastructureFact + \beta_6 TechnicalFact + \beta_7 MarketFact + \beta_8 Policy\,\mathrm{Re}\,g \quad 3.4$$

where $\ln\left(\frac{\lambda}{1-\lambda}\right)$ is the odd ratio for a firm receiving clean energy finance, β_i's are scalers of the estimation and ε is the error term associated with the estimation.

Definition of Variables

Firm Age (FirmAge): This variable is a measure of the number of years a prospective firm for clean energy finance has been in operation. A summary of the measurement of the variable and *a priori* expectation has been presented in Table 3.2.

Firm Size (FirmSize): The data gathered on the firm size entailed the number of employees at the prospective firm seeking clean energy finance. This variable helped in determining if the firm is a small, medium and large enterprise.

Local Administrative Capacity Factor (LocalAdmin): In measuring the Local Administrative Capacity Factor, the study looked at the processes involved in procuring land, the permits and the local content requirements for the establishment of a clean energy company.

Revenue Factors (RevenueFact): In estimating Revenue Factors that could affect clean energy financing, the study focused on payments for electricity traded on the electricity market of Ghana.

Infrastructure Factors (InfrastructureFact): The grid connection constraints, the ability of the grid to accommodate clean energy technologies, the energy traded based on the power purchase agreement, and the impact of net metering were the areas examined in the estimation of Infrastructure Factors.

Technical Factor (TechnicalFact): The Technological Factors employed was estimated by measuring the uncertainty on the performance of clean energy technologies, the expertise of installers, the expertise of financial institutions, and the challenges with clean energy technologies.

Market Factors (MarketFact): For any clean energy technology to be financed, investors or financiers must be convinced that the project is bankable. In measuring the bankability of the project, these financiers will consider the volatility in the exchange rate, the end user tariff, the predictability or stable inflation, interest rate and the development in the local market.

Policy and Regulatory Factors (PolicyReg): The Policy and Regulatory Factors (PRF) were estimated by measuring the risk and regulatory uncertainty in the wholesale electricity market. The measure comprised the risk allocation to parties involved in a power purchase agreement, and the unexpected or frequent changes in regulations.

Table 3.3: Objective 2: Measurements of Variables, and A Priori Expectations of the Independent Variables

Variables	Measurement level of Variable	A priori expectation
FirmAge	Discrete	Positive
FirmSize	Discrete	Positive
LocalAdmin	Dummy variable: =1 if LocalAdmin is necessary condition, and =0 otherwise	Indeterminate
RevenueFact	Dummy variable: =1 if RevenueFact is necessary condition, and =0 otherwise	Positive
InfrastructureFact	Dummy variable: =1 if InfrastructureFact is necessary condition, and =0 otherwise	Negative
TechnicalFact	Dummy variable: =1 if TechnicalFact is necessary condition, and =0 otherwise	Negative
MarketFact	Dummy variable: =1 if MarketFact is necessary condition, and =0 otherwise	Positive
PolicyReg	Dummy variable: =1 if PolicyReg is necessary condition, and =0 otherwise	Positive

Source: Author’s Construct (2022)

Specific Objective 3: To estimate an optimal level of integrating clean energy in the electricity market of Ghana.

To determine the lowest capacity of renewable energy technologies that can be incorporated into Ghana's electrical market and the related CO_2 emissions, the LEAP model was used in the research as an integrated modelling tool.

At its heart, LEAP enables users to develop comprehensive regional energy system models. Various fossil fuels and renewables, along with energy conversion processes like power production and the eventual use of energy across sectors like industrial, transportation, and residential, are all accounted for in this modelling.

LEAP's capacity to do scenario analysis is a standout feature. To learn how alternative energy policies, technology, and tactics could affect the energy system and related results, users can create and assess several scenarios. Policymakers and researchers benefit from this adaptability since it allows them to make well-informed choices and prepare for the future.

In addition to its many other strengths, LEAP's data management capabilities really shine when it comes to collecting, storing, and organising data such as energy consumption records, emission statistics, and other socioeconomic metrics. This solid database allows for in-depth research as well as forecasts into the future.

The model also evaluates the social, economic, and ecological costs and benefits of potential energy policies. LEAP helps decision-makers understand the costs and benefits associated with different energy options by quantifying these impacts.

Another advantage of LEAP is its adaptability, as users can modify it to suit the needs of a particular region or nation. For many purposes, including energy planning at the national and subnational levels, climate change mitigation, and sustainable development, this tool is indispensable.

Ultimately, the LEAP model is a helpful tool for making choices about energy. Stakeholders can make educated decisions in the quest for sustainable and efficient energy solutions because of its capacity to offer a comprehensive overview of energy systems, evaluate the efficacy of policies, and visualise data.

Against its capabilities, the model was considered. To estimate the various clean energy technologies that can be integrated in Ghana's electricity market, modelling was done based on the current policy of the GoG, such as the REMP, the IPSMP, the NDC as per the COP 21 Paris Agreement, and other development plans. Based on new information gathered from the EC, the MoEn, the ESRP, and specialists in the Ghanaian power market, Microsoft Excel was used to supplement the LEAP model. The best level of clean energy technologies that can be included into Ghana's power market was determined by combining the least expensive energy strategy with strategies for energy security (based load) and environmental sustainability (low CO_2 emissions). According to the timetables of the Updated Nationally Determined Contribution under the Paris Agreement, which is anticipated to increase until 2030, the ideal level of integrating renewable energy technology was limited to that year. The study was able to determine the ideal degree of renewable energy integration in Ghana's power market by using the LEAP model.

The end users' need for power and the technology necessary to supply that demand served as the study's driving forces in pursuing this purpose. The NDC's guidelines for 2030 were the only ones used in the research. The main existing policies promoting the growth of renewable energy in Ghana were examined in the study's analysis of their impact.

The research considered additional choices, such as the aggressive use of new sustainable energy technology. Since the research only included solar, wind, hydro, biomass, and biogas technologies, it eliminated choices like nuclear power generation and CCUS technology.

The primary underlying assumption for the energy demand was based on macroeconomic data, which included Ghana's GDP, and demographic data, which included population projections and access to power rates until 2030.

Regarding the performance of the nation, the macroeconomic assumptions provide a comprehensive grasp of the Ghanaian economy. The GDP-based classification of the economy's major sectors served as a foundation for the factors that fuelled the increase in power consumption. Manufacturing, agriculture, and services are essential to this, as shown in Ghana. The expansion of the GDP provided some justification for the anticipated shifts in demand from 2023 to 2030. The research concluded that there is a direct correlation between power use and people's ability to pay for it. This correlation was taken into consideration by including GDP per capita as a variable to determine the willingness to spend money on electricity and other electrical items.

Demographic information had a significant impact on electricity consumption projections. To estimate how much power would be required throughout the predicted time, many factors, including population size, population growth rate, and average household size, were considered. Ghana's electricity rate goals are in line with national targets because of the assumptions made about family size.

Table 3.4: Key Optimization Modelling Assumptions

Key Modelling Assumptions												
Macroeconomic Assumptions												
Variables	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
GDP (Billion US$)	52.4	70.0	79.1	83.0	87.2	91.5	96.1	100.9	106.0	111.3	116.8	122.7
GDP Growth (percent/Year)		5 percent Annual Growth Rate with 2019 as base year										
GDP Per Capita: GDPUS$/Population ($/Person)	1,729.4	2,272.5	2,565.0	2,636.0	2,709.0	2,784.1	2,861.2	2,940.4	3,021.9	3,105.6	3,191.6	3,287.7
Demographic Assumptions												
Variables	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Population (Million People)	30.3	30.8	30.8	31.5	32.2	32.9	33.6	34.3	35.1	35.8	36.6	37.3
Population Growth (percent/Year)		1.5 percent Annual Growth Rate with 2019 as base year										
House Hold (HH) Size: People	4.1	4.1	4.0	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.9

Source: Energy Commission (2022)

Specific Objective 4: To synthesize an improved system of clean energy financing for enhanced sustainable development in Ghana.

To accomplish this, the study created a forecast model for the energy sector based on the financial performance of the sector agencies, the contracted power plants that are currently supplying electricity, as well as the planned power plants that are anticipated to produce electricity between 2023 and 2030. The model's assumptions consider macroeconomic data, the electrical market's economic and financial components, the technologies used to generate energy in Ghana, billing and collection of electricity, and the market's components. The research concentrates on the electricity market and synthesizes solutions to increase the market's viability to draw funding for clean energy. Additionally, the research offers advice on the elements of the clean energy financial system, its participants, the clean energy policy framework for sustainable development, and the details of the clean energy financial system.

The study was able to establish a better clean energy finance system for increased sustainable development in Ghana based on the synthesis framework of analysis via system improvement.

CHAPTER FOUR: THE STATE OF CLEAN ENERGY FINANCING AND SUSTAINABLE DEVELOPMENT IN GHANA

4.1 Introduction

This section of the research used descriptive statistics to offer an overview of the present state of clean energy finance in Ghana. This research made use of information amassed from a wide range of Ghanaian energy industry stakeholders. In this context, "stakeholders" refers to anybody with an interest in the country's clean energy or electricity markets, from consumers to developers to financiers to end users.

This was done through questionnaires, interviews, direct data collections from the respective institutions, as well as secondary data from the websites of the agencies. The analysis in this chapter includes the state of the electricity market of Ghana; clean energy technologies in the electricity market of Ghana; sustainable development; sustainable development indices in the electricity market of Ghana; clean energy financing institutions in Ghana; evidence of clean energy financing in Ghana; and clean energy technology developers in Ghana.

4.2 Clean Energy Financing and Electricity Market of Ghana

The description of the electricity market in this study provides a foundation to the commercial perspective of the utilization of the clean energy technologies and clean energy financing in Ghana.

4.2.1 Overview of the Electricity Market of Ghana

Before the introduction of modern means of power generation techniques, local and cottage industries as well as households depended on wood, fuel, and biomass for their operations and cooking. This was until 1914, when the Ghana Railway Administration introduced the first public electricity supply, whose objective was to support the operations of the railway system and the auxiliary facilities that went with its operations.

Subsequently, work started on power distribution to Kumasi where a power station was brought into full operation in October 1927. In addition, Winneba had an Alternating Current (AC) installed in 1938 (Electricity Company of Ghana, 2022). Other power stations were established, such as the Cape Coast power station, which was later taken over by the Ghana Electricity Company. Many stations were set up across the country including an 11kV overhead transmission line from Accra and the Tema power station in 1956 with a 3 x 650 kilowatts diesel generating set, and the Ho power station in 1957 in an attempt to make access to electricity possible in every part of the country (Electricity Company of Ghana, 2022).

The revolution of Ghana's energy sector was palpable after the establishment of the Akosombo hydroelectric plant with two generating units in 1972, as it facilitated the exportation of electricity to Togo, Benin, and Burkina Faso. The total electricity demand in 1972 generated by the Akosombo hydro plant had increased to 1,300 GWh, with an estimated annual growth rate of 10 percent thereafter (ISSER, 2005). The second hydroelectricity plant at Kpong was built in 1982 to support the Akosombo hydro plant operations. The country's energy crisis at that time was due to unfavourable weather conditions leading to drought, which triggered the institution of the PSRP in the early 1990s. This program was to decentralize and unbundle the power sector by improving the commercialization of power utility operations, encouraging private sector investment, reducing the need for government sovereign guarantees, and establishing a transparent regulatory framework.

Improvements in the country's electricity production were also seen in other industries, including mining and other industrial sectors, which contributed to increased income creation and, eventually, an overall improvement in the socioeconomic development of the nation.

Ghana's power generation now comes from hydro, thermal and solar sources, which hitherto was primarily from the Akosombo hydroelectric plant. An energy sector advisor recounted the history of the electricity generation in Ghana: "During the colonial days, fossil fuel (largely diesel) was used in electricity generation prior to the development and operations of the Akosombo Hydro Electric Power Plant. This was described as the **first energy transition** in Ghana from the use of fossil fuel to the use of a clean energy technology for electricity generation".

The many methods of power production are a result of the ongoing rise in electricity consumption. However, due to the high installation costs for renewable energy sources, little progress has been made in attempting to increase their share of the nation's power generation. The sole renewable energy source available in Ghana at the moment (apart from hydro) is solar, which accounts for less than 1 percent of the nation's total power production. However, as of December 2021, 34.66 percent of the world's electricity was generated by renewable energy, primarily hydroelectric power. The country's abundant renewable energy resources should be promoted and developed for sustainable economic growth, enhanced social life, and a reduction in the negative consequences of climate change, according to the REMP, a significant renewable energy initiative. It aims to boost local involvement in the renewable energy sector, lessen reliance on fossil fuel as the primary fuel for thermal energy uses, and raise the share of renewable energy in Ghana's energy generating mix to 1363MW by 2030. As of 2021, hydropower and PV solar systems accounted for 34.12 percent and 0.55 percent of the nation's power sources, respectively, making them the two most important renewable energy sources.

The underdevelopment of the sector's power infrastructure as a result of pressure from both the supply and demand sides is a significant issue. Because obsolete transmission equipment sometimes overloads during times of heavy demand, the transmission system needs infrastructural improvements. Additionally, the inability of distribution firms to recoup costs through tariffs prevents them from paying transmission and generating companies, which restricts the amount of money available for investment.

4.2.2 Electricity Market Structures and Clean Energy Financing

With the exception of transmission, Ghana's electricity market has evolved from a complete monopoly to a liberalized market (unbundled) and is now close to being a competitive market. In Ghana today, both the generation and distribution business have more than three participants. The VRA and BPA, both operating power facilities controlled by the government, can be divided into the generation firms. GoG, through these agencies, has spearheaded renewable energy development and installation in addition to thermal power generation. The private sector companies, which are referred to as the IPP, have nine thermal power plants that are owned by different private parties with investment from varied countries as well as four renewable energy power plants. EPC is a privately owned distribution utility operating in the regulated space, whiles, the other two are government-owned utilities ECG and NEDCo. Genser Energy Limited serves as a power generator, a gas distributor/transporter as well as an electricity distributor.

The study identified that the electricity market of Ghana is a well-diversified market with varied off-taker risk exposure. Based on price determination, the electricity market can be grouped into regulated and deregulated markets. The regulated market price is determined by the PURC, which is also contingent on meeting certain minimum regulatory license requirement by the EC; whereas the deregulated market has price determination left to the sole purview of the power supply and power off-taker.

4.2.3 Vertically Integrated Market in Ghana

VRA, which was created in 1961 in accordance with the Volta River Development Act 1961 (Act 46), was the first vertically integrated monopoly to operate in Ghana's electricity market. During this time, the VRA was given exclusive authority to produce, transmit, and supply power to its customers. After its inception in 1983, the ECG was to continue to be the only organization in charge of the nation's distribution networks and the provision of electricity, with VRA continuing to be in charge of transmission. The southern regions of Ghana—where there was also a higher consumer concentration—were the only portions of Ghana where the ECG could operate in 1987. All of this was done in reaction to the shifting industrial structure to deal with the problems that were starting to surface at the time. These difficulties included the second significant national power crisis that occurred in 1992–1993 as a result of low-level water imports into the Volta Lake and the ensuing requirement for other sources of power generation.

In line with the Volta River Authority (Amendment) Act of 2005 and the Energy Commission Act of 1997 (Act 541), the Ghanaian government formed the independent transmission utility Ghana Grid Company in 2006 (Act 692). Through the provision of transparent, egalitarian, and open access to the NITS for all participants in the wholesale electricity market, GRIDCo was established with the goal of fostering competition in Ghana. By providing all participants in the power market, particularly power generators and bulk consumers, with transparent, non-discriminatory, and open access to the NITS, the GRIDCo was established with the goal of fostering competition in Ghana's wholesale power market and enhancing the effectiveness of power delivery.

The NITS and its legal framework for providing market participants in Ghana's wholesale electricity market with open, equitable, and non-discriminatory access to electricity transmission infrastructure were established with the passage of the Electricity Transmission (Technical, Operational and Standards of Performance) Rules, 2008, L.I.1934 (GWEM). The 2008 Electricity Regulations helped pave the way for a competitive electricity market (L.I.1937). In order to allow wholesale energy trading and the supply of ancillary services in the National Interconnected Transmission System, the L.I. 1937 created the GWEM and NITS. A reform in the sector was required because the vertical integration of the current structure of the power industry was deterring or unappealing to private finance and there was insufficient public financing for timely growth of the existing capacity.

4.2.4 Single Buyer’s Market in Ghana

The Power Sector Reforms (PSR) recommendations led to the separation of GRIDCo and ECG as the industry's transmission and distribution functions, respectively. This resulted in the industry moving to a single buyer structure where ECG was the only buyer of electricity from the power generators, and it also saw the entry of independent power producers into the industry in the southern part of Ghana. As demonstrated by VRA's dual role as a transmission company and generation company in Ghana, this restructuring was required to encourage private sector participation in the generation sector and to prevent the conflict of interest associated with a single entity responsible for both generation and transmission.

The Government's goal to restructure the electricity sector and enable IPPs to invest in it was maintained as a consequence of the division of the transmission function of the VRA. ECG was the energy off-taker for the IPPs' energy, which came from both thermal and renewable sources. A number of IPPs, mostly on the generating side, have invested in the Ghanaian power market as a result of this effort.

The industry's three primary functions—generations, transmission, and distribution—were separated, necessitating the assistance of independent sector regulators for both the technical and commercial facets of the sector. In order to control the provision of utility services in the area of electricity, the PURC was established by the Government of Ghana in October 1997 as a multi-sectoral regulator under the Public Utilities Regulatory Act, 1997 (Act 538 and 541).

By issuing licenses for the transmission, wholesale, supply, distribution, and sale of electricity and natural gas, among other things, the EC was established by the Energy Commission Act, 1997 (ACT 541) with the purpose of regulating and managing the development and utilization of Ghana's energy resources. It also provides the legal, regulatory, and supervisory framework for all the nation's energy providers.

The commercial regulator controls pricing and tariffs under the single buyer model of the power sector. Long-term life-of-plant agreements are signed by the utility with the IPPs, and these costs are then passed on to the ultimate customers as part of a blended tariff that also includes the cost of transmission. The IPP contracts shield the IPPs from market pricing and newer, more efficient technologies, thus the market structure, which is built on long-term contracts like the IPP markets under regulation, transfers market, technology, and most credit risks to the consumers. Only the generational part of rivalry exists in the single buyer model. It is important to note that Ghana's regulated power market restricts the use of single purchasers.

4.2.5 Wholesale Competition/Industry Structure

Over the period the distribution coverage of ECG has been segmented and portions allocated to other distribution companies. Ghana now has two markets: the deregulated market, where "bulk customers" purchase power from the grid at the rates they have agreed upon with the producers, and the regulated market, where distribution utilities provide electricity to users at prices that are set by the PURC.

The Ghanaian electrical market is divided into the following main market divisions from the off-taker's perspective, along with the related geographic location:

Regulated Market

1. ECG Market – Southern Ghana
2. NEDCo Market – Northern Ghana
3. EPC – Industrial Enclave in Tema

Deregulated Market

4. Export Market – Togo, Benin, Burkina Faso, Cote D'Ivoire
5. Mines and Bulk Electricity Consumers – Mining and Industrial Consumers

While EPC is the only privately-owned electricity distribution company operating in the Tema Free Zones Enclave in the Greater Accra Region serving about 50 industrial customers, the NEDCo distributes electricity to the northern part of the country (Bono, Ahafo, Bono East, Northern, Savanna, North East, Upper East and Upper West Regions).

With the entry of two more distribution firms, the goal was to create a wholesale industry structure with a fully competitive sector. Competition and deregulation in generation attracts many buyers, resulting in lower prices, avoid the costs and problems of providing retail access for all the small customers. This model gives the distribution companies a monopoly over all the smaller final customers. This monopoly is being diluted with the introduction of roof top solar, which provides the customer base of the distribution utilities an alternative source of electricity supply.

Ghana is still not out of the woods yet with respect to the development of a fully-fledged wholesale electricity market. The EMOP has been formed and the GWEM is being prepared for launching as a fully functional market in 2024. The objectives of the GWEM include to:

1) Attract private sector investment in electricity supply.
2) Promote efficiency in the electricity sub-sector.
3) Promote transparency.
4) Enhance system reliability.
5) Provide access to larger pool of supply and promote competition.
6) Regulate and ensure the market is competitive.

As of December 2021, about 35 power plants had been installed with an estimated total capacity of approximately 5,488.87 MW (see Figure 4.1). Hydroelectric plants have dominated the power supply industry with VRA owning over 80 percent of the total capacity. However, Ghana's investment in thermal generation saw the country's total generation capacity almost equivalent between the two power generation sources (thermal and hydro).

The electricity market comprises the regulated and deregulated sectors. ECG and NEDCo are the two state-owned distribution companies that dominate the regulated market, accounting for 70 percent of the country's total energy demand. The deregulated market accounts for the remaining 30 percent whereas the PURC approves consumer tariffs in the regulated market.

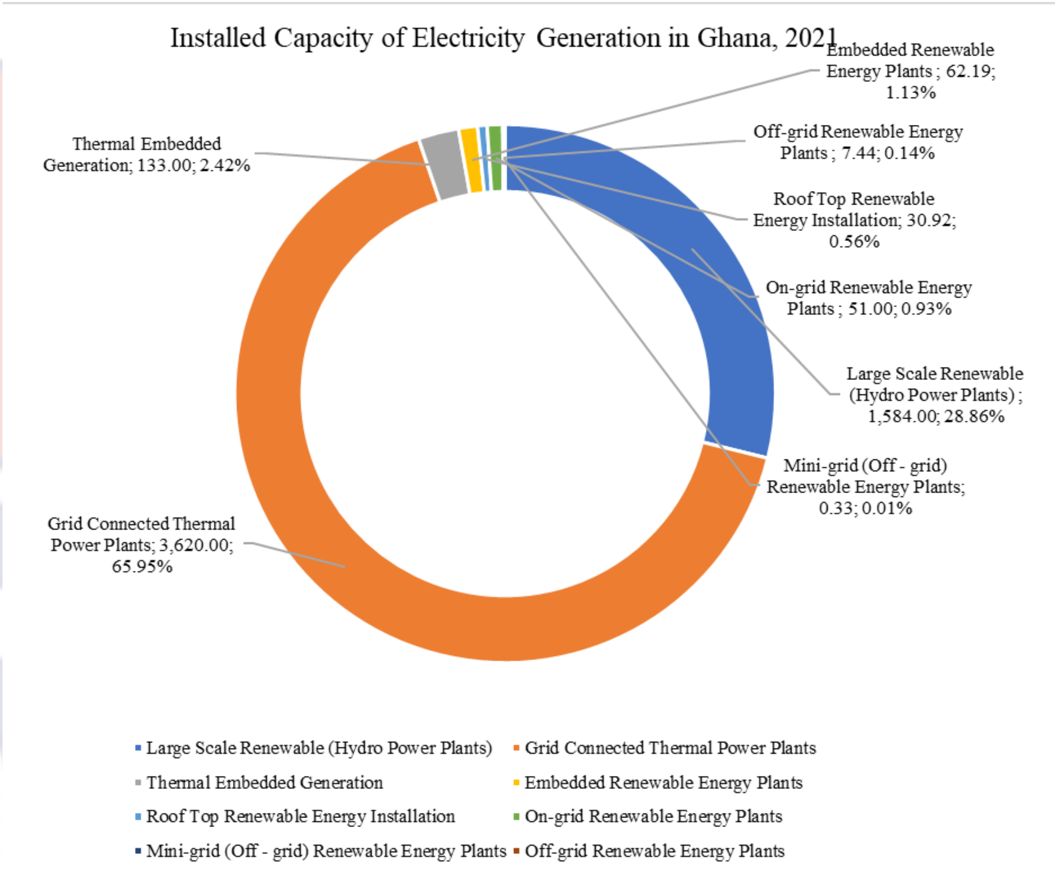


Figure 4.1: Installed Capacity of Electricity Generation in Ghana (2021)
Source: 2022 Energy Statistics

Electricity generation from thermal and hydro sources is mostly the responsibility of the VRA, Bui alongside IPPs, such as Takoradi International Company (TICo), Sunon Asogli Power Plant, and CENIT. The NEDCo, the EPC, and the ECG are the recipients of the transmission, which is handled by the GRIDCo, mostly at 161 kV. Exports to nations including Togo, Benin, and Burkina Faso are also handled by GRIDCo. The NEDCo distributes electricity to the northern portion of the country. The ECG is the largest distributor and is wholly owned by the government.

It provides electricity to numerous homes and businesses in six regions of southern Ghana (the Central, Eastern, Greater Accra, Volta, Western, and Ashanti Regions). However, the only privately held power distribution business functioning in Tema is EPC. It serves about 50 customers.

The changes in Ghana's export of electricity over the years are a result of competition from Cote d'Ivoire and Nigeria anchored on price and stable power supply. Furthermore, an improvement in the regional grid interconnection network coupled with an improvement in bilateral relationships among neighbouring countries, in-country generation, and the potential of natural gas have been the main determinants of the undulating nature of Ghana's exports over the years.

Over time, the composition of installed electricity generation capacity in Ghana showed that the installation of thermal plants is constantly increasing, while renewable energy power plants[3], on and off-grid installation, and hydro power plants, respectively, are significantly low and fairly constant as shown in Figure 4.2. However, in total, from 2009 to 2021, the installation of electricity power plants has virtually increased. For the decomposition of the installation capacity of on and off-grid electricity generation plants see Appendix 1.3.

[3] This includes embedded renewable energy plants, roof top renewable installation, on-grid connected renewable energy, off-grid renewable energy plants.

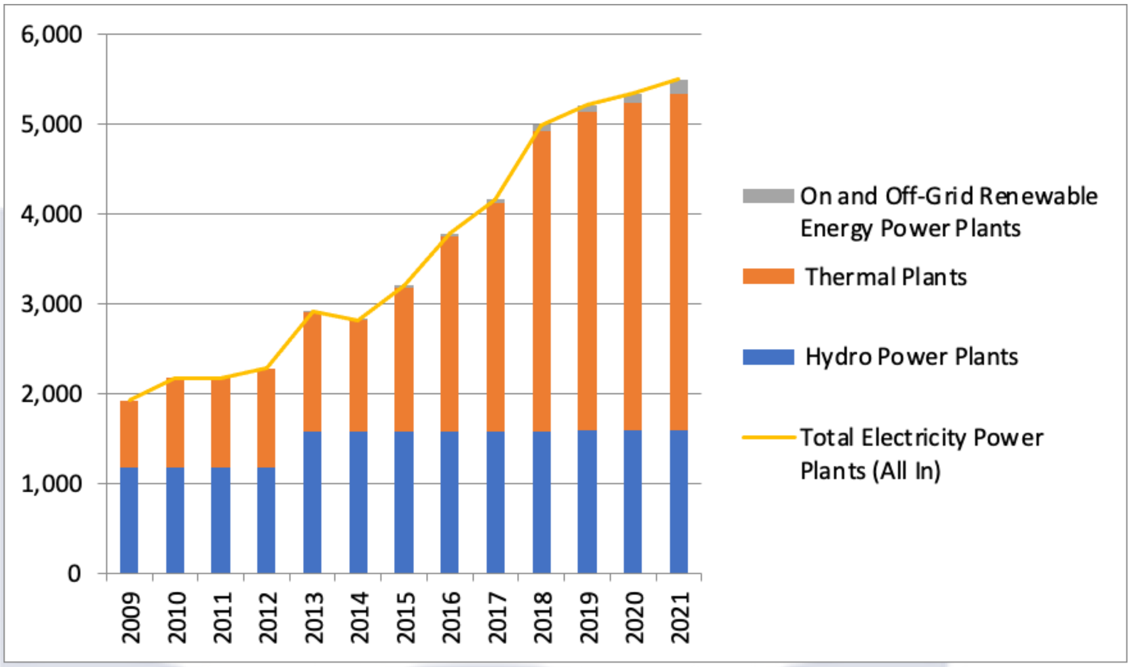


Figure 4.2: Electricity Generation Capacity Installation (2009-2021)

Source: 2022 National Energy Statistics

4.3 Ghana's Electricity Market Value Chain

The electricity market value chain of Ghana is made up of generators, transmitters, and distribution companies. The generators are both state-owned and independent power producers that generate power from thermal, hydro, and renewable sources, whereas transmitters act as intermediaries between generators and distribution companies. The distributors ensure power gets to the end users. The participants of the electricity market are licensees of the EC. The EC issues licenses for the following services.

4.3.1 Electricity Generation

The players in this market are either the distribution network or energy producers who supply the NITS (sub-transmission). There are 14 power generation firms currently in operation. Of them, three are connected to the distribution network and

11 to the NITS. Natural gas, diesel, and crude oil are the principal sources of fuel for Ghana's hydroelectric and thermal power plants. The VRA and BPA are state-owned organizations that manage the nation's hydroelectric and renewable energy generation. Together, they have an installed capacity for current facilities of 5,488.55 MW and a reliable capacity of 4,975.25 MW. Akosombo Hydro Plant and Kpong Hydro Plant are operated by VRA.

Thermal Generation: Kpone Thermal Power Station, Takoradi Thermal Power Complex (TT1PP & TT2PP), Takoradi Thermal Power Station (T1 or TAPCo), Renewable energy sources that are connected to the grid include the Navrongo, Lawra, and Kaleo solar power plants. Off-grid renewable energy sources include the development of mini grids in five island villages in Ada. The Takoradi International Power Corporation (TICO) thermal plant, which is also located in Aboadze, is owned and operated by TAQA, a private company, and is a joint venture between VRA and TAQA. Additionally, the Bui Hydroelectric Power Project and Solar Power Plants, which include a floating solar plant, are run by Bui Power Authority. In addition to these state-owned organizations, the nation's thermal power generation is also carried out by a number of IPPs, including Sunon Asogli Power Plant, Ameri Power Plant, Karpowership, Trojan Power Plant, Genser, CENIT Energy and Cenpower, Amandi, and AKSA. As of December 2021, thermal generating accounts for around 65.34 percent of the nation's electrical energy generation, with hydropower making up 34 percent.

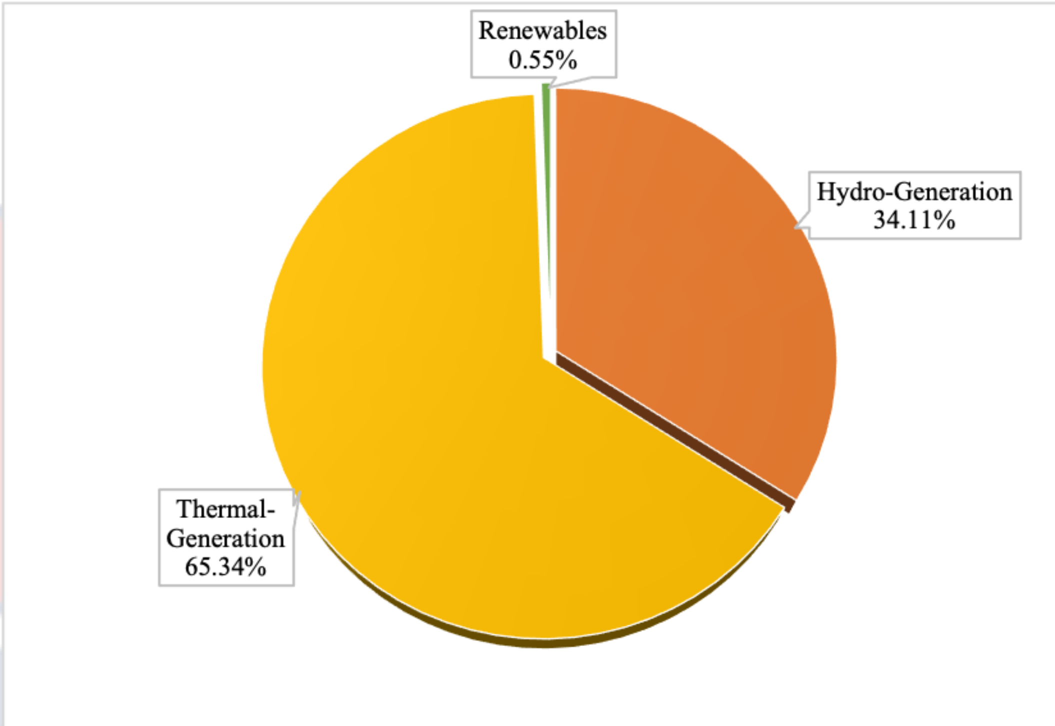


Figure 4.3: Grid Connected Power Supply Sources

Source: 2022 National Energy Statistics

4.3.2 Electricity Distribution

With the exception of the free zones enclave, the ECG enables distribution and sale to the southern region of Ghana. The distribution of power in Ghana's northern regions is handled by the NEDCo, a division of VRA. The private company, Enclave Power Company, has a small but important part in the Tema-free zones' power delivery. The operational zones for the electrical distribution firms are depicted in Figure 4.4.

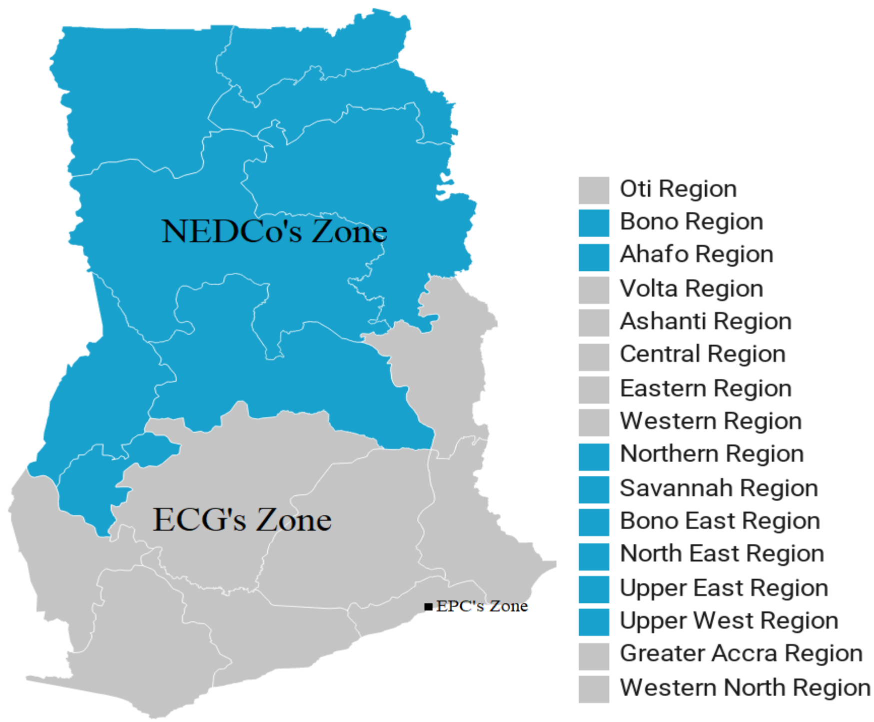


Figure 4.4: Operational Zones for the Electricity Distribution Companies

Source: Energy Commission

4.3.3 Bulk Consumer Permit

A bulk consumer is any consumer with a maximum demand of at least 500KVA for three successive months or a minimum annual electrical energy consumption of 1 million kWh. The VRA is responsible for electrical energy distribution to bulk consumers, particularly mining companies. A bulk customer per the permit can negotiate for the bulk supply of power to their facility with an electricity generator or a distribution company. The EC has issued 27 bulk customer permits as of 2022. Out of the 27 bulk consumers, seven steel companies have a special regulated tariff approved by the Commission; seven other bulk customers have negotiated their tariffs with ECG; while the remaining 13 are yet to request a negotiated tariff.

4.3.4 Electricity Export

Ghana contracts to sell power to its neighbours, including Burkina Faso through La Société Nationale d'Electricité du Burkina Faso, Togo and Benin through The Communauté Electrique du Bénin (CEB) and Société Nationale d'électricité du Burkina Faso (SONABEL). In addition, the government of Ghana and the Compagnie Ivoirienne d'Electricité (CIE) of Côte d'Ivoire have a power exchange agreement. The VRA is one of the organizations that the EC has charged with providing this energy. Ghana's power export and import from 2000 to 2021 are depicted in Figure 4.5. The graph makes it clear that Ghana has been mostly producing excess electricity, making it a net exporter of electricity.

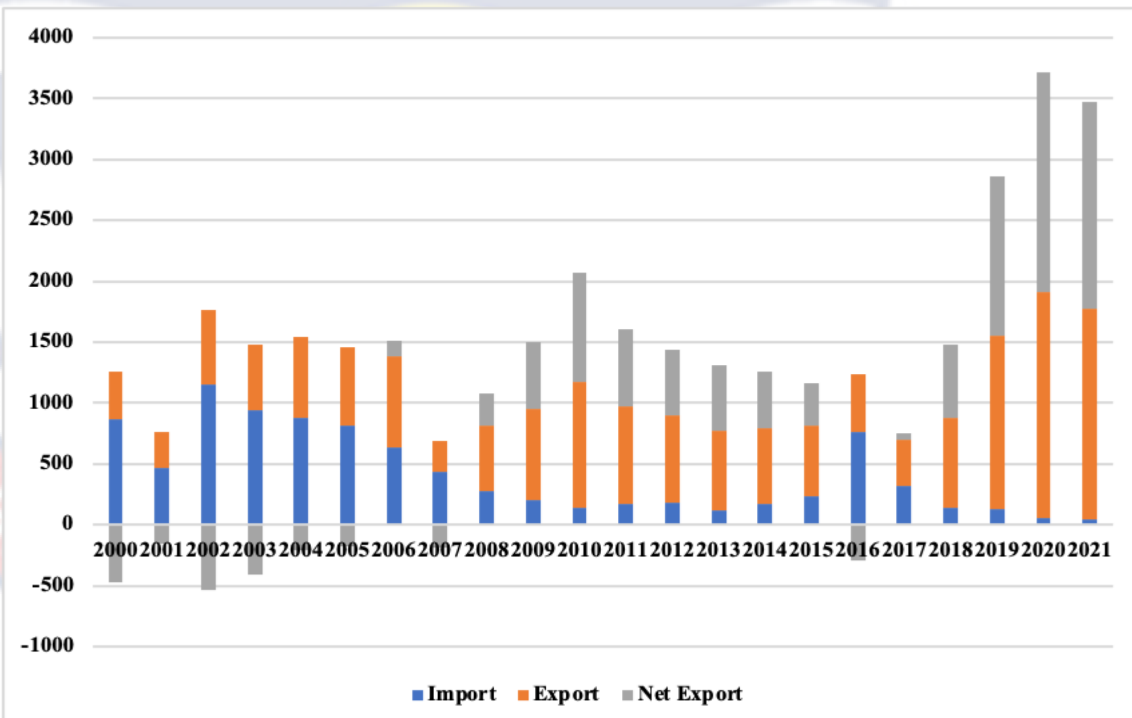


Figure 4.5: Electricity Export and Import

Source: 2022 National Energy Statistics

Broker

An electricity broker acts as a liaison in deregulated energy markets between energy suppliers and end-users. These brokers help customers to secure fair pricing for their energy needs by comparing rates and contracts across suppliers and negotiating contract terms on behalf of their clients. This is yet to be practiced in Ghana.

4.4 The Evolving Nature of the Electricity Market (beginning, and current structure) and Clean Energy Financing

In the early stages of the distribution of electricity, the country relied solely on hydroelectric power supply from the Akosombo Dam operated and managed by the VRA. The Ghana GRIDCo, being responsible for energy transmission, transmits the energy produced by VRA to ECG for distribution to the end users. This was the channel of energy distribution until thermal and other renewable sources were introduced as a result of increasing population; hence, increasing the demand for electricity and climatic factors causing the government to institute reforms to allow private investors to engage in electrical energy production with VRA to meet the increasing demand levels.

The study demonstrates the changes that have taken place in the electricity market by presenting the current framework in the electricity market as shown in Figure 4.6. The study asserts that the electricity market structures are not static in nature but are continuously evolving based on the innovations of technology. The complex nature of the electricity market can be better described using the compelling trio: commercial or legal, technology or engineering and finance & investment. The development in the electricity sector is underpinned by the compelling trio. The electricity market of Ghana today is comprised of varied power generating sources from fossil fuel to renewable energy technologies that are owned by government, the private sector, as well as joint investments between government and the private sector. Energy is solely transmitted by the transmission utility; however, competition for market share driven by price and innovation in technology has resulted in some power plant supply power getting to the doorsteps of the end users as demonstrated in the case of energy supply by renewable energy installations and Genser Energy. This poses direct competition not only to their peers in the generation sub-sector of the electricity value chain but also the transmission and distribution utilities and demonstrates the evolving nature of the market driven interests of the end users of electricity.

The development partners, multilateral organizations, the GEF, and several other entities are examples of multinational communities. The MoEn, with assistance from the MoF, is the principal organization in control of the energy industry. The Ministry is responsible for carrying out governmental directives. The two regulating organizations in the industry are the EC and the PURC. Since its jurisdiction is not limited to just energy, the PURC reports directly to the Office of the President, as opposed to the EC, which is immediately under the MoEn. The producers, transmitters, distributors, and consumers of electricity are the other sector participants.

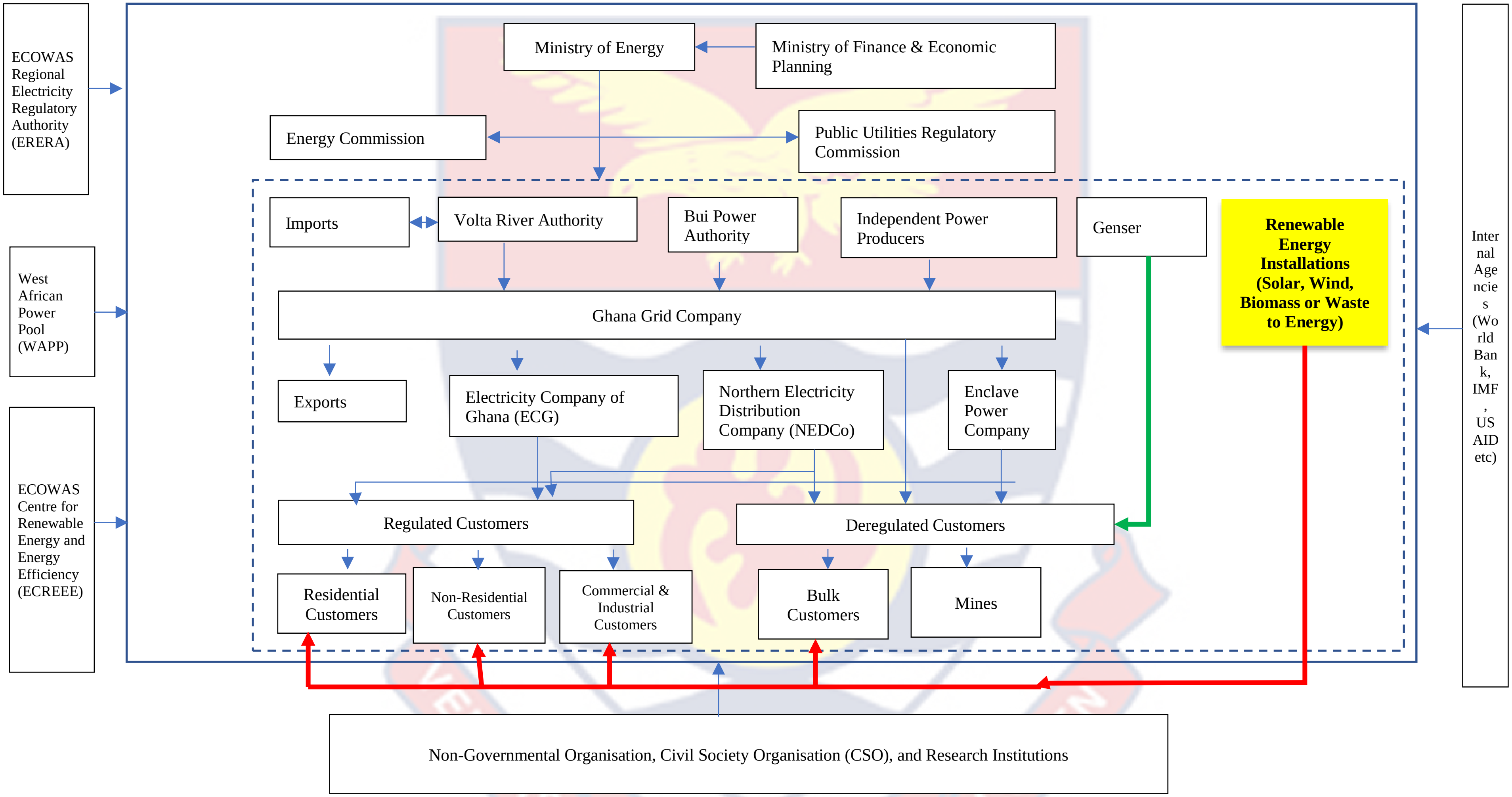


Figure 4.6: Current Electricity Market Framework in Ghana

Source: Author's Own Construct

4.5 Electricity Regulation in the Energy Sector

4.5.1 The Ministry of Energy

The National Electrification Scheme (NES), which aims to distribute the availability of electricity to all communities throughout time, is to be implemented by the MoEn, which is also in charge of establishing, assessing, and monitoring policies, programs, and projects in the energy sector. The ministry performs the following primary duties:

a) Make sure there is a consistent supply of inexpensive energy services to satisfy domestic demand and export.

b) Transform the national energy policy's directives and the government's plan for energy development into strategies and initiatives.

c) Expand access to modern energy sources, especially in remote regions.

d) Make sure that future energy supplies are secure and readily available.

e) Boost the entities responsible for planning and coordinating the energy industry.

4.5.2 Energy Commission (EC)

The EC was created in accordance with the Energy Commission Act of 1997 (Act 541), and is in charge of policing the technical activities of the energy service providers in the natural gas and electricity sectors. In addition, the EC offers the Energy Minister advice on issues pertaining to planning and development policies for the energy sector. Subsidiary laws 2008 (LI 1934) and 2008 (LI 1937) were passed with the help of the EC.

NDPC delegate, the Chairman, the Executive Secretary, and additional individuals knowledgeable in topics pertinent to the Commission's duties make up the governing body of the EC. The commission's primary duties are:

a) Suggest national strategies for the growth and use of indigenous energy resources
b) In light of the national economy, advise the Minister on national strategies for the efficient, affordable, and safe supply of electricity, natural gas, and petroleum products.
c) Prepare, analyse, and update indicative national plans on a regular basis to guarantee that realistic energy demands are satisfied.
d) Promote and uphold best practices for the wholesale supply, distribution, and sale of natural gas and electricity.
e) Pursue and make sure that this Act and Regulations are strictly followed.

4.5.3 Public Utilities Regulatory Commission (PURC)

To oversee the services provided by power and water corporations, the PURC was founded under the Public Utilities Regulatory Commission Act, 1997 (ACT 538). In the Energy Commission Act of 1997, the PURC's regulatory authority was expanded to include fees associated with the transportation of natural gas (ACT 541). The PURC carries out its ACT 538 tasks independently of other institutions, although the Office of the President is in charge of overseeing its administrative responsibilities.

The Trade Union Congress (TUC), the Association of Ghana Industries (AGI), a representative of domestic consumers, and four specialists on the duties of the commission are among the nine commissioners that make up the PURC. The commission's primary duties consist of:

a) safeguarding the interests of customers and utility service providers by examining and approving rates charged for the supply of utility services; and
b) undertaking research on the economics and efficiency of public utilities, to keep an eye on performance criteria for the delivery of services, to encourage fair competition among public utilities.

4.5.4 The Other Stakeholders

a) **Volta River Authority** – The VRA is in charge of producing power utilizing the Volta River and any other methods under the Volta River Development Act, 1961 (Act 46), which established it.
b) **Bui Power Authority** – To facilitate the generation of electricity on the Black Volta in Bui and other possible hydroelectric power sites on the Black Volta River, the Bui Power Authority Act, 2007 (Act 740) was established.
c) **Ghana Grid Company (GRIDCo)** – created by the EC, this system primarily acts as a middleman for the dispatch and transfer of power from electricity producers to electricity distributors (ECG and NEDCo) as well as to mines or large clients.
d) **Environmental Protection Agency (EPA)** – EPA was created by the EPA Act of 1994 (Act 490), with the primary goals of preserving the nation's environment and authorizing power projects only after thorough evaluations based on scientific research to guarantee the safety of the environment.

e) **Independent Power Producers:** These are private investors in the generation phase of the country's power sector.

f) **Distribution Companies:** These organizations deliver energy to the end customers. The two largest distributors in the nation are ECG and NEDCo. While NEDCo, a subsidiary of VRA, distributes to the northern portion of the country, ECG serves the southern region. Power for the Tema-free zones is provided by a private company called EPC.

g) **Customers:** these are the end-users of the power generated for household and commercial purposes.

4.6 Clean Energy Technologies and Clean Energy Financing in the Electricity Market of Ghana

Even though the CO_2 emission from Ghana is relatively low as compared to advanced economies, it is worth noting that there has been significant growth in the CO_2 emissions from 637,536 tonnes in 1950 to 16,001,330 tonnes in 2020 resulting in a 2,409.87 percent cumulative growth in CO_2 emissions over a 70-year period. This necessitates the the development of mitigation actions to slow down the growth in CO_2 emissions as Ghana strategizes its industrial development. When Ghana turned on its oil faucets in 2010 by commencing commercial exploration of oil, this economic activity contributed to increasing GHG emissions as shown in Figure 4.7.

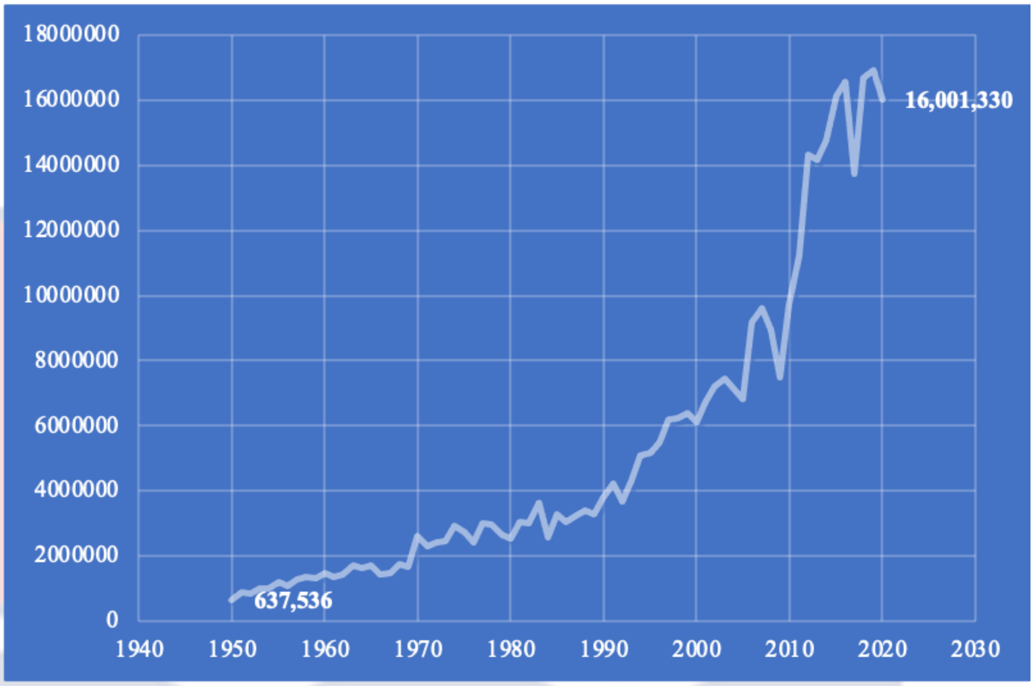


Figure 4.7: Trends in CO_2 Emissions in Ghana (tonnes) (1950-2020)

Source: Global Carbon Project https://ourworldindata.org/co2-dataset-sources

The use of clean energy sources is a major strategy that can offset or significantly reduce the level of CO_2 emissions. Consequentially, over the past three decades, the energy sector of Ghana has evolved due to various reforms that have created an enabling environment to attract financing, as well as welcome private sector participation in the electricity market. According to a Renewable Energy Advisor, "the increasing cost of electricity which emanated from cost of fuel including gas served as basis to explore alternative energy source. Renewable energy technologies were identified as an option worth exploring". This was supported by the Renewable Energy Law (Act 832, 2011).

Based on data collected from the EC, MoEn, ESRP, Renewable Energy Association, renewable energy installers, consultants and advisors working for development and donor agencies with projects in Ghana and interviews from about

48 energy sector stakeholders identified through a purposive sampling approach from the electricity market, it was important to classify the clean energy technologies into renewable energy technologies and energy efficient technologies. Table 4.1 shows the decomposition of renewable energy installations in Ghana as at December 2021.

Table 4.1: Renewable Energy Installation (MW), December 2021

Embedded Renewable Energy Plants	**Type**	MW
VRA Solar (Navrongo)	Solar	2.5
VRA Solar (Lawra)	Solar	6.54
VRA Solar (Kaleo)	Solar	13
BXC Solar	Solar	20
Meinergy	Solar	20
Safisana Biogas	Waste to Energy (Biogas)	0.1
Tsatsadu Hydro	Hydro	0.045
Sub-total of Embedded Renewable Energy Plants		**62.185**
Roof Top Renewable Energy Installation		
Distributed Solar PV	Residential Solar Roof Top & C&I	30.9198
Sub-total Roof Top Renewable Energy Installation		**30.9198**
On-grid Renewable Energy Plants		
Bui Solar	Solar	51
Sub-total on-grid connected RE		**51**
Mini-grid (Off - grid) Renewable Energy Plants		
Wayokope (GoG)	Solar	0.03
Atigagorme (GoG)	Solar	0.0405
Kudorkope (GoG)	Solar	0.054
Perdiatorkope (GoG)	Solar	0.05
Aglakope (GoG)	Solar	0.054
MOEN (GoG)	Solar	0.0275
Black Star (Private)	Solar	0.0583
Wind	Wind	0.011
Sub-total of mini-grid (off-grid) RE Plants		**0.3253**
Off-grid Renewable Energy Plants		
Solar (Off-grid)	Solar	7.42444
Wind (Off-grid)	Wind	0.02
Sub-total Off-grid Renewable Energy		**7.44444**
Total Renewable Energy Power Plants	Solar, Hydro, Waste to Energy (Biogas), Wind	151.875

Source: Energy Commission 2022

Renewable Energy Technologies in Ghana

As of December 2021, Ghana has successfully integrated solar photovoltaic, hydro and biomass (waste to energy) technologies into the grid as embedded generation and through the NITS. The research also identified that there exist bulk customers in the deregulated market of electricity who utilize electricity generated with solar technology.

On-grid Renewable Energy Installation (Embedded & Connected to NITS)

The 2011 Renewable Energy Act (Act 832) affirms Ghana's commitment to integrate renewable energy generation in the total generation mix up to 10 percent by 2030. The VRA implemented the REDP to demonstrate the VRA's commitment to align its corporate objectives with the broader national policy of the GoG. Two sizable hydroelectric power plants, located in Akosombo and Kpong, are already up and running and managed by VRA. In order to achieve this, VRA installed a total of 22.04 MW between 2013 and 2021 using cash it earned itself (equity funding) to receive finance from development partners. The Upper East Region of Ghana's Navorongo 2.5 MW Solar PV Plant was Ghana's first grid-connected solar PV plant, and it was linked via the distribution network. There is more capacity for renewable energy projects that VRA aims to create, according to the report.

Act 1046, the Amendment Act 2020, requires Ghana's BPA to build renewable energy facilities and other clean energy options. To accomplish this, the Bui Switchyard was enlarged to hold and evacuate 250MWp of solar energy for the construction of a hydro-solar PV hybrid (HSH) system, which led to the establishment of a solar PV facility, a control room, and transmission system in

2019. The analysis confirms that as of November 2020, BPA will have its first solar PV plant with a 50MWp capacity connected to the NITS. The Power Africa Bui Project (50 MWp), according to the USAID, is anticipated to reduce GHG emissions by more than 47,000 tons annually. Additionally, the plant has a 1 MW floating solar component.

The research supports evidence of private sector involvement in the construction of a solar power facility that is directly linked to the distribution network and has a signed PPA with ECG as stated below:

20MW solar PV facility owned by BXC (Ghana) Company Limited; Gomoa Onyadze, Central Region.

Safi Sana Ghana Limited: Ashaiman, in the Greater Accra Region, is home to a 100kW waste-to-energy facility.

20MW solar PV project owned by Meinergy Technology Company Limited, situated in the Central Region in Gomoa Onyadze.

Hydro Power Plant

BPA developed a micro-hydropower plant called the Tsatsadu Generating Station (TGS) situated on the Tsatsadu Waterfalls Volta Region, which has a capacity of 45kW under the MoEn's Renewable Energy initiative. The project was valued at US$ 400,000 with equity funding from internally generated funds (IGF) from BPA and support from the Danish Government funded project called UNDP/Energy Commission Renewable Energy Technology Transfer (RETT) worth an amount of US$ 80,000.

Solar Home System Installation

It was identified from the research that there was evidence of roof top solar home system installation, which was a resultant of a combination of programmes led by government, private sector and the development partners. The government programme was led by the Energy Commission through the roof top solar programme as part of efforts to ensure the development and utilisation of the renewable resources to contribute to mitigating the 2014-2016 power crisis in Ghana. The objective of the programme was to reduce the daily national peak load by 200 MW through self-generation using solar PV technology. Government provided a capital subsidy to beneficiaries in the form of rebate that paid for part of the total cost of the solar system; specifically, the solar PV module (500 peak Watts (Wp)) was installed for each residential applicant while the beneficiaries pay for the balance of the system[4] (BOS) components. According to the EC, they partnered

[4] Changed all lamps in residential facility to LED lamps; and purchased and installed the requisite components such as inverter, batteries, charge controllers, change over, etc. from an Energy

with banks at the time to provide financing in the form of loans for interested parties. This resulted in financial institutions such as UMB Bank (an indigenous local commercial bank) to design loan products.

Although several applications were received by the EC, a total of about 641 installations were undertaken by about 50 registered and licensed Energy Commission solar installers.

Commercial and Industrial Development

The study also identified some commercial and industrial development in Ghana utilizing electricity from solar PV as described below based on data from the EC, Renewable Energy Association and Solar Installer:

i. Crossboundary Energy Ghana Limited (400kWp rooftop solar PV plant at Kasapreko Company Limited located at Spintex Road, Accra.
ii. CrossBoundary Energy Ghana Limited for their projects of 1.0MW each at Coca-Cola Bottling Company and Unilever Ghana Limited.
iii. Cargill has installed 562 kWp Solar PV at Tema
iv. ITFC has installed 46 kWp Solar PV at Gushie
v. IWAD has installed 499kWp Solar PV at Yagaba
vi. Total has installed 144 kWp Solar PV across various offices in Ghana
vii. Dutch Embassy in Accra has in Solar PV with capacity of 27 kWp
viii. Nyaho Medical Center in Accra has installed 195 kWp of Solar PV.
ix. A&C Development Ltd has installed a 1.8MWp off-grid Solar PV.

Commission licensed solar vendor, whose products meet the minimum Technical Standards set by Ghana Standards Authority (GSA).

Mini-grid Development in Ghana

As of December 2021, a total of 0.3253 MW of mini-grid installation was undertaken using both solar PV (0.3242 MW) and wind (0.011 MW) technologies by both GoG through the MoEn with funding from the WB and the private sector. This was identified to be situated on both 5 Island Communities in Ada and other inland communities. The wind installation of 0.011 MW was situated in Ada as part of the 5 Island Communities and are recorded in Table 4.2.

Table 4.2: Mini-installations at the 5 Island Communities

LOCATION	SYSTEM CONFIGURATION
Aglakope	57 kW solar with 33 kVA diesel genset & 3523 Ah battery bank
Kudorkope	54 kW solar with 33kVA diesel genset & 4248 Ah battery bank
Atigagome	41.31 kW solar with 20 kVA diesel genset & 2124 Ah battery bank
Wayokope	30.6 kW solar with 20 kVA diesel genset & 2124 Ah battery bank
Pediatorkope	39 kW solar & 11 kW wind energy

Source: EC, VRA and MoEn

4.6.1 Energy Efficiency Technologies in Ghana

The distribution of six million incandescent bulbs, which decreased peak load by 124 MW in 2007, was pushed by the EC, the Commission claims. The Osu Castle, Parliament House, Accra Sports Stadium, Food and Drugs Board, Korle Bu Teaching Hospital, and the Ministry of Defence were the six public institutions that had automated capacitor banks built in 2009. This intervention was thought to have saved a total of 1,851kVA. The Refrigerator Energy Efficiency initiative was started by the Commission in the last quarter of 2011. The initiative was designed to improve the roughly 2 million ineffective refrigerators used in Ghana. These refrigerators use an average of 1,200 kWh annually, compared to 250 kWh for more efficient ones. The initiative aims to gradually phase out inefficient refrigerators and put highly efficient refrigerators into the market, with the potential to reduce refrigerator power use by 50 percent over the course of a few years.

Table 4.3: Off-grid Renewable Energy Installations

Source: Renewable Energy Association, 2022

	2016		2017		2018		2019		2020		2021	
Type of Product/Activity	**No. of Households / Quantity Installed**	**No. Companies**	**No. of Households / Quantity Installed**	**No. Companies**	**No. of Households / Quantity Installed**	**No. Companies**	**No. of Households / Quantity Installed**	**No. Companies**	**No. of Households / Quantity Installed**	**No. Companies**	**No. of Households / Quantity Installed**	**No. Companies**
Solar Home Systems	11,090	1	288,558	3	55,873	2	14,845	5	9,717	5	18,514	5
Mini-grid Connections	0	0	0	0	0	0	0	0	2	1	230	1
Health-Institutional Solar Power System	0	0	0	0	0	0	7	1	5	1	45	3
Schools-Institutional Solar Power System	0	0	0	0	0	0	30	1	58	2	14	2
Solar Water Pumps-Health	0	0	0	0	0	0	3	1	3	1	10	2
Solar Water Pumps--Domestic/Business	0	0	0	0	0	0	45	2	1,362	4	297	3
Refrigerators-Health	0	0	0	0	0	0	16	2	6	2	1,447	2
Refrigerators-Domestic/Business	0	0	0	0	0	0	10	1	2	1	51	1
Maize Mills	0	0	0	0	0	0	0	0	0	0	0	0
Fishing Lights	0	0	0	0	0	0	80	1	20	1	20	1

Note: Solar Home System (SHS) is described as household as defined, hence SHS represents individual purchases with capacity of technology is between 50Watts to 100 Watts; mini grids are described by the households that benefited from the installation; health-institutional solar power system: is counted based on the number of facilities that benefited from the installation; schools-institutional solar power system: is counted based on the number of facilities that benefited from the installation; productive use of electricity (solar water pumps-health, solar water pumps--domestic/business, refrigerators-health, refrigerators-domestic/business, maize mills and fishing lights) is the number of installations.

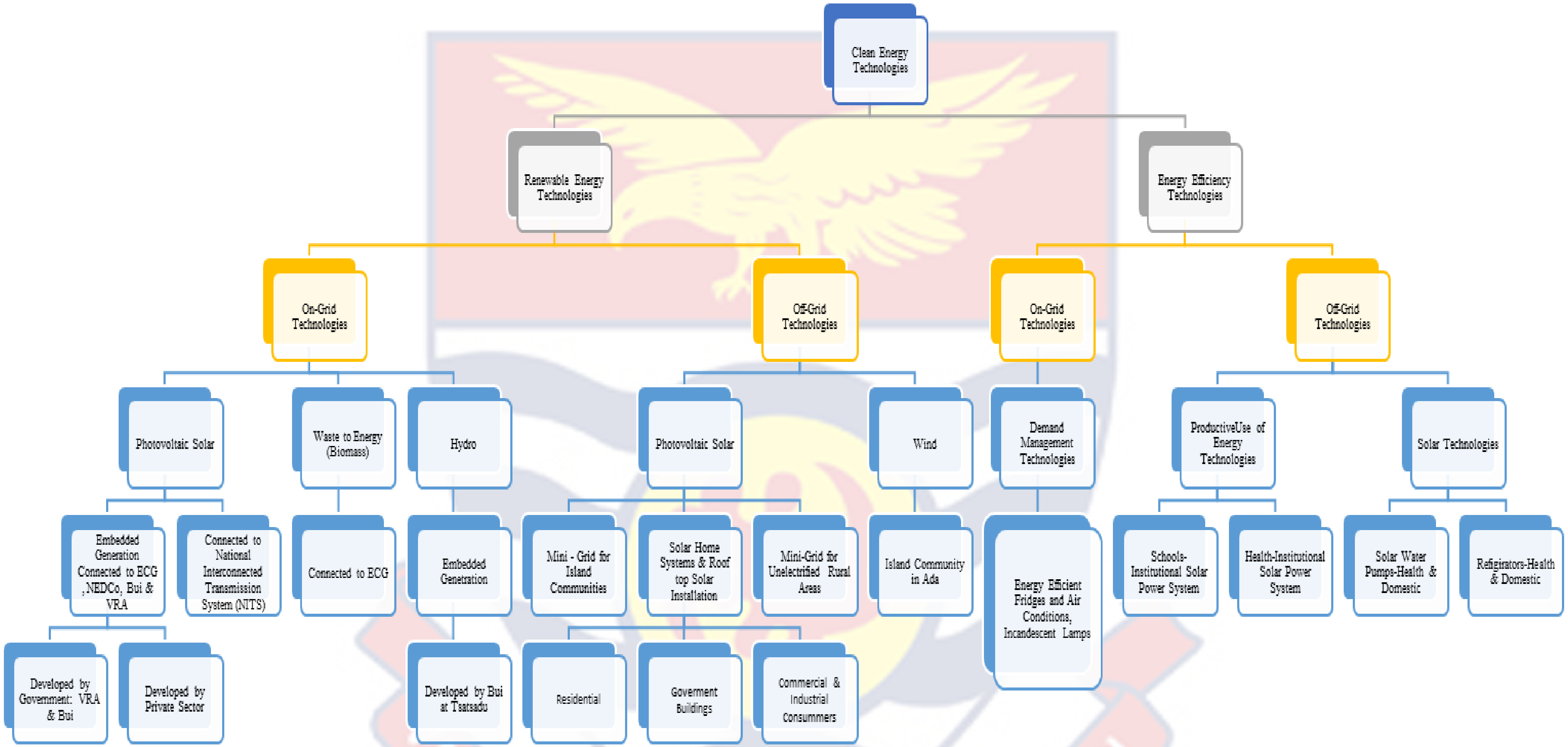


Figure 4.8: Framework for Clean Energy Technologies in the Electricity Market of Ghana as at December 2021

Source: Author's Own Contract

4.7 Sustainable Development

In describing sustainable development as part of the study, empirical data described the following: entrepreneurial participants in clean energy & skills development; access to electricity; employment; and economic development indicators.

4.7.1 Entrepreneurial Participants in Clean Energy & Skills Development

According to the EC of Ghana, approximately 130 temporary wholesale electricity supply licenses have been granted to potential IPPs to produce a total of 7,030.6 MW of electricity from various renewable energy sources. The projects are at various stages of development, as shown in Table 4.4 below:

Table 4.4: Stages of Renewable Energy Development on Specific Projects

Stage 1: Provisional License				
NO	**Number of Companies Licensed**	**Plant Capacity (MW)**	**Plant Type**	**Proportion (percent)**
1	2	68	Biomass	1.07%
2	1	120	Hybrid Hydro-Solar Plant	1.88%
3	13	207	Hydro-power plant	3.24%
4	51	3,727	Solar PV Plant	58.46%
5	15	963	Waste-to-Energy	15.11%
6	13	1,290	Wind Powered Plant	20.23%
Total	95	6,375		100.00%
Stage 2: Siting Permit				
NO	**Number of Companies Licensed**	**Plant Capacity (MW)**	**Plant Type**	**Proportion (%)**
1	1	100	Hybrid System (Solar and Wind)	7.26%
2	2	60	Hydro-solar hybrid power plant	4.36%
3	18	941	Solar PV Plant	68.34%
4	1	6	Waste-to-Energy	0.44%
5	3	270	Wind	19.61%
Total	25	1,377		100.00%
Stage 3: Construction Permit				
NO	**Number of Companies Licensed**	**Plant Capacity (MW)**	**Plant Type**	**Proportion (%)**
1	10	535	Solar PV Plant	34.85%
2	1	1,000	Wave	65.15%
Total	11	1,535		100.00%
Stage 4: Operational				
NO	**Number of Companies Licensed**	**Plant Capacity (MW)**	**Plant Type**	**Proportion (%)**
1	1	0.03	Hydro Power Plant	0.03%
2	1	0.782	Rooftop Solar PV	0.69%
3	1	0.1	Waste-to-Energy	0.09%
4	7	111.97	Solar PV Plant	99.19%
Total	10	112.882		100.00%

Source: Energy Commission, 2022

According to the information gathered from the study, Ghana's entrepreneurial development after the adoption of the renewable energy law and its commitment to the NDC made as part of the Paris Agreement at COP 21 are both described in the statistics above. This has drawn both domestic and foreign investors, which has led to the development of local capacity through different technical studies and consultations that must be carried out at each level of licensing.

4.7.2 Access to Electricity

The stability in the annual rise in access to electricity in both Ghana's urban and rural areas clearly demonstrates the government's commitment to achieving universal access to energy. Since the early 1990s, successive governments have maintained this developmental strategy, further reinforcing the idea that the electrical sector is a catalyst for development and industrialisation.

The EC's 2022 Energy Statistics show that as of 2021, 86.3 percent of Ghanaian homes have access to electricity. Figure 4.9 demonstrates that nearly 96 percent of people in the Greater Accra Region have access to electricity, with the Central (91 percent), Western (89 percent), and Eastern (88 percent) Regions following behind. Less than 60 percent of the population in the Upper East and Savannah Regions have access.

Figure 4.9: Distribution of Electricity across Regions in Ghana

Source: Energy Commission

The pattern of access is starkly disproportionate between the urban and rural population. As shown in Figure 4.10, on average, between 1993 and 2020, the population in the urban areas enjoyed around 71 percent of electricity access compared to 29 percent of the rural population. Therefore, if the commitment towards ensuring universal electricity access is to be achieved, massive and urgent investment in electricity infrastructure is required.

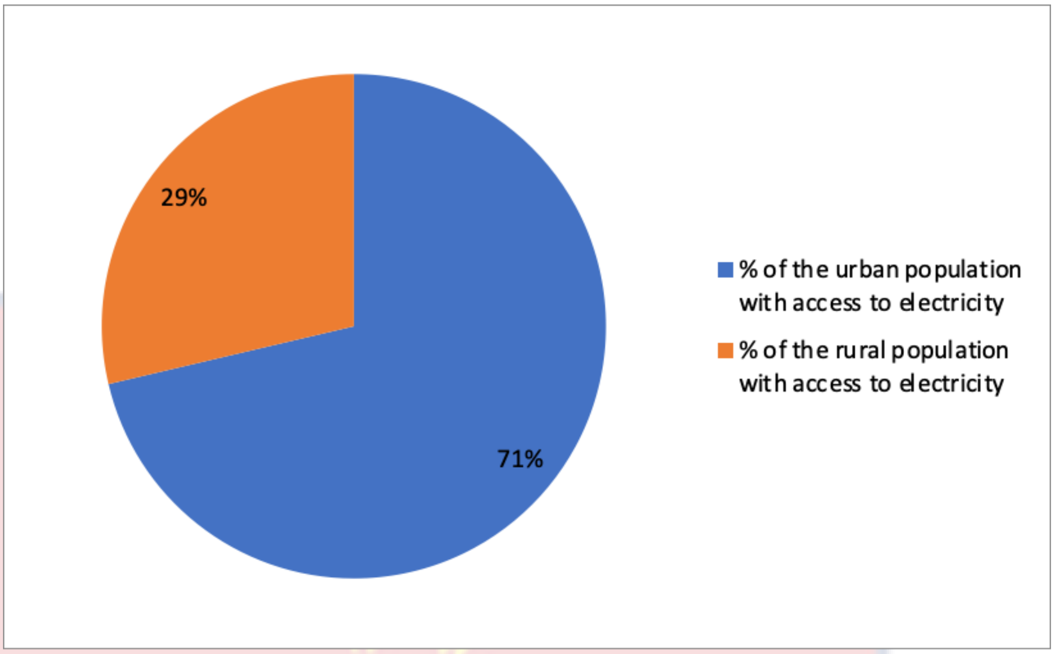


Figure 4.10: Population with Access to Electricity in Ghana (Average 1993-2020)

Source: World Bank (2022).

4.7.3 Employment

Unemployment, as described by the International Labour Organization, refers to the share of the labour force that is without work but available for and seeking employment. The unemployment rate in Ghana as at 2021 (4.7 percent) has significantly reduced relatively to the high levels recorded in the year 2000 (10.5 percent). This suggests that drivers of economic activities and entrepreneurial activities have positively affected this. While this reduction brings relief, it is worth noting that Ghana is experiencing its third wave on increasing unemployment rates. The first wave: 1991 (3.5 percent) to 2000 (10.5 percent), second wave: 2006 (4.6 percent) to 2015 (6.8 percent) and third wave: 2017 (4.2 percent) to 2021 (4.7 percent). Even though the analytics suggests slower growth in the wave due to unequal time periods, the macro fiscal environment suggests economic turbulence at each wave. Ghana joined Highly Indebted Poor

Countries (HIPC)[5] in 2001. The second wave is characterized by Ghana seeking a bailout from the International Monetary Fund (IMF)[6] in 2015. Finally, during the third wave Ghana is again seeking a bailout from the IMF[7] in 2022. Figure 4.11 shows the trends and waves in employment in Ghana between 1991 and 2021.

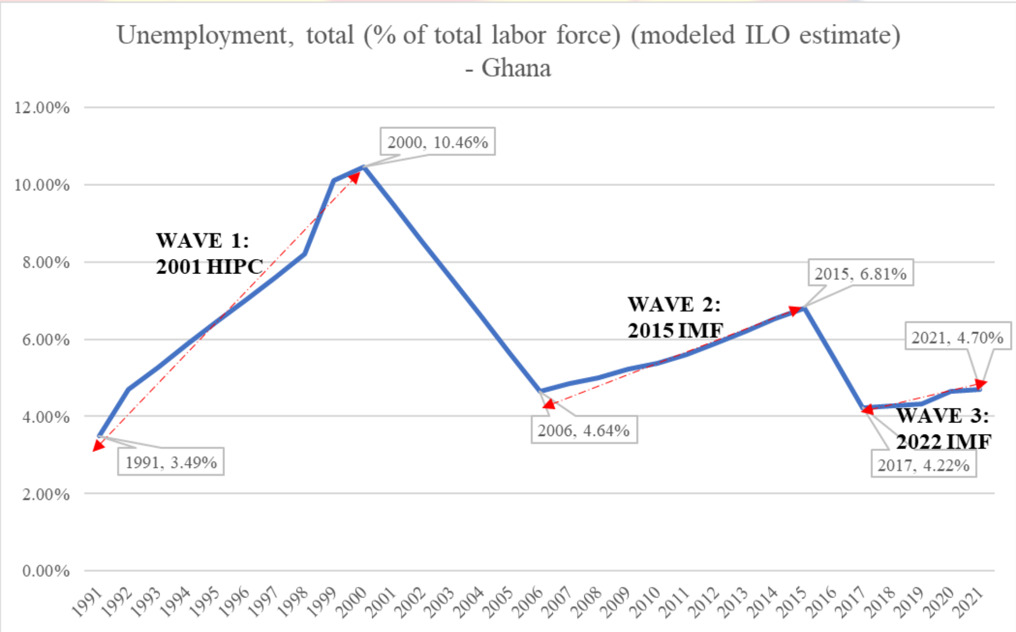


Figure 4.11: Employment Trends and Waves in Ghana (1991-2021)

Source: Author's Own Construct and World Bank (2022).

4.7.4 Economic Development Indicators

The economy of Ghana has experienced varied changes that project the country as an attractive destination for investment while at the same time there exist moments in the economic cycle where both internal governance and external shock that took place in the global economy disqualifies the country as an

[5] https://www.imf.org/en/News/Articles/2015/09/14/01/49/pr0211
[6] In early 2015, Ghana turned to the IMF for a $918 million loan to help stabilize the economy.
[7] https://www.imf.org/en/News/Articles/2022/12/12/pr22427-imf-reaches-staff-level-agreement-on-a-3-billion-three-years-ecf-with-ghana

investment destination. The study realized that there is the urgent need to undertake pragmatic steps for Ghana to reduce the widening fiscal deficit as well as implement a long-term strategic plan that strengthens the economic fundamentals that can spur development.

Overall, GDP growth (annual percent) has largely fluctuated over the years. As shown in Figure 4.12, from 2000 to 2006, the growth rate in Ghana was virtually increasing before becoming inconsistent. Due to the global financial crisis in 2008, in 2009 Ghana experienced a sharp decline in growth by almost 5 percent. However, the country quickly recovered in 2010 before doubling its growth rate in the following year, 2011 (14 percent). Afterwards, the country once again experienced a consistently steep fall in growth till 2015 when the country achieved a 2 percent growth rate. Meanwhile, the bounce back did not last long as the country was overwhelmed by a major failure by several financial institutions from the banking sector between 2017 and 2019 (see Dwamena & Yusoff, 2022). Furthermore, the advent of the COVID-19 pandemic, which affected and continues to affect the global supply chain, led to the country experiencing its lowest growth rate in the past two decades, 0.5 percent in 2020.

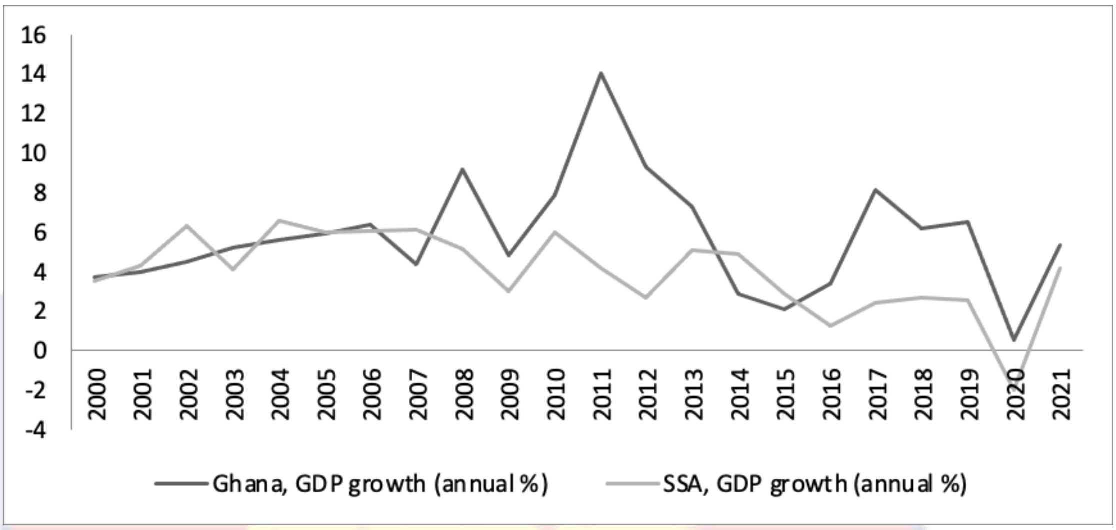


Figure 4.12: Trend in GDP Growth in Ghana (2000-2021)
Source: World Bank (2022)

However, while Ghana has maintained positive growth levels since 2000: between 2000 and 2021, it averaged a growth rate slightly below 6 percent annually. Comparatively, this is greater than the SSA average of 4 percent, and many other low-income countries.

Relatively, the level of inflation in Ghana has improved over the years (Figure 4.13). Compared to 40 percent in 2000, the level of inflation fell by over 30 percent in 2021. From the graph, one can easily conclude that inflation has generally fallen. Nevertheless, the average inflation rate during the period under review has been 16 percent. This, in comparison to SSA's average of 6 percent, is very high.

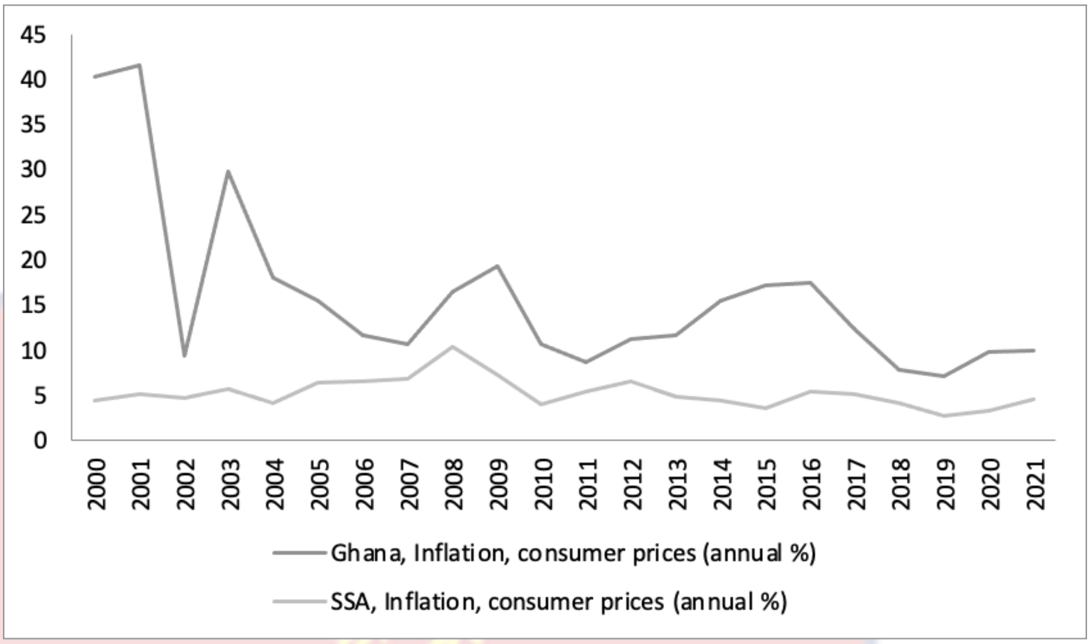


Figure 4.13: Trends in Inflation in Ghana (2000-2021)

Source: World Bank (2022)

In recent times, against major international currencies, the Ghanaian cedi has been amongst the worst performing currencies in the World. Monthly economic data[8] from the central BoG showed that in between the beginning and end of the year 2022 the Ghanaian cedi fell by over 70 percent against the United States Dollars, British Pound Sterling and Euros. Annual presentation of the performance of the official exchange rate trend speaks to the poor performance of the cedi. From the graph in Figure 4.14, over the years the Ghana cedi has been gradually depreciating against the US dollars. Worryingly, the Ghana cedi has lost value from almost 1:1 rate of exchange in the early 2000 to around 8.4 cedi for a dollar in 2022. This performance of a key macroeconomic indicator holds significant consequence on restoring or maintaining the confidence of investors, as well as the creation of an enabling business environment to drive growth.

[8] https://www.bog.gov.gh/economic-data/exchange-rate/

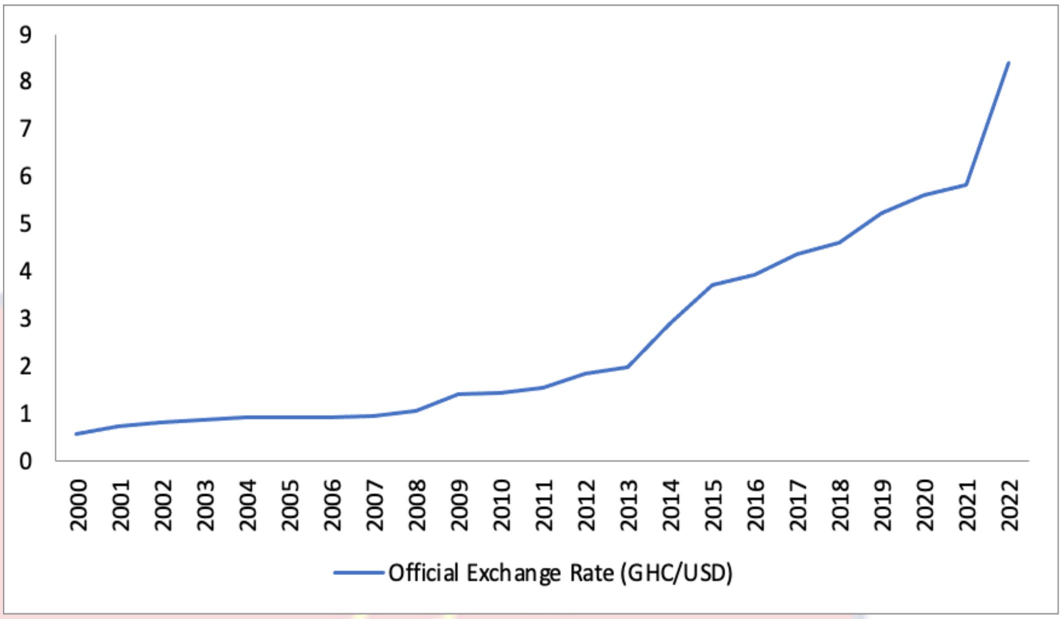


Figure 4.14: Trend in Official Exchange Rate (GHc/US$; 2000-2021)
Source: World Bank (2022)

With low saving capacity, government debt in Ghana continues to rise over time. As shown in Figure 4.15, government debt in 2021 was 77 percent as a share of GDP, 40 percent greater than it was in 2010; with government capacity to generate revenue seriously outweighed by its ability to spend. As reflected in Figure 4.15, since 2005, government expenditure has consistently been greater than government revenue. Ultimately, this only increases government reliance on more borrowing to undertake developmental projects.

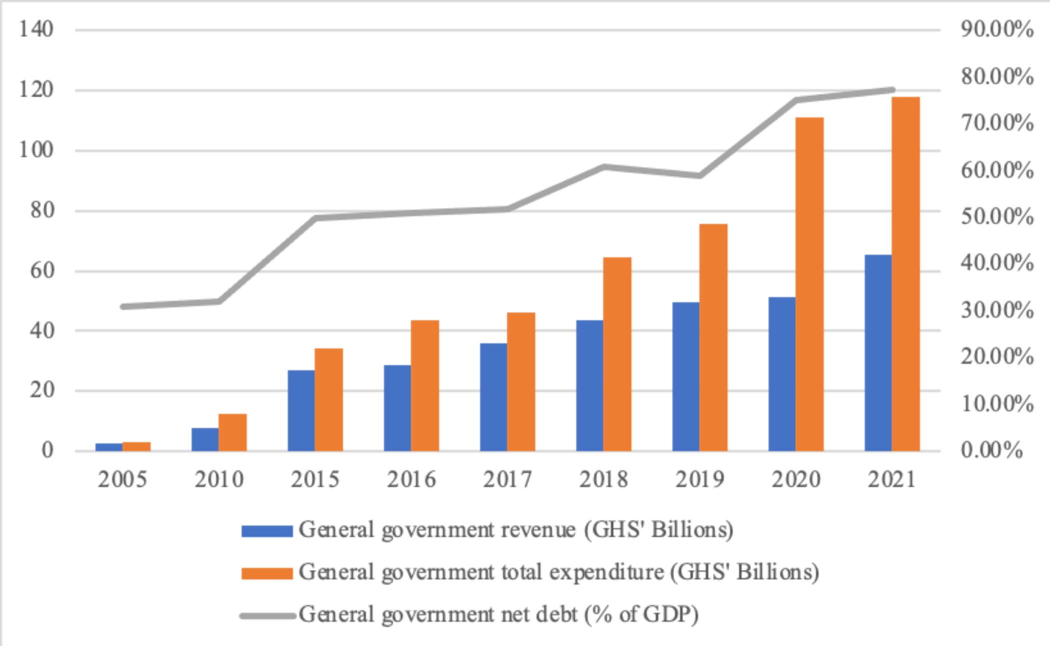


Figure 4.15: Fiscal Consolidation Trend of Ghana (2005-2021)

Source: Author's Own Construct (2022)

4.7.5 Sustainable Development Indicators in the Electricity Market of Ghana

The study discussed various metrics for measuring sustainable development in Ghana's energy sector.

While the total electricity consumption increased annually at a rate of 4.7 percent from 2000 to 2021 due to growth in the industrial and residential sectors of the economy, the total electricity generation has doubled from 10,166 GWh in 2010 to 22,051 GWh in 2021 with a generation mix of hydro, thermal, and renewables. With a cumulative annual growth rate of 3.3 percent from 2000 to 2011, Ghana's overall energy supply has expanded with the biggest portion coming from biomass, followed by oil and natural gas. Over the time, final energy consumption grew, with the residential and transportation sectors accounting for the majority of it starting in 2000.

Table 4.5: Energy Sector Dashboard

Indicator	Unit	2000	2010	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Population	*million*	18.91	24.66	25.9	26.43	27.04	27.67	28.31	28.96	29.61	30.28	30.6	30.8
GDP (current US$)1	*million US$*	4983	32197	41271	64832	54058	48595	56010	60327	67299	68338	70029	79,083*
GDP, PPP (constant 2017 international $)	*million $*	54123	94867	118247	126894	130518	133286	137782	148983	158220	168516	169215	172,331**
Total Energy Supply	*ktoe*	6255	7001	8121	8723	8907	9296	9302	9150	10791	11094	12038	12371
Total Final Energy Consumed	*ktoe*	5467	5573	6574	6894	6986	7250	7181	7208	7792	8051	8654	9345
Total Electricity Generated	*GWh*	7224	10166	12024	12870	12963	11491	13023	14067	16246	18188	20230	22051
Total Electricity Consumed	*GWh*	6889	8317	9258	10583	10695	10625	12528	13036	14401	15232	16531	18067
Total Petroleum Products Consumed	*ktoe*	1442	2394	3189	3308	3275	3552	3320	3162	3593	3849	4255	4630
Total Biomass Consumed	*ktoe*	3432	2464	2589	2676	2792	2785	2783	2925	2961	2892	2977	3162
Energy Intensity (TES/GDP current million US$)	*toe/million US$*	1255	217	197	135	165	191	166	152	160	162	175	156
Energy Intensity in PPP (TES/ GDP in PPP)	*toe/million $*	116	74	69	69	68	70	68	61	68	66	72	72
Energy Intensity in PPP (FEC/ GDP in PPP)	*toe/million $*	101	59	56	54	54	54	52	48	49	48	51	54
Total Primary Energy Supply/capita	*toe/capita*	0.33	0.28	0.31	0.33	0.33	0.34	0.33	0.32	0.36	0.37	0.4	0.4
Energy use per capita (TFC/persons)	*toe/capita*	0.29	0.23	0.25	0.26	0.26	0.26	0.25	0.25	0.26	0.27	0.28	0.3
Total Electricity Generated/capita	*kWh/capita*	382	412	464	487	479	415	460	486	549	601	654	715
Total Electricity Consumed/capita	*kWh/capita*	364	337	357	400	396	384	443	450	486	503	534	586
Total Petroleum Products Consumed/capita	*toe/capita*	0.08	0.1	0.12	0.13	0.12	0.13	0.12	0.11	0.12	0.13	0.14	0.15
Total Biomass Consumed/capita	*toe/capita*	0.18	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total Electricity Consumed/GDP	*kWh/US$ 1,000 of GDP*	1382	258	224	163	198	219	224	216	214	223	236	228
Total Energy Supply/GDP	*toe/US$ 1,000 of GDP*	1255	217	197	135	165	191	166	152	160	162	175	156
Total Petroleum Products Consumed/GDP	*toe/US$ 1,000 of GDP*	289	74	77	51	61	73	59	52	53	56	61	59
Grid Emission Factor (wind/solar projects)	*tCO2/MWh*		0.35	0.35	0.35	0.32	0.28	0.39	0.43	0.46	0.39	0.36	0.36*
Grid Emission Factor (all other projects)	*tCO2/MWh*		0.51	0.48	0.46	0.36	0.31	0.43	0.47	0.53	0.45	0.4	0.40*

Source: 2022 Energy Statistics, Energy Commission
*Provisional, **Estimated

NB: Grid emission factor is the amount of CO_2 emitted per unit of electricity generated and supplied into the national electricity grid. In simple terms, it measures the carbon intensity of the national electricity grid. Project activities displacing electricity from the grid can use this emission factor to estimate the CO_2 emissions impacts of the project.

4.8 Evidence of Clean Energy Financing and Financing Institutions in Ghana

The study's results corroborate the existence of green energy funding in Ghana's power sector. The adoption of renewable energy and energy-efficient technology may significantly reduce the negative effects of carbon dioxide emissions, and here is where clean energy funding comes in. Findings from Table 4.2 suggest that clean energy financing is not only limited to acquisition of the technology but also encapsulates other areas such as technology transfer, consulting, capacity building & training, transactions advisory as well as supporting the enabling environment to further develop clean energy as a subsector of the energy sector.

There exists evidence of financing funding from commercial banks, and savings and loans and microfinance companies, which are all licensed by the Central Bank of Ghana. They also identified financing by an investment advisory firm, which extended a commercial paper, all in support of Solar Installers for residential, commercial and industrial customers. Notable examples are Ecobank Ghana Limited, CAL Bank, Ghana Commercial Bank, Fidelity Bank, Republic Bank Ghana Limited and Stanbic Bank Limited. Some of these banks have been supported by development partners in respect of capacity building and development of clean energy lending products as part of development partners' support of this phenomenon.

Developing Partners, through the MoEn, made a commitment by disbursing more than US$1.44 billion to support and strengthen the clean energy sector in Ghana. The details of the breakdown to the disbursed amount by the Energy Sector Development Partners Working Group Activities in Ghana are attached as Appendix 1.1 of this work. The Energy Sector Development Partners Working Group consists of Denmark, European Union, France, Germany, Spain and Switzerland. These development partners have contributed significantly; hence, they can be cited as another case of clean financing in Ghana.

The GCF has an accredited institution in Ghana that demonstrates the prevalence of clean energy financing institutions, namely Ecobank Ghana Limited. As of 2019, data retrieved from the MoF affirms that the following companies have pending approval for accreditation: Ghana Infrastructure Investment Fund (GIIF), EC, Segregated Market Capital Limited and Agricultural Development Bank (ADB).

The study found that certain commercial banks in Ghana have received on-lending facilities from development partners through their development finance institutions and based on bilateral agreements between their nation and Ghana. The Sustainable Use of Natural Resources and Energy Financing (SUNREF) funding support for RE and EE projects aimed at private households and small and medium-sized enterprises (SMEs), which was disbursed through Ghana Commercial Bank and Cal Bank Limited, is a case in point. The Agence Française de Développement (AFD) granted GIIF a 10-year credit line to pay for climate and sustainability initiatives in Ghana. The study found that the financing structure for sustainable energy was affected by on-lending services run by commercial banks.

An Energy Sector Advisor affirms that, "USAID brought a biomass expert to offer capacity for the MoEn, entities, and individuals on the nature of biomass projects and their tariff structure". This forms part of capacity building and technology transfer. USAID / Development Credit Authority issued a loan guarantee to Ecobank Ghana Limited to help minimize the risk of collateral as it was a barrier to clean energy financing.

Table 4.6 presents a composition of instruments used in financing clean energy in the electricity market in Ghana.

Table 4.6: Evidence of Clean Energy Financing in the Electricity Market of Ghana with both Local and International Funding and Instruments

Category of Electricity Generation	Project Name	Type of connection	Type of Technology	Plant Capacity (MW)	Off-Taker	Cost of project (US $)	Source of Funding	Country of origin of the Financier	Project Location in Ghana
Large Scale Renewable (Hydro Power Plants)	Akosombo	Grid	Hydro	1,020	Utility	$196,000,000	Debt	IBRD,UK,USA	Akosombo
	Kpong Hydro	Grid	Hydro	160	Utility	$196,867,000	Debt	Canada,EU,OPEC,BADEA	Kpong
	BUI Hydro	Grid	Hydro	404	Utility		Debt	China	Bui
Embedded Renewable Energy Plants	VRA Solar (Navrongo)	Grid	Solar	2.5	Utility		Debt	Germany	Navrongo
	VRA Solar (Kaleo and Lawra)	Grid	Solar	19.62	Utility	$22,816,666.67	Debt	Germany	Kaleo and Lawra
	BXC Solar	Grid	Solar	20	Utility	$30,000,000	Equity	China	Gomoa Mankoadzi
	Meinergy	Grid	Solar	20	Utility	$20,000,000	Equity	China	Gomoa Onyaadze
	Safisana Biogas	Grid	Solar	0.1	Utility		Grant	African Water Facility of the AfDB and Netherlands Enterprise Agency (RVO)	Ashaiman
	Bui	Grid	Hydro	0.045	Utility	$400,000	Equity	Government of Ghana	Tsatsadu
Roof Top Renewable Energy Installation	912kWp Jubilee Solar	Grid	Solar	0.9	C&I	$1,494,350	Equity	Ghana	Accra
	Ministry of Energy Rooftop Solar 60.2kwp	Grid	Solar	0.0602	C&I	$700,000	Equity	Ghana	Accra
	Noguchi Solar	Grid	Solar	0.715	C&I	$7,500,000	Grant	Japan	University of Ghana
On-grid Renewable Energy Plants	Bui Solar	Grid	Solar	50	Utility	$81,700,000 + Financing of $ 44,408,400	Equity / Debt Funding / Grant	Ghana	Bui
	Bui Solar	Grid	Floating Solar	1	Utility				
	Bui Solar	Grid	Solar	10	Utility	$9,430,814,93			
Mini-grid (Off - grid) Renewable Energy Plants	5 Island Mini-grids projects under GEDAP	Off-grid	Solar and wind	0.197	Household	$2,500,000	Loan	World Bank	Oti and Greater Accra Region
Off-grid Renewable Energy Plants	ARB Apex Bank SHS project under GEDAP	Off-grid	Solar	0.48	Household	$10,000,000	Grant and Loan	World bank	Nationwide

Note: Total Clean Energy Financing undertaken in Ghana is valued at a minimum of US $ 221,519,417 as at December 2021. This excludes Large Scale Renewables Power Generating Plants (Akosombo, Kpong and Bui Hydro Plants)

Source: Ministry of Energy, Energy Sector Recovery Programme (2022)

In conclusion, electricity generation in Ghana has transitioned from the use of fossil fuel only to the full use of only hydro fuel; then further transitioned to the use of a blend of hydro fuel and fossil fuel and is currently using a cocktail of fuel options, which include hydro, solar, wind and fossil fuel. Electricity generation in Ghana using clean energy technologies has been an integral part of Ghana's electricity development.

Ghana has a dynamic electricity market structure, which has also evolved from a monopoly (vertically integrated market) to an unbundled market that allows for competition. The study identified that further steps are being taken to make the market a more competitive one with the introduction of the wholesale electricity market. The classification of the electricity market entails a degree of complexity as the market classification can be a regulated market (comprising of ECG, NEDCo and EPC as separate off-takers of electricity) and a deregulated market (comprising of export and mines & bulk consumers). Price determination of electricity and regulation is key to the classification. The regulator determines the tariff in the regulated market, whereas in the deregulated market it is based on bilateral negotiation. This finding was central to the understanding of a varied risk profile of each off-taker in the electricity market, which is key to clean energy financing. Furthermore, the electricity market of Ghana allows for consumers to procure electricity indirectly through the distribution utilities connected to the grid infrastructure, which the study labelled as grid connection, or procure power directly from power generators or utilize other forms of clean energy technologies, which is also deemed as off-grid installations.

Ghana has regulatory institutions and authorities in place that spearhead the implementation and operationalization of the policies and regulations. The study identified that improvement in coordination can harness clean energy financing.

The research examined the complex relationship between financing for clean energy and its actual effect on long-term development in Ghana. It found that access to capital for clean energy projects played a critical role in encouraging entrepreneurial endeavours, which in turn led to a substantial increase in the number of new jobs created. Evidence of this trend can be seen in the large number of businesses given permission by the EC to launch various projects that aim to make use of sources of clean energy, including solar, wind, biomass, hydro, and biogas. Additionally, clean energy finance had a significant impact on Ghana's strategic policy decisions, which was most obviously evident in the nation's tenacious pursuit of universal access to electricity. This was a calculated policy shift with the express intent of helping Ghana reach its lofty objective. Notably, the study used the unemployment rate as a lens to analyse the government's macro-financial decisions on renewable energy funding. Ghana's electrical market is a sizable one, estimated to be worth at least US$ 222 million, and it felt the effects of clean energy finance. It also highlighted the importance of a healthy macroeconomic climate in determining the risk profiles and finance structures used by renewable energy projects. The research found evidence of participation in clean energy finance by indigenous Ghanaian financing enterprises; nonetheless, the bulk of funding came from bilateral and foreign sources, highlighting the complex nature of this vital endeavour.

CHAPTER FIVE: DETERMINANTS OF CLEAN ENERGY FINANCING IN GHANA

5.1 Introduction

In this section of the chapter, the study investigated the factors influencing clean energy financing within Ghana's electricity market. Financing plays an integral function in respect of the utilization of clean energy technologies in Ghana. It was evident from the study that both the direct components of clean energy technology and the balance of plants (the core and periphery components of clean technologies) are not manufactured in Ghana. The components of the technologies utilized for clean energy development were imported from various countries that required financing from the supply of technology to the demand of the technology. Hence, the study discussed the determinants of clean energy financing in Ghana.

5.2 Approach for Analysis

The binary logistic regression model was employed because the dependent variable in the regression model is dichotomous (Bryman & Cramer, 2009). An application for financing a clean energy technology has a binary outcome of either approved or declined. The independent variables in the logistic model assumed either a quantitative or qualitative nature (Garson, 2012). The impact of the firm size, firm age (years in operations), policy and regulation, local administrative capacity, revenue, enabling infrastructure, technology and existing market on clean energy financing can best be examined with the binary logistic model since any entity would have its project financed or not. The clean energy financing variable becomes a dichotomous result with 1 representing access to clean energy finance and 0 being no access to clean energy finance.

With the help of the logistic regression model, the study estimated the level of impact of the explanatory variables on clean energy financing and specific components of clean energy financing. The number of years the clean energy firm has been in operation and the number of employees at the firm were the only variables that were estimated. The Policy and Regulatory Factors were estimated by measuring the risk and regulatory uncertainty in the wholesale electricity market. The measure comprised the risk allocation to parties involved in a power purchase agreement, and unexpected or frequent changes in regulations. In measuring the Local Administrative Capacity Factor, the study looked at the processes involved in procuring land, the permits and the local content requirements for the establishment of a clean energy company. In estimating Revenue Factors that could affect clean energy financing, the study paid attention to the delays electricity generation companies experience for the payment of service. For clean energy technologies, it was vital for the study to know how environmental conditions and maintenance schedules could influence the financial viability of the project. The grid connection constraints, the ability of the grid to accommodate clean energy technologies, the flows in power purchase agreement, and the impact of net metering were the areas examined in the estimation of enabling infrastructure factors for the study. The technological factors employed in the study was estimated by measuring the uncertainty on the performance of clean energy technologies, the expertise of installers, the expertise of financial institutions, and the challenges with clean energy technologies. For any clean energy technology to be financed, investors or financiers have to be convinced that the project is bankable. In measuring the bankability of the project, these financiers will consider the volatility in the exchange rate, the end user tariff, the predictability or stable inflation, interest rates and the development in the local market. Therefore, the study used these variables to estimate the market factors.

For a thorough review of the determinant of clean energy financing in Ghana, the study performed three different forms of analysis. The first was to assess the effect of the explanatory variables on the dependent variable.

5.3 Summary Statistics

The questionnaire employed for the study was structured in 10 sections. The first section was to introduce the respondents to the questionnaire. The section was to collect information on the respondents' characteristics. The remainder of the sections (i.e., 3 to 10) was to collect responses on the eight variables used in the study.

A total number of 104 clean energy stakeholders responded to the questionnaire. Out of these respondents, 87 (83.7 percent) were males and the remaining 17 (16.3 percent) were females. The largest group of these respondents were energy consultants (31.7 percent), which were followed by clean energy financiers (24 percent). The least group of respondents was climate adaptation consultants, which was an individual.

Table 5.1: Demographic Characteristics of the Study Participants

Characteristics	Variable	Frequency (percent)
Sex of the study participant	Male	87(83.7)
	Female	17(16.3)
Profession/Occupation/Position status of the study participant	Energy Consultant	33(31.7)
	Developer/ Entrepreneur	23(22)
	Government Official	7(0.1)
	Financier	25(24)
	Climate Adaptation Consultant	1(0)
	End-User (Consumer)	12(11.5)

Source: Author's Construct, 2022

Analysis of Main Variables

In this research, the dependent variable is the binary answer to the question of whether clean energy finance was received; hence, the use of binary logistic regression is acceptable. The results of this study classified clean energy finance as either (1) successful or (0) unsuccessful.

To further understand what factors, affect clean energy finance, the study used logistic regression to determine the likelihood of securing clean energy financing using market conditions, enabling infrastructure, firm size, local administration support, revenue considerations, technical factors, market factors, and policy.

The results presented in Table 5.2 indicate that two of the eight variables could significantly influence clean energy financing in Ghana. These variables are market factors and enabling infrastructure. A unit change in enabling infrastructure in terms of weak grid connectivity, grid adaptability to variable sources and demand, power purchase agreements, and the potential for a secondary market for excess energy sales in Ghana reduces the likelihood of achieving favourable clean energy financing.

Similarly, favourable market factors (improved interest rates, low inflation, capital markets, currency restrictions, and low clean energy tariffs) increase the likelihood of improving clean energy financing by 1.704 times compared to unfavourable market factors. Inflation, exchange rates, electricity tariffs, and interest rates collectively described the market factors that were significant variables in making a clean energy financing decision.

The finding on market factors is consistent with that of Roy et al. (2013). Moreover, the result was consistent with the a priori expectations stipulated. The significant influence exerted by the enabling infrastructure on clean energy financing was negative and was measured at a significance level of 5 percent. This implies that the existing infrastructure is not a barrier to acquiring finance for clean energy. Sarangi (2018) made the same recommendation on financing a clean energy project in India. This finding confirms the a priori expectation stated above.

In Ghana, clean energy financing may flourish with the help of supportive market and infrastructural conditions. Investors and lenders are more at ease when market conditions are favourable, including low inflation, stable currency rates, moderate power prices, and reasonable interest rates. As a result, renewable energy projects become more appealing to investors when these conditions are stable and favourable.

A developed electricity grid, solid transmission and distribution networks, and effective regulatory frameworks are all critical to the success of clean energy finance. Power from renewable sources can be transferred and delivered more safely and effectively with a solid infrastructure in place. Additionally, straightforward regulatory guidelines and effective administrative procedures facilitate the funding and implementation of sustainable energy projects.

All of these things work together to make clean energy initiatives seem safer and more profitable to investors. This, in turn, increases access to clean and renewable energy sources, which contributes to sustainable development and attracts greater capital investment. Ultimately, the growth of the clean energy industry and its beneficial influence on sustainable development in Ghana are driven by favourable market and infrastructural factors that boost investor confidence, minimise risks, and provide a suitable climate for clean energy finance in the nation.

Table 5.2: Determinants of Clean Energy Financing

Variables	**Odd ratio (SE[9])**
FirmAge	0.886 (0.22)
FirmSize	0.801 (0.258)
LocalAdmin	0.891 (0.187)
RevenueFact	1.233 (0.222)
InfrastructureFact	0.563** (5.415)
TechnicalFact	0.92 (0.199)
MarketFact	1.704** (0.213)
PolicyReg	1.507 (0.256)
Constant	0.374 (0.224)

***,**,* significant at 1 percent, 5 percent and 10 percent, respectively; SE in brackets

Source: Author's Construct, 2022

[9] SE is Standard Error

The findings of this study have revealed that market factors could influence clean energy financing in Ghana.

The first instance is the import taxes imposed on clean energy equipment. These taxes, when paid to the GRA, increase the revenue of the government. Between 2017 and 2020, the tax imposed on clean energy equipment is estimated to be 2.6 million Ghana Cedis. Besides the value added by this investment, the taxes obtained by GRA is given to the government and these monies are spent in other sectors of the economy.

However, the total tax amount paid by importers of varied clean energy technologies in Ghana between 2020 and 2022 amounted to about GHS 38.774 (GRA, 2022). This represents imports from about 90 countries, affirming the north south dichotomy in that the technologies required for clean energy installation are largely imported from advanced countries whereas the utilization of the technologies in Ghana is driven by imports as there are no manufacturing plants in Ghana. Components of technologies imported include wind turbines, biogas digesters, solar panels and battery cells and invertors.

CHAPTER SIX: OPTIMAL LEVEL OF INTEGRATING CLEAN ENERGY IN THE ELECTRICITY MARKET OF GHANA

6.1 Introduction

The study at this point sought to utilize current Ghanaian government policies, including the REMP, IPSMP, NDC in line with the COP 21 Paris Agreement, and other development plans, to estimate the potential integration of diverse clean energy technologies into Ghana's electricity market. To achieve this goal, the LEAP model was utilized alongside Microsoft Excel, utilizing additional data sourced from EC, MoEn, ESRP, and industry experts. An integrated approach encompassing the least-cost energy strategy, energy security (based load) strategy, and environmental sustainability (low CO_2 emissions) strategy was applied to determine the optimal level of clean energy technology integration within Ghana's electricity market.

The analysis focused on the optimal integration level up to the year 2030, aligning with the timelines specified in the updated NDC as per the Paris Agreement, which extends until 2030. This timeframe provides a comprehensive outlook on the potential adoption of clean energy technologies within the context of Ghana's evolving energy landscape.

6.2 Optimization Model Assumptions

In pursuit of this objective, the study primarily focused on meeting the electricity demand driven by end-users and the necessary technologies to fulfil this demand. The analysis was constrained within the timeframe of 2030, aligning with the NDC's guidelines. The study considered the influence of key existing policies that propel the advancement of renewable energy in Ghana.

Various scenarios were contemplated, including an assertive adoption of additional clean energy technologies. However, it should be noted that certain options, such as nuclear power generation and CCUS technology, were excluded from the model due to the study's specific focus, which encompassed solar, wind, hydro, biomass, and biogas technologies.

The key underlying assumption for the energy demand were macroeconomic data such as GDP and demographic data such as population, and access to the electricity rate up to 2030.

The macro-economic assumptions provided a holistic view of the Ghanaian economy in respect of the country's performance. The various sectors of the economy, as measured by the GDP, provided a basis for the drivers of electricity demand growth. Key to this, as reflected in Ghana, are industry or manufacturing, agriculture, and services. The growth in GDP helped explain the projected changes in demand from 2023 to 2030. Finally, demand for electricity should be backed by purchasing power; hence, the study incorporated GDP per capita as a variable to estimate the purchase of electricity and other electrical appliances.

The demographic assumptions assisted in estimating the quantum of electricity that will be in demand over the forecast period where population, population growth rate and household size are relevant. Household size further assists with the electrification rate goals of Ghana.

To estimate the quantum of clean energy technologies that can be utilized in the electricity market, the focus of the study was directed towards the renewable energy technologies and juxtaposes the potential of the renewable energy sources in Ghana to be used to generate electricity. As defined in the literature, the renewable fuel sources include solar, wind, hydro, biomass, and biogas. The figures below describe the potential in Ghana:

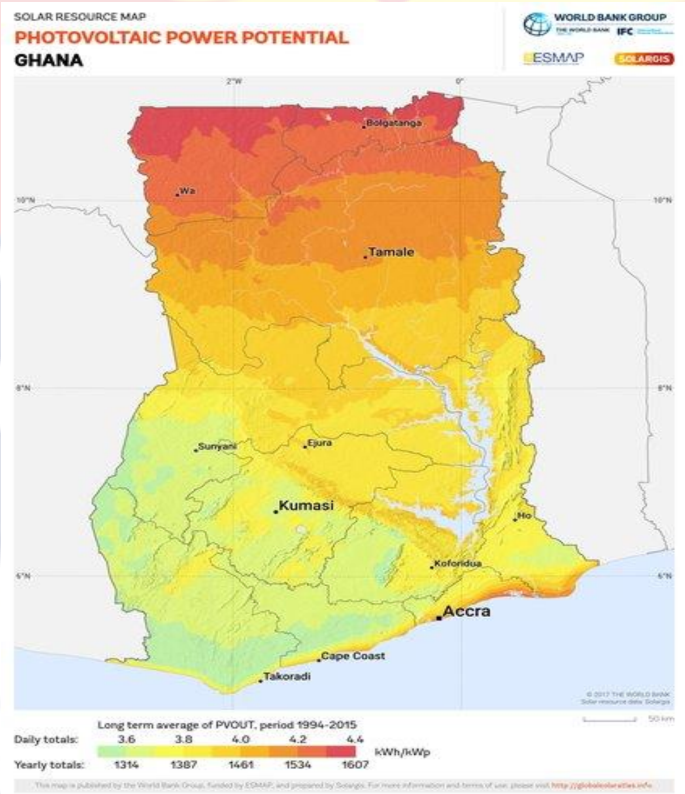


Figure 6.1: Solar Radiation Potential in Ghana

Source: Energy Commission, 2022

Based on the long-term average of PVOUT[10] from the WB, Energy Sector Management Assistance Program (ESMAP) between 1994 and 2015, the solar irradiation in Ghana ranged from 3.6 to 4.4 kWh/m² per day, which translates

[10] The PV power output (PVOUT), defined as the specific yield, is used to illustrate this potential. PVOUT represents the amount of power generated per unit of the installed PV capacity over the long-term, and it is measured in kilowatt hours per installed kilowatt-peak of the system capacity (kWh/kWp).

to an average of 1314 to 1607 sun hours on an annual basis. Relatively, Ghana has a high solar potential, and it is evident from the map above that the northern part of Ghana has the highest irradiation levels on a yearly basis, which affirms the justification for about four existing operational VRA (Kaleo Phase 1 and 2, Lawra, and Navorango) solar powered plants generating electricity.

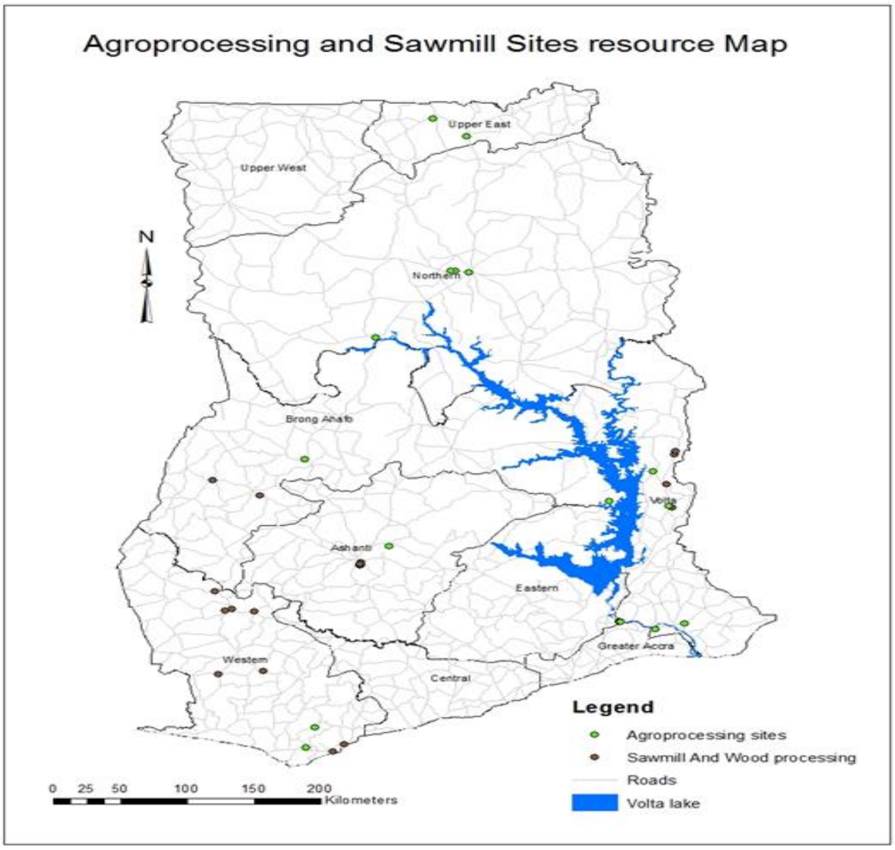


Figure 6.2: Biomass Resource Potential in Ghana

Source: Energy Commission Ghana, 2022

Ghana has a potential of biomass sources that can be used for energy generation as evidenced in the above map. Although the potential exist, further analysis will be required to ascertain the capacity of an electricity power plant that can be situated at each location on the map.

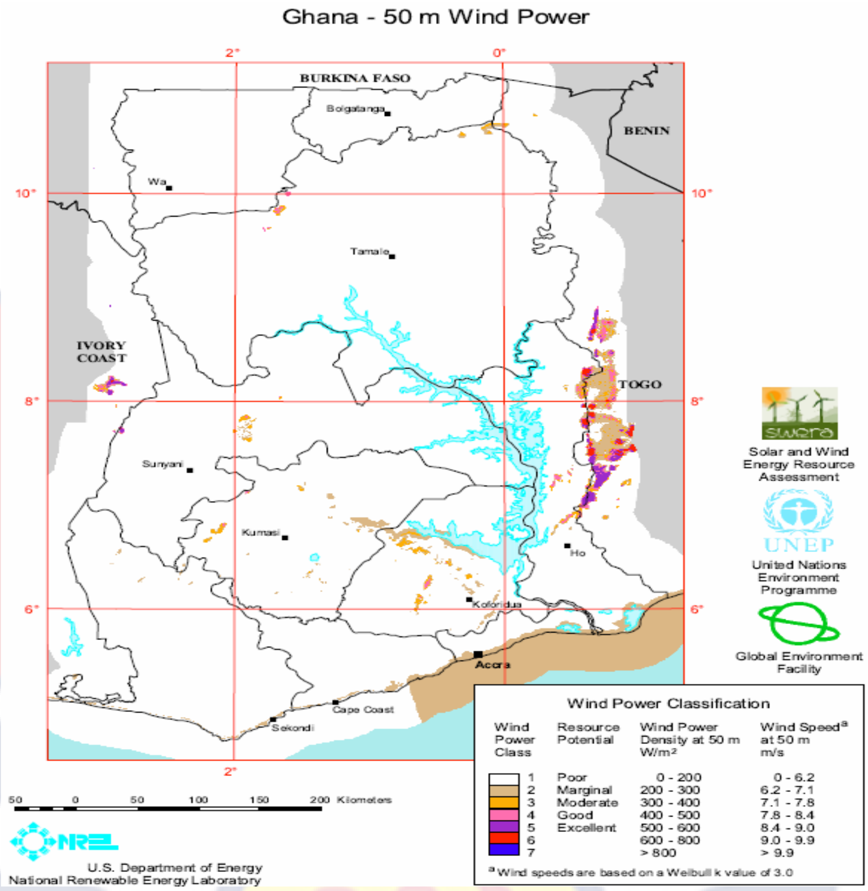


Figure 6.3: Wind Potential for Ghana

Source: Energy Commission, 2022

The data from Energy Commission presents an opportunity for the development of power projects using wind in Ghana; however, the greatest potential is identified around the eastern coastal areas and the mountainous areas around the south-eastern part of Ghana where average annual wind speed ranges from 4.0 m/s to 6.0 m/s at 50 m hub height. On the contrary, other parts of Ghana record low wind speeds in the range of 2-5 m/s. It is worth noting that the minimum wind speed for current wind turbines is about 3 m/s4, which suggests that a wide range of areas in Ghana are not suitable for wind power projects. The potential locations in Ghana suitable for siting power plants using wind energy include Keta, Ada, Mampong, Ashanti Akim, Kwahu, Upper Manya and Fanteakwa. These areas are suitable because they have a wind speed more than 5.3 m/s.

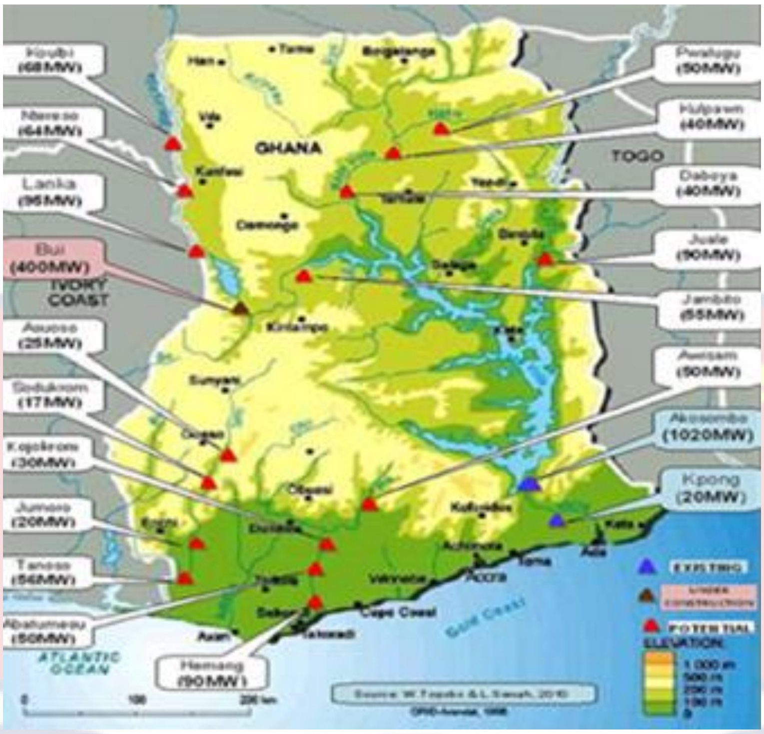


Figure 6.4: Hydro Potential in Ghana

Source: Energy Commission, 2022

Ghana has in excess of 14 potential small-scale hydro sites with a total unexploited capacity of 740 MW for hydroelectric generation.

6.3 Development Plans and Clean Energy

The study reviewed how Ghana has integrated the development of clean energy as part of the Paris Agreement commitment. The modelling undertaken in this chapter was aligned with the Energy Commission’s assumptions used in the development of the following strategic energy sector plans:

1. REMP (February 2019)
2. NDC (September 2014, Updated 2021)
3. National Energy Transition Framework (NETF) (November 2022)
4. IPSMP (2018 and Updated 2019).

In addition to the above, the study observed consistency from the respective governments to diversify the total electricity generation mix to include renewable energy as described below:

a) As part of the sustainable socio-economic development plan, Vision 2020, which was launched by NDPC in 1995, demonstrated Ghana's interest in expanding electricity supply clean energy sources.
b) In 2003, the GPRS 1 developed a policy framework to ensure reduction in poverty and economic growth. In this plan, Ghana strategically committed to integrating clean energy sources as part of the existing energy portfolio.
c) Between 2006 and 2009, the second phase of the GPRS II reaffirmed the country's commitment to integrate clean energy sources as part of the existing energy portfolio.
d) REDP had the objective of advancing development and setting a target of integrating 10 percent of clean energy sources as part of the existing energy portfolio by 2020. A key achievement of this policy was the development of a National Renewable Energy Strategy (NRES).
e) GSGDA was consistent with the need for Ghana to integrate clean energy sources as part of the existing energy portfolio.
f) NEP of 2010 provides an enabling environment to attract financing in the energy sector and push for the agenda of integrating more clean energy sources as part of the existing energy portfolio.
g) The Energy Sector Strategy and Development Plan (ESSDP) of 2010 reaffirms the need for 10 percent of clean energy sources as part of the

existing energy portfolio by 2020, which is consistent with the Strategic Nation Energy Plan (SNEP) that advocates for a similar agenda.

6.4 Electricity Demand

The demand growth projections used in the study (LEAP modelling) reconciles with the EC forecast assumptions used for the various energy sector planning. The bottom-up approach was used in developing an indicative demand forecast for electricity consumption. The study results are as demonstrated in Figure 6.5.

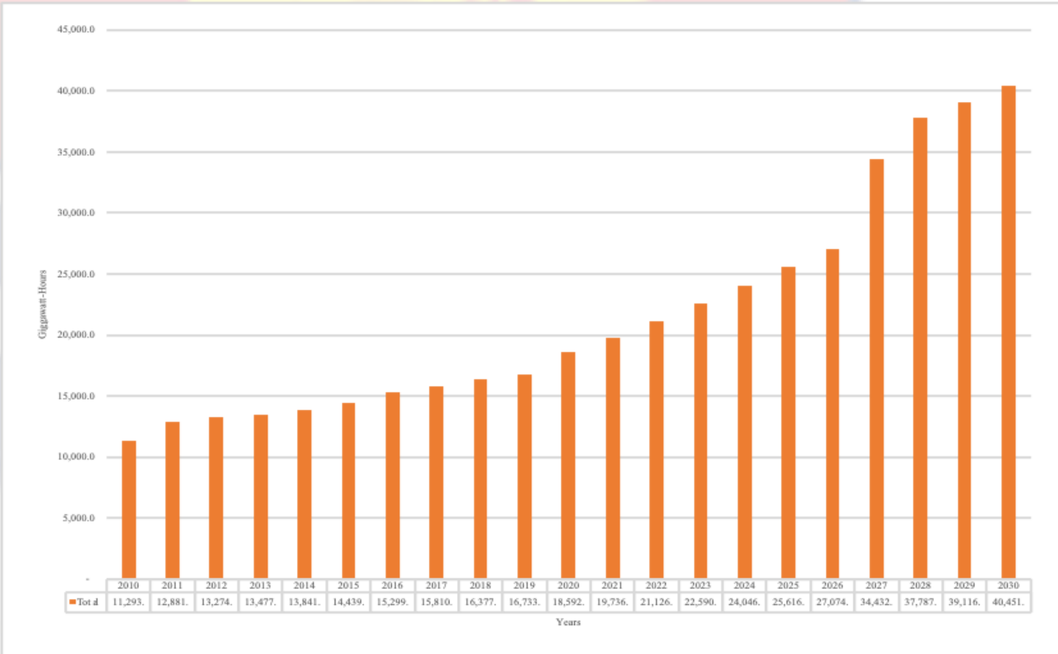


Figure 6.5: Total Electricity Demand of Ghana

Source: Author’s Own Construct

Ghana’s total demand for electricity will grow from an estimated consumption of 21,126 GWh as of 2022 to a projected consumption of 40,452 GWh as of 2030.

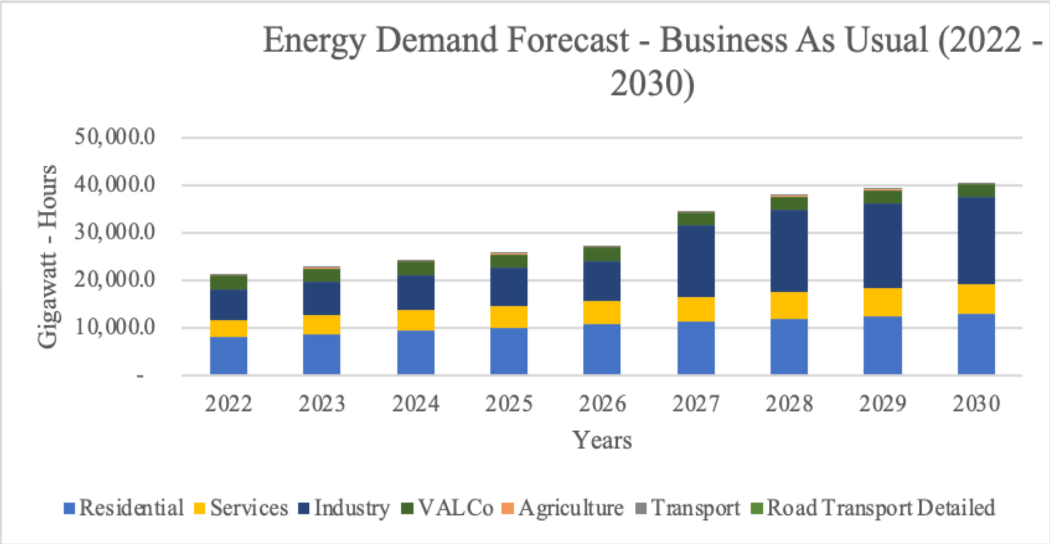


Figure 6.6: Energy Demand Forecast – Business as Usual (2022-2030)

Source: Author's Own Construct

Table 6.1: Energy Demand Forecast (2022-2030) – Giga Watt hours (GWh) -Business as Usual

Energy Demand Forecast (2022-2030) – Giga Watt hours (GWh) – Business as Usual										Average Growth Rate (percent)	CAGR[11] (percent)
	2022	2023	2024	2025	2026	2027	2028	2029	2030		
Residential	7,933.40	8,602.80	9,298.30	10,020.20	10,728.90	11,327.50	11,876.30	12,425.60	12,969.20	6.35%	63.48%
Services	3,748.70	4,031.00	4,319.80	4,615.10	4,916.90	5,224.80	5,539.00	5,859.10	6,185.00	6.46%	164.99%
Industry	6,499.70	7,008.90	7,480.30	8,035.20	8,486.20	14,943.50	17,443.50	17,913.30	18,390.40	15.72%	182.94%
VALCo	2,889.90	2,880.90	2,868.90	2,854.00	2,836.10	2,815.40	2,791.60	2,765.00	2,735.40	-0.68%	-5.35%
Agriculture	41.3	51.5	62.4	74	86.3	99.3	113.1	127.6	142.8	16.84%	245.67%
Transport	13.5	15	16.6	18.3	20.1	22	24.1	26.3	28.7	9.86%	112.17%
Road Transport Detailed	-	-	-	-	-	-	-	-	-		
Total	21,126.50	22,590.00	24,046.30	25,616.70	27,074.50	34,432.50	37,787.60	39,116.80	40,451.60		

Source: Author's Own Construct

[11] CAGR: Cumulative Average Growth Rate

Table 6.2: Energy Forecast (2022-2030) – Business as Usual

Energy Demand Forecast (2022-2030) – Giga Watt hours (GWh)	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Residential	7,933.4	8,602.8	9,298.3	10,020.2	10,728.9	11,327.5	11,876.3	12,425.6	12,969.2
Urban	5,781.6	6,205.5	6,654.2	7,128.9	7,594.3	8,085.6	8,604.1	9,151.2	9,705.2
Rural	2,151.8	2,397.3	2,644.1	2,891.2	3,134.6	3,241.9	3,272.2	3,274.4	3,264.0
Services	3,748.7	4,031.0	4,319.8	4,615.1	4,916.9	5,224.8	5,539.0	5,859.1	6,185.0
Formal	3,748.7	4,031.0	4,319.8	4,615.1	4,916.9	5,224.8	5,539.0	5,859.1	6,185.0
Informal	-	-	-	-	-	-	-	-	-
Industry	6,499.7	7,008.9	7,480.3	8,035.2	8,486.2	14,943.5	17,443.5	17,913.3	18,390.4
Water production	434.4	493.5	552.5	611.6	670.6	729.7	788.7	847.8	906.8
Mining and Quarrying	4,040.1	4,255.9	4,435.3	4,699.3	4,889.0	5,085.1	5,323.8	5,532.1	5,747.1
Construction	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3
Manufacturing	2,023.8	2,258.1	2,491.1	2,722.9	2,925.2	9,127.3	11,329.5	11,532.0	11,735.1
VALCo	2,889.9	2,880.9	2,868.9	2,854.0	2,836.1	2,815.4	2,791.6	2,765.0	2,735.4
Electricity for smelting	2,889.9	2,880.9	2,868.9	2,854.0	2,836.1	2,815.4	2,791.6	2,765.0	2,735.4
Agriculture	41.3	51.5	62.4	74.0	86.3	99.3	113.1	127.6	142.8
Irrigation	18.1	23.5	29.8	36.7	44.4	52.8	62.0	71.9	82.6
poultry	22.8	27.4	32.0	36.6	41.1	45.7	50.3	54.8	59.4
Land ploughing	-	-	-	-	-	-	-	-	-
Crop harvesting	-	-	-	-	-	-	-	-	-
Post-Harvest processing	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
Fishing	-	-	-	-	-	-	-	-	-
Transport	13.5	15.0	16.6	18.3	20.1	22.0	24.1	26.3	28.7
Passenger	-	-	-	-	-	-	-	-	-
Freight	13.5	15.0	16.6	18.3	20.1	22.0	24.1	26.3	28.7
Road Transport Detailed	-	-	-	-	-	-	-	-	-
Passenger Cars	-	-	-	-	-	-	-	-	-
Light Commercial Vehicles	-	-	-	-	-	-	-	-	-
Heavy Duty Vehicles	-	-	-	-	-	-	-	-	-
Urban Buses	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Total	21,126.5	22,590.0	24,046.3	25,616.7	27,074.5	34,432.5	37,787.6	39,116.8	40,451.6

Source: Author's Own Construct

Following up from the above analysis in Table 6.3, the carbon emission objective necessitated the need to revise the demand of energy to consider it as another scenario that considers the use of clean energy technologies amidst a more aggressive demand scenario that was termed as an optimistic scenario. Under this scenario, electricity demand will grow based on an increase in economic activities and dependency on electricity for industrialization.

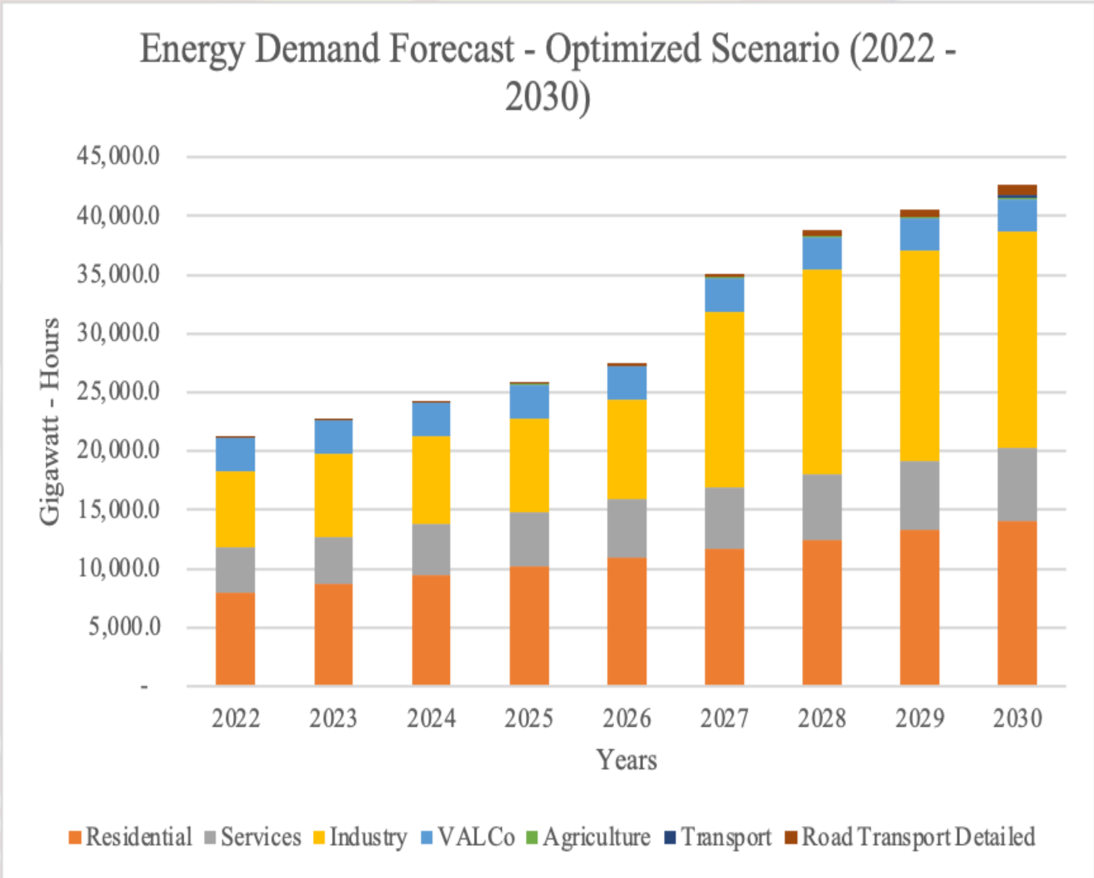


Figure 6.7: Energy Demand Forecast - Optimized Scenario (2022-2030)

Source: Author's Own Construct

The model assumes transitioning to the utilization of electricity from clean energy technologies to achieve the emissions levels projected in the NDC. Evidenced from the analysis is a structural change in the Ghanaian economy where consumption of electricity by electronic vehicles becomes prevalent. The variance in CAGR of the optimized and BAU is 9.65 percent.

6.5 Energy Supply

Based on the projected electricity demand for Ghana up to year 2030, it was imperative to have power plants with the required capacity that will generate electricity to meet the demand. The study identified during the analysis that clean energy technologies are not going to replace the existing fossil fuel to meet the required demand, but rather clean energy technologies will be augmenting the capacity of the existing power plants (hydro, thermal, solar, waste to energy, wind and other low carbon emission technologies) to generate electricity. It is expected that the capacity of clean energy technologies will be increased over the period of the analysis and expected to further increase aggressively beyond the timeframe of the study (2030).

6.6 Renewable Energy Master Plan (REMP) Energy Supply Estimates

The REMP assumes electricity generation to satisfy the demand for both grids connected and off-grid consumers. The total capacity of the grids connected, according to the REMP, is 1,056MW. Even though this is national data, there are several other factors that are serving as a setback for this goal to be achieved, e.g., low pay-out out rate by distribution utilities; receivables by the distribution utilities are cedi denominated whereas the payables are foreign currency denominated; and absence of guarantees by the GoG.

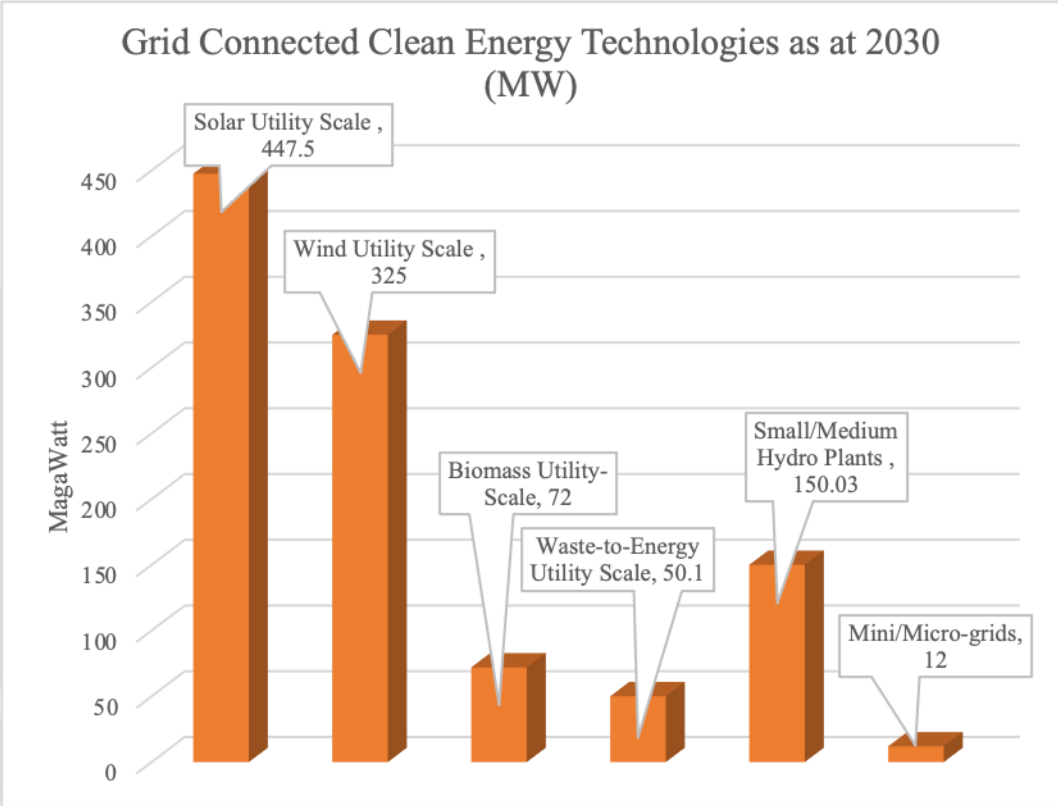


Figure 6.8: Grid Connected Clean Energy Technologies as at 2030 (MW)

Source: Author's Own Construct

Table 6.3: REMP Implementation Schedule 2019 to 2030

REMP IMPLEMENTATION PLAN - RE TARGETS UP TO 2030										
Renewable Energy Technologies	**Reference 2015**		**Cycle I (2019-2020)**		**Cycle II (2021-2025)**		**Cycle III (2026-2030)**		**Cumulative in 2030**	
	No. of units	**MWp**	**No. of Units**	**MWp**	**No. of Units**	**MWp**	**No. of Units**	**MWp**	**No. of Units**	**MWp**
Solar Energy										
Solar Utility Scale	-	22.5	-	130	-	195	-	100	-	447.5
Distributed Solar PV		2		18		80		100		200
Standalone Solar PV	-	2	-	8	-	5	-	5	-	20
Solar Street/Community lighting	-	3	-	4	-	4	-	14	-	25
Solar Traffic signals (% of total traffic signals installed in the country)	14	3	11	-	15	-	20	-	60	-
Solar Lanterns	72,000	-	128,000	-	300,000	-	500,000	-	1,000,000	-
Solar irrigation	150	2.8	6,000	6	20,000	20	20,000	20	46,150	48.8
Solar Crop Dryers	70	-	80	-	250	-	300	-	700	-
Solar Water Heaters	4,700	-	15,300	-	50,000	-	65,000	-	135,000	-
Wind Energy										
Wind Utility Scale	-	0	-	0	-	275	-	50	-	325
Standalone Wind Systems	-	0.01	-	0.1	-	0.9	-	1	-	2
Wind Irrigation/Water Pumping	10	-	25	-	30	-	35	-	100	-
Biomass / Waste-to-Energy										
Biomass Utility-Scale	-	0	-	0	-	72	-	0	-	72
Waste-to-Energy Utility Scale	-	0.1	-	0	-	30	-	20	-	50.1
Biogas (Agricultural/Industrial Organic Waste)	10	-	20	-	70	-	100	-	200	-
Biogas (Institutional)	100	-	80	-	140	-	180	-	500	-
Biogas (Domestic)	50	-	30	-	50	-	70	-	200	-
Woodlot Cultivation (ha)	190,000	-	60,000	-	100,000	-	78,000	-	428,000	-
Charcoal (Local Demand)	1,551,282	-	94,017	-	93,947	-	100,877	-	1,840,123	-
Charcoal (Export)	190,450	-	59,550	-	100,000	-	78,000	-	428,000	-
Briquetting/Pelleting	19,700	-	20,300	-	25,000	-	35,000	-	100,000	-
Biofuel (tonnes)	0	-	100	-	4,900	-	15,000	-	20,000	-
Hydro / Wave Power										
Small/Medium Hydro Plants	-	0	-	0.03	-	80	-	70	-	150.03
Wave Power	-	0	-	5	-	0	-	45	-	50
Hybrid Mini-Grids										
Mini/Micro-grids	13	-	73	-	114	-	100	-	300	12
End User Technologies										
Improved Biomass Cookstove (Domestic)	800,000	-	500,000	-	500,000	-	1,200,000	-	3,000,000	-
Improved Biomass Cookstove (Institutional/Commercial)	1,800	-	1200	-	7,000	-	8,000	-	18,000	-
Total Installed RE Electricity Capacity										***1,353.63***

Source: Renewable Energy Master Plan, 2019

6.7 Nationally Determined Contribution (NDC) Energy Supply Estimates

The NDC was developed taking into consideration Ghana's international obligation as a party to the UNFCCC, while at the same time dovetailing into the country's Policy of Action. Ghana's NDC is anchored on national and sector policies: Coordinated Programme of Economic and Social Development Policies (2017-2024), Medium-term Development Policy Framework (2018-2021), National Climate Change Policy (2015-2020), National Adaptation Strategy (2012), Ghana at 100 frameworks and the accompanying national infrastructure plan, Coordinated Programme of Economic and Social Development Policy, 2022 to 2025 Medium-Term Development Policy Framework, Ghana Beyond Aid Charter Strategy Document and COVID-19 Alleviation and Revitalisation of Enterprises Support. There exist 20 mitigation and 11 adaptation programmes of actions in seven priority economic sectors for implementation in the 10-year period (2020-2030) to attain low carbon climate resilience through effective adaptation and GHG emission reduction. Specific to this study and focusing on the electricity market solely, the commitment of Ghana within the electricity market is detailed below:

a) Scale up renewable energy penetration by 10 percent by 2030

b) Promote clean rural households lighting

c) Expand the adoption of market-based cleaner cooking solutions

d) Double energy efficiency improvement to 20 percent in power plants.

6.7.1 Features of the NDC

The features of NDC include: bottom-up (level of ambition is determined by what countries put forward – (Article 4.2)); nationally determined (national priorities, circumstances, capabilities) (domestic measures); medium-term in nature (10-year outlook); option for 5-year updates (Article 4.9); no backsliding in successive NDC (Article 4.3); links to long term strategies (LTS) (Article 4.19); NDC emission accounting (Article 4.13); global stocktake driving update (Article 4.9); wide diversity in scope, theme and have different starting points; and links to SDG, Sendai Framework, SLCPs etc.

Based on the various development plan and policies of Ghana, the commitment of the country from the electricity market to reduce climate emission between 2020 and 2030 will be to integrate about 710 MW of installed capacity of power plants as demonstrated below:

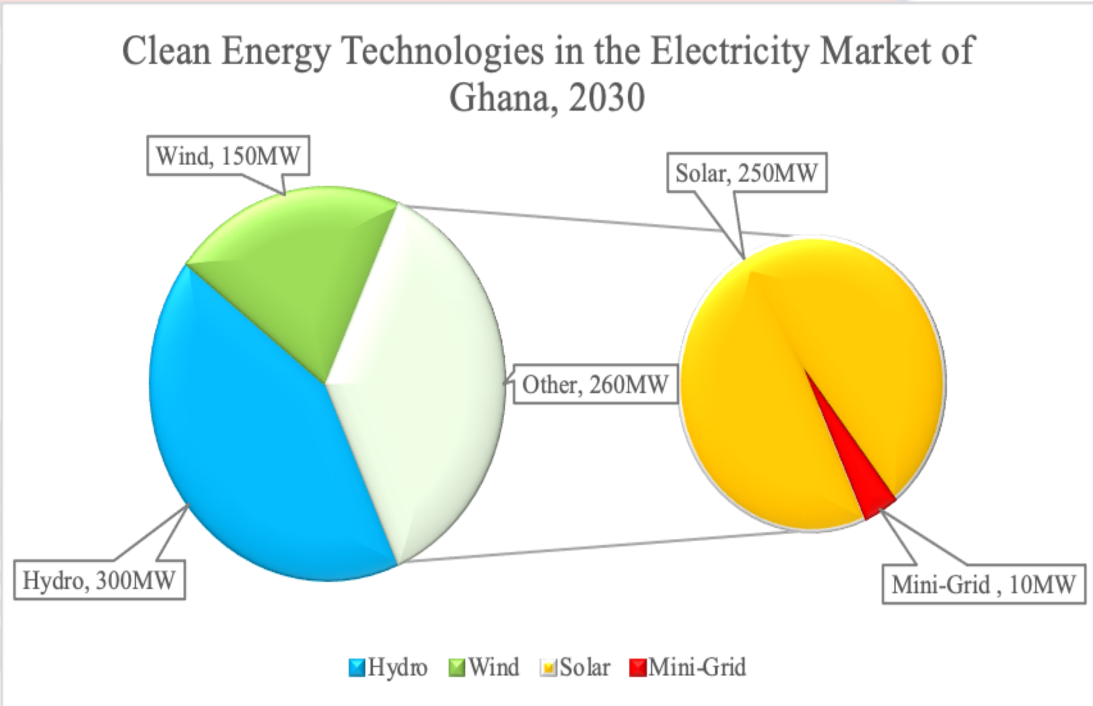


Figure 6.9: Clean Energy Technologies in the Electricity Market of Ghana

Source: Author’s Own Construct

Table 6.4: NDC Indicators for Mitigation Actions

Description of Action	Threshold Target by 2030	Sub-units	Indicators
Increase small-medium hydro installed capacity up to 150-300MW	300	MW	mini-hydro installed capacity
Attain utility-scale wind power capacity up to 50-150MW	150	MW	Grid-connected wind power installed capacity
Attain utility-scale solar electricity installed capacity up to 150-250 MW	250	MW	Grid-connected solar installed capacity
Scale-up the 200,000 solar systems for lighting in residential and non-residential buildings	200,000	500W	Number of installed solar home systems
Establish 55 mini-grids with average capacity of 100kW.	55	100kW	Number of 100kW mini-grids installed
Increase solar lanterns penetration in rural non-electrified households to 2 million	2,000	1000 lamps	# of LED lamps distributed
Scale-up adoption of LPG in at least 50 percent households	134	1000 LPG stoves	# of LPG stoves adopted, percent of household using LPG for cooking
Scale-up access and adoption of 2 million efficient stoves	2,000	1000 efficient stoves	# of efficient stoves distributed
Fuel switch from heavy fuel oil to natural gas in existing electricity power plants	50	100 TJ fuel use/year	Quantity of natural gas per thermal electricity generated
Improve the efficiency of the thermal power plants by converting the single cycle power plants to combine cycle	3.3	100 MW increase	single cycle to combined cycle conversion
Recovery and utilisation of associated gas from Jubilee and Tein oil fields	120	1 MMSCF/day	Amount of gas recovered from oil field
Promote efficient lighting with LED bulbs	20,000	1000 bulbs	# of LED bulbs distributed

Source: Nationally Determined Contribution (2021)

6.8 Energy Supply Estimates from LEAP Modelling

The study was guided by the respective policies used in the development of the REMP, NDC and further aligned to the assumptions used by the energy sector amidst data from industry experts. The modelling assumed that 10 percent of electricity generation capacity is renewable energy. Based on the projects that exist in the pipeline, the objective is to achieve affordable electricity by utilizing the least cost fuel procurement policy amidst competitive procurement of energy supply and service contracts.

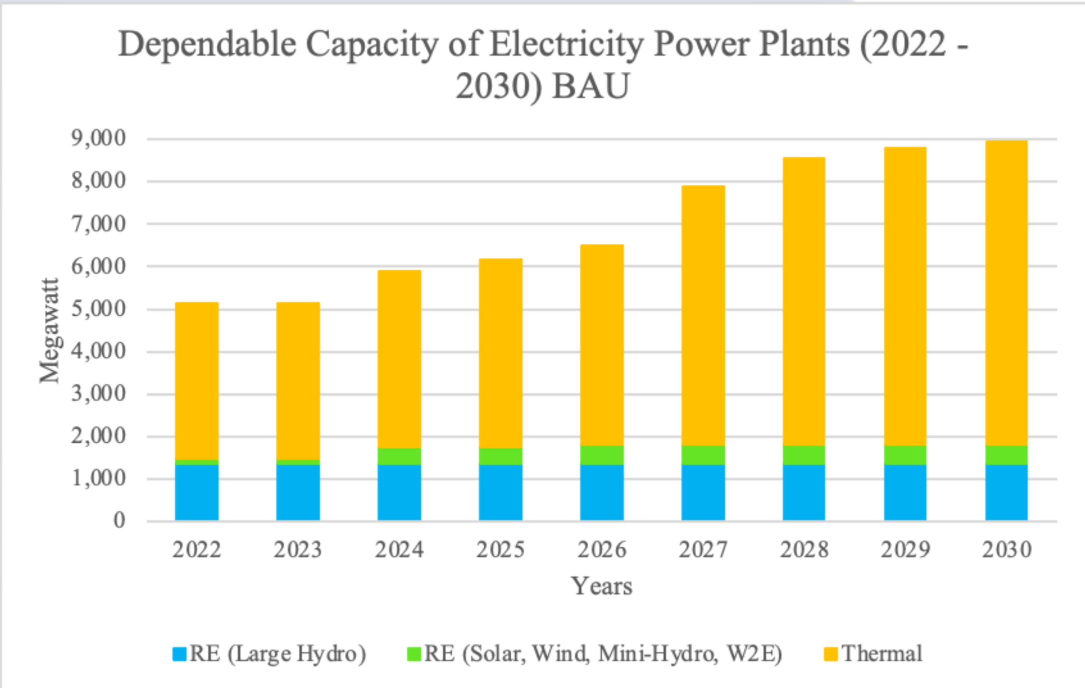


Figure 6.10: Dependable Capacity of Electricity Power Plants (2022-2030) BAU

Source: Author's Own Construct

The dependable capacity of the power plants in Ghana was used for the forecast to generate stable electricity to meet demand. Under the BAU scenario, it was evident that Ghana continues to rely on electricity from thermal plants that are using fossil fuel to meet the required demand. The results that present more utilization of thermal power plants explains the existing development of power plants that intend to use fossil fuel. There exists a commercial and legal risk that also threatens the immediate replacement of the thermal electricity plants with clean energy technologies. Under this scenario, the CO_2 emissions associated with the electricity generation is significantly higher. In view of the contractual obligations backed by PPAs and financial obligations for the utilization of the indigenous (Ten, Jubilee, OCTP Sankofa gas fields) gas, electricity generation from fossil fuel will continue for some time. These gas contracts have guarantees that possess a contingent liability on GoG and further threaten the sustainable development of the country. These possess additional constraints in the modelling. Results from the modelling suggests that clean energy technologies excluding the large hydro plants as a proportion of the total dependable capacity was 4.94 percent whereas including the large or legacy hydro results in 20.25 percent of the total capacity.

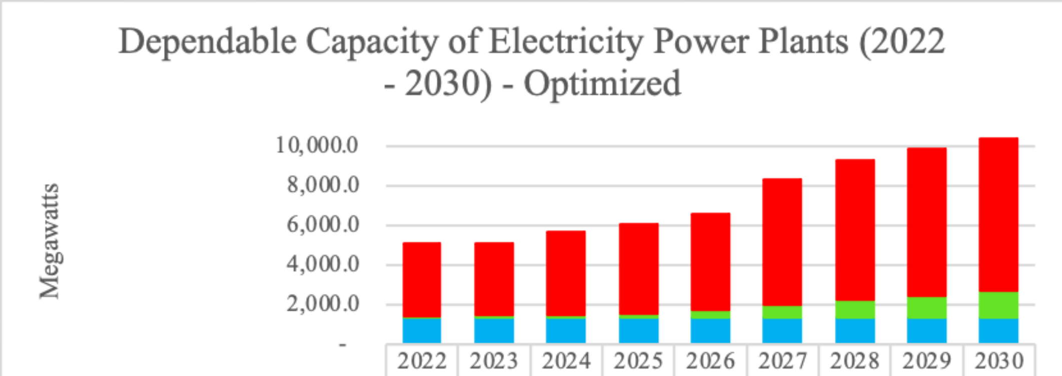
Sequel to the above, there was the need to consider an optimized scenario, where Ghana achieves its industrial goals amidst the high utilization of lower carbon emission technologies with higher electricity demand potential and increasing use of electric vehicles.

Even though the study was able to identify an optimal level of clean energy technologies that can be integrated into the electricity market, the energy technologies, excluding the large hydro plants as a proportion of the total dependable capacity, was 13.05 percent, whereas when including the large or legacy hydro plants the results came to 26.21 percent of the total capacity.

However, significant growth of clean energy technologies was emanating from the installation of solar PV, which accounts for 91 percent of clean energy technologies as of 2030.

6.9 Optimized Scenario

Details on the scenarios have been provided in the appendix of this work.



	2022	2023	2024	2025	2026	2027	2028	2029	2030
Thermal Power Plants	3,661.	3,661.	4,240.	4,534.	4,864.	6,317.	7,035.	7,377.	7,683.
Clean Energy (Solar, Wind, Mini-Hydro, W2E)	80.9	101.8	101.8	165.6	355.9	639.2	888.3	1,110.	1,358.
Large Scale Renewable (Hydro Power Plants)	1,370.	1,370.	1,370.	1,370.	1,370.	1,370.	1,370.	1,370.	1,370.

Figure 6.11: Dependable Capacity of Electricity Power Plants (2022-2030) - Optimized

Source: Author's Own Construct

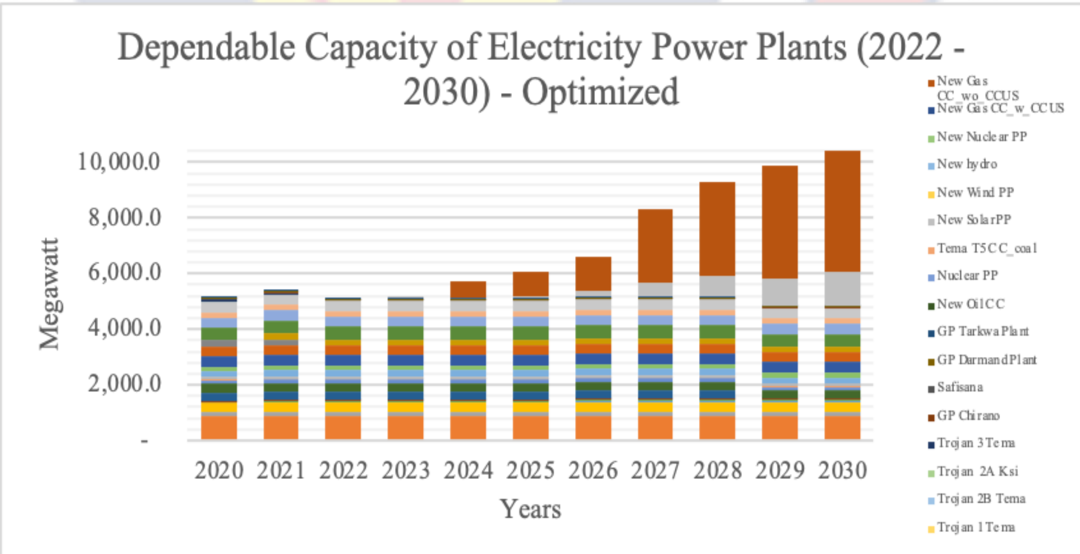


Figure 6.12: Dependable Capacity of Electricity Power Plants (2022-2030) - Optimized

Source: Author's Own Construct

6.10 CO_2 Emissions

There is a 12.84 percent reduction in CO_2 emission as at 2030 under an optimized scenario of 49.9 million metric tonnes as compared to a BAU scenario of 57.3 million metric tonnes. The net effect of the modelling also suggests an increase in CO_2 emissions in both scenarios as Ghana has planned thermal power plants to be integrated in the electricity market in order to meet the expected demand.

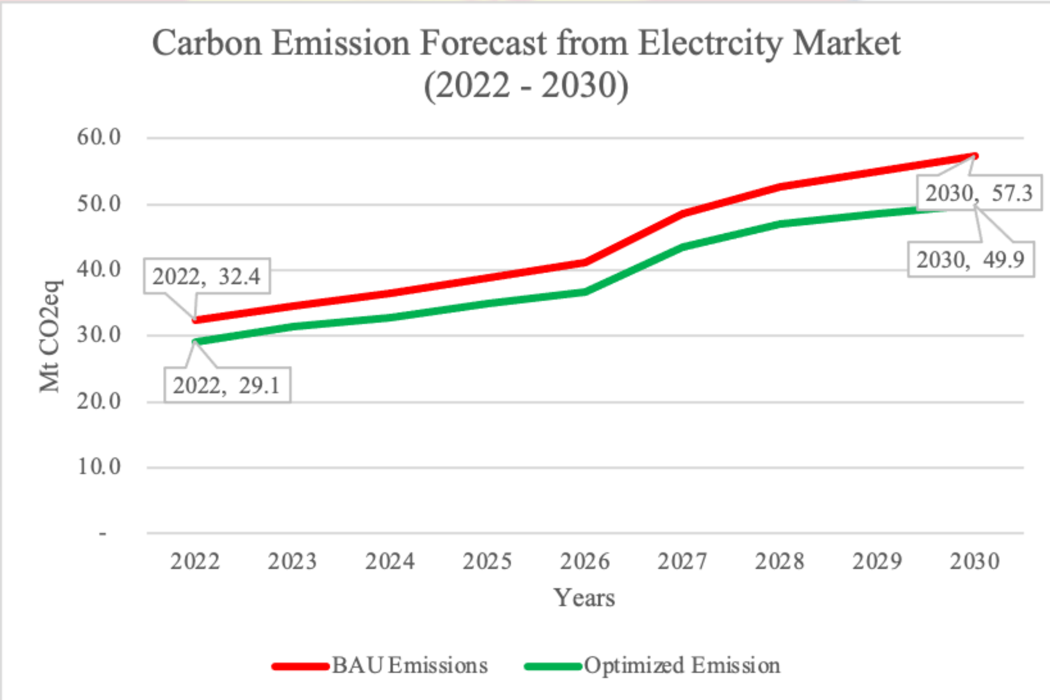


Figure 6.13: Carbon Emission Forecast from Electricity Market (2022-2030)

In conclusion, the total electricity demand in Ghana is expected to increase from an estimated consumption of 21,126 GWh as of 2022 to a projected consumption of 40,452 GWh as of 2030.

The study identified that Ghana is endowed with the resource potential for solar power plant development. The Northern Region of Ghana has the relative highest solar irradiation.

Additionally, potential locations in Ghana suitable for siting power plants using wind energy include Keta, Ada, Mampong, Ashanti Akim, Kwahu, Upper Manya and Fanteakwa. These areas are suitable because it has a wind speed more than 5.3 m/s. Ghana furthermore has about 14 potential sites for the development of about 740 MW of small-scale hydro dams

Based on the country's development aspiration, it was observed that there will be significant growth emanating from the industry sector (average annual growth of 15.72 percent and CAGR of 182 percent) and services sector (6.46 percent of average annual growth and CAGR of 164.99 percent). The fastest growing sector over the period is the agriculture sector (CAGR of 245 percent). These growth figures reflect transition to the use of technology based on modernized equipment and machines. However, it is important to acknowledge that during these periods there existed complementary emissions of GHG, which tends to affect the environment, which was identified under the BAU Scenario. To mitigate the adverse effect of the emissions under BAU Scenario, the study further modelled an Optimized Scenario that suggests a migration to the utilization of clean energy technologies.

Based on the various development plan and policies of Ghana, the commitment of the country from the electricity market to reduce climate emission between 2020 and 2030 can potentially integrate about 710 MW of installed capacity of power plants as per the NDC. However, the optimized capacity that can potentially be integrated is about 1,358.8 MW.

The study affirmed that CO_2 emissions reduced by 12.84 percent as at 2030.

The study further recommends that Ghana will require a long term comprehensive strategic plan that integrates contractual obligations, legal ramifications, financing arrangements and engineering possibilities of clean energy technologies to achieve the required low levels of CO_2 emissions.

CHAPTER SEVEN: SYNTHESIZING AN IMPROVED SYSTEM OF CLEAN ENERGY FINANCING FOR SUSTAINABLE DEVELOPMENT IN GHANA

7.1 Introduction

The study affirmed that the electricity market of Ghana has about five main off-takers, which classifies the market as a multiple buyer market. The unique nature of each off-taker in the electricity market presents a distinct risk profile that is key in making a clean energy financing decision. Hence, to improve the clean energy financing system for sustainable development, the credit worthiness of each specific off-taker is critical. To achieve the objective of this chapter, the study analysed the financial statements of SOEs over a five-year period, as well as the economic and technical regulatory data as published by PURC, EC, GRIDCo and ESRP. The analysis focused on electricity generation (VRA, BPA and IPPs), transmission (GRIDCo), and distribution (ECG and NEDCo). The analysis further used the key significant variables as established as determinants for clean energy financing for the individual analysis of the electricity value chain (VRA, BPA, IPPs, GRIDCo, ECG, and NEDCo) before consolidating all the stakeholders into one electricity market in Ghana.

The quantum of the clean technologies that can be integrated in the electricity market between 2023 and 2030 was contingent on the determinants of clean energy financing. The potential effect of clean energy financing on sustainable development was the underlying reason for proposing options that were synthesized to improve the components, processes and policy requirement of the clean energy financing system.

7.2 Assumptions for the Options Analysis

The type of procurement approach and financing structure of clean energy projects are key in achieving the expected effect of clean energy financing. This helps in deciding a suitable type of financing instrument and conditions for clean energy financing. The study affirmed that there are varied options of funding sources available for clean energy financing; however, juxtaposing the outcome of the macroeconomic environment assessment and the sector characteristics in terms of sustainable development indices with the eligibility criteria of the respective funding sources presents challenges that need to be addressed. For an improved system of clean energy financing, the enabling environment for the actors was firstly considered, followed by the eligibility of prospective clean energy projects interested to secure clean energy financing. The results of the analysis are used to determine the off-taker credit worthiness of the electricity market in Ghana to attract clean energy financing. The scope of the analysis is described in Table 7.1.

Table 7.1: Electricity Value Chain in Ghana

Generation	VRA BPA IPP
Transmission	GRIDCo
Distribution	ECG NEDCo

Source: Author's Own Construct

The analysis captures historical data from 2017 as well as forecasts for the period up to 2030.

7.3 Results for Options Analysis

The key findings from the analysis focused on cashflow reliability, which was demonstrated by the revenue (power paid) and cost (power cost or invoice) analysis (also referred to by the author as the pay-out ratio), the system losses of electricity, the levelized cost of electricity and revenue performance.

Firstly, the revenue and cost analysis from the analysis demonstrated a shortfall between revenue collected from electricity sales and cost of electricity. From Figure 7.1, as shown below, it is very clear that the cost of generation far outstrips the revenue collected. This means that for every invoice issued as cost of electricity generation in the electricity market of Ghana, only 74.45 percent on an average will be paid and classified as the market pay-out ratio.

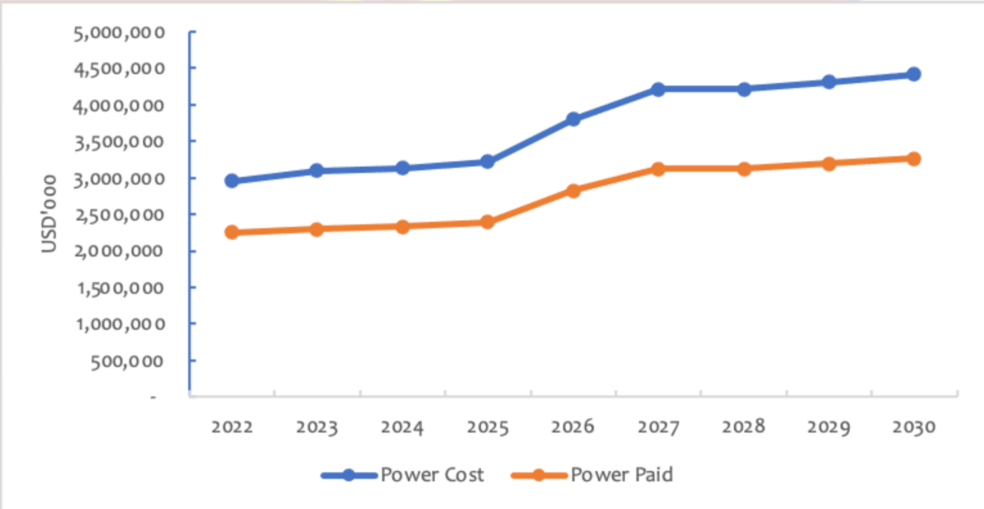


Figure 7.1: Electricity Cost Compared to Electricity Revenue

Source: Author’s Own Construct

The shortfall from the revenue and cost analysis presents a payment and liquidity risk to investors and entrepreneurs in the electricity. This demonstrates the off-taker risk exposure of the electricity market.

It is important to note that the specific pay-out ratio for each off-taker in the electricity market varied, and that subsequently demonstrates the varied risk profile of the market. Based on the analysis, the average tariff pay-out ratios between 2022 and 2030 were determined. In the regulated market, ECG had a pay-out ratio of 61.44 percent, while NEDCo's ratio stood at 54.36 percent. For the deregulated market, bulk customers supplied by VRA exhibited a pay-out ratio of 93 percent, and it was 100 percent for the export or regional market. This affirms the unique specific risk of each off-taker in the electricity market of Ghana and subsequently clean energy financing decisions. To this end, the study suggests that even though there are general heightened concerns regarding the long-term viability of the entire electricity market, there is a viable option in the deregulated market for clean energy financing.

Secondly, the system losses of electricity generated: the systemic risk in the electricity market emanates from the distribution utilities (ECG and NEDCo) in the regulated market where system losses are identified to be relatively high. This poses the risk of payment and liquidity that translates to additional comfort or guarantees from the off-taker, which tend to increase the financing cost. Essentially the cash flow required to be used to make payment for invoices is lost as demonstrated in Table 7.2. The analysis further affirms the relative viability of the deregulated market as compared to the regulated market of the electricity market of Ghana. Specific policy actions will be required to attract clean energy financing.

Table 7.2: System Losses in the Electricity Market in Ghana

System Losses					
(Percent of Gross Power Sales)	2017	2018	2019	2020	2021
ECG System Losses	24.3%	24.3%	24.4%	26.1%	30.5%
NEDCo System Losses	28.9%	30.7%	27.3%	27.0%	27.3%
VRA/GRIDCo System Losses	5.0%	4.9%	5.0%	4.5%	5.0%

Source: Energy Sector Recovery Programme (2022)

Thirdly, the levelized cost of energy: this was also used to compare the cost of energy to the tariff that is being paid to consumers of electricity. The study used the contracted dispatch of energy as well as the obligation of whether a power plant has a take or pay contract or not to determine the total cost of generating electricity. This resulted in a LCOE generation in the regulated market that is higher than the end user tariff used by ECG and NEDCo for the billing of its customers. The LCOE in 2022 is estimated at 171.97GHp/kWh, which increases to 258.4GHp/kWh by 2030, whereas the end user tariff in 2022 is estimated at 88.15GHp/kWh and 176.13GHp/kWh by 2030. The variance suggests a tariff under recovery within the regulated market of the electricity market. The analysis suggests that the tariff under recovery can be cured by reviewing the tariff upwards. The 27.15 percent electricity end user tariff increase, which took effect on 1st September 2022 by the implementation of the 3-year (2022-2023) MYTO[12] by PURC, supports the argument of increasing tariffs in Ghana. The MYTO is basically setting the electricity tariff on a glide path of cost recovery. Furthermore, the additional 29.96 percent tariff increase effective 1st February 2023 through the implementation of the quarterly adjustment[13] of the electricity tariff also supports the argument of increasing tariffs. The quarterly adjustment is used to adjust the electricity tariff for changes in exchange rate fluctuations, inflation and fuel prices.

[12] https://www.purc.com.gh/attachment/459725-20220816110856.pdf
[13] https://www.purc.com.gh/attachment/512332-20230116010139.pdf

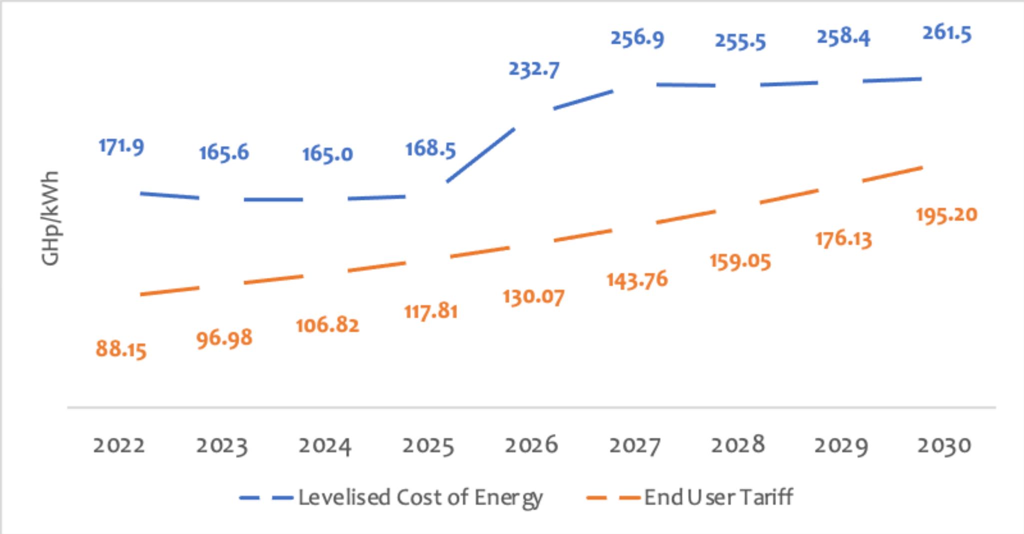


Figure 7.2: Levelized Cost of Electricity

Source: Author's Own Construct

While the study acknowledges the benefit of addressing the tariff under recovery in the regulated market, it is important to note that the consistent increase of tariff will result in electricity in Ghana being expensive, which will further cause consumers to explore cheaper alternatives such as clean energy technologies. This will further result in either consumers of electricity in the regulated market complementing the grid electricity with clean energy technologies or replacing the grid with a clean energy source. This will create an incentive for clean energy financing.

Finally, revenue performance of the regulated market: the result of the analysis shows that the profitability of the state-owned distribution companies, particularly ECG, are severely hampered because they are not able to generate sufficient revenue to cover its direct cost; thus, reporting negative EBITDA margins. This situation will constantly create a viability situation for clean energy financing investors.

Table 7.3: Revenue Analysis of Distribution Companies in Ghana

Distribution SOE

		2022	2023	2024	2025	2026
Revenue	GHS'000	9,507,951	13,069,104	17,775,771	24,378,421	33,456,849
EBITDA	GHS'000	(28,560,027)	(17,013,445)	(13,055,984)	(6,734,619)	(7,940,734)
EBITDA Margin	%	-300%	-130%	-73%	-28%	-24%
EBIT	GHS'000	(29,007,717)	(17,446,811)	(13,476,961)	(7,141,751)	(8,335,925)
Net Profit	GHS'000	(28,977,309)	(35,321,319)	(27,933,943)	(15,974,923)	(19,361,875)
Net Profit Margin	%	-305%	-270%	-157%	-66%	-58%

Source: Author's Own Construct

The study identified weakness in performance of the distributing utilities that operate in the regulated market of the electricity market of Ghana; further affirming that the challenges and risks associated with the regulated market should not be used as a basis for clean energy financing decisions as the deregulated market presents a relatively attractive market. In view of the above, the electricity deregulated market is relatively positioned to attract clean energy financing; however, the components of the clean energy financing system can be tweaked to also attract clean energy financing for both the regulated and regulated market.

7.4 Improvement of the Clean Energy Financing System Components

In describing the state of clean energy financing and sustainable development in Ghana, the following were identified as the existing components of the clean energy financing system: clean energy financing sources; clean energy financing instruments; clean energy determinants; and clean energy financing policies and regulations. Based on the analysis of the electricity market, it became necessary for the study to propose options to improve the components of the clean energy financing system by introducing a clean energy financing type of procurement, clean energy financing structure and clean energy financing instruments. The study likewise recommends that clean energy funding sources should be expanded to include pension funds and the inclusion of clean energy financing payment mechanisms as a separate component.

Firstly, **clean energy financing type of procurement**: the adoption and integration of competitive procurement of clean energy technologies should be a requirement in the electricity market. The study identified that bilateral and unsolicited procurement of power plants is a major cause of the high cost of electricity with its associated contractual obligations. To mitigate this risk, the competitive procurement of power plants provides a well-structured and coordinated approach to achieve affordable electricity tariffs. Competitive procurement affords Ghana an opportunity to transparently undertake cost comparison and technological capability before procuring clean energy power plants. This component ensures that the expected effect of clean energy financing on sustainable development can be ascertained before procurement of clean energy technologies.

Secondly, **clean energy financing structure:** the mitigation strategy of the risk identified for each specific off-taker is key to clean energy financing decisions. It is evident from the analysis that the deregulated market, which consists of large industrial and mining companies that are privately owned as well as neighbouring countries, are more eligible to attract clean energy financing based on relatively stronger off-taker credit worthiness as compared to the regulated market, which is largely government owned. The mitigation of the off-taker risk will redefine the project structure and subsequently the type of financing instrument. The clean energy financing structure allows for amendment of the off-taker, changes in the company responsible for the engineering procurement and construction, and the type of financing. To this end, the changes, as demonstrated by Table 7.4, suggest that a clean energy financing structure optimizes the eligibility of projects to attract clean energy financing.

Table 7.4: Financing Instruments of Potential Investors

No.		Applicable Financing Instrument	Financing Description
1	Debt	Concessional (Soft Loans)/ Flexible Loans and Credit Lines	Loans with low interest rates.
2	Debt	Public Sector Commercial Loan	Loans from Public sector actors- Development Banks, PPP Funds, Bilateral Agencies- at market rates
3	Debt	Private Sector Commercial Loan	Loans from Private Sector actors - Global, regional and local private financial institutions- at market rates
4	Equity and Quasi-Equity	Public Sector Equity	Direct Equity Capital from Public Sector Actors - Government (and its agencies); PPP Funds; Development Banks
5	Equity and Quasi-Equity	Private Sector Equity	Direct Equity Capital from Private Sector Actors - Project Developers; Institutional Investors; Private Equity
6	Equity and Quasi-Equity	Public Sector Mezzanine	Quasi-Equity (mix of debt and equity characteristics) Capital from Public Sector Actors - Government (and its agencies); PPP Funds; Development Banks
7	Equity and Quasi-Equity	Private Sector Mezzanine	Quasi-Equity Capital from Private Sector Actors - Project Developers; Institutional Investors (pension funds, sovereign wealth funds, etc.); Private Equity
8	Funds and Structured Products	Debt and Equity Funds	Collective investment schemes in debt or equity from sources including Development Banks, Bilateral Agencies, Governments, Institutional Investors, Private Equity
9	De-risking Instruments (Insurance, Guarantees, etc.)	Public Sector De-risking Instruments	Insurance and Guarantees from Public Sector Actors - Governments, Developments Banks, Bilateral Agencies
10	De-risking Instruments (Insurance, Guarantees, etc.)		Insurance and Guarantees from Private Sector Actors - Insurance Companies

No.	Applicable Financing Instrument	Financing Description
11	Export Credit Agency Finance (ECA)	An Export Credit Agency (ECA) is set up as a government entity or it can be structured as a private firm however ownership is still government. ECA Finance is indexed to a contract established between an exporter and an importer. ECA finance can be extended as direct loans to the importer or indirect loans through a bank. Securities, guarantees and insurance are required safeguard the ECA financing. ECA financing is concessionary relative to commercial lending.

Source: Author's Own Construct

Thirdly, expanding the existing clean energy financing instruments to include **green bond listed on the stock exchange**. The GSE has launched the green bond manual to allow funds to be raised for clean energy projects. SEC has set guidelines for the kind of securities that fund managers can invest in, including green bonds issued on the stock exchange that aligns with the eligible asset classes fund managers can invest in, such as capital and money market instruments. The local funding source from the GSE, as part of the clean energy financing instrument, mitigates the electricity tariff from exchange rate fluctuations that form part of the basis that makes electricity tariffs unaffordable.

Fourthly, expanding the existing funding sources to include pension funds. Pensions in Ghana have evolved over the years with a 3-tier structure. The underlying principles for pension investment are safety and security.

The NPRA has developed minimum guidelines that permit the use of pension funds to be invested in the real sector[14], which includes the clean energy sector of the electricity market. The permissible investments include Government of Ghana securities, local government and statutory agency securities, corporate debt securities, listed ordinary shares and non-redeemable preference shares, bank securities, collective investment schemes, and alternative investments.

To create a positive environmental impact on the Ghanaian economy, a special provision for up to 5 percent of the scheme AUM can be invested in green bonds and shall not count towards the attainment of the maximum 75 percent and 35 percent allocations for the Government of Ghana Securities and Corporate Debt Securities, respectively. Furthermore, for the pension funds to be utilized to create the expected positive effect on the environment, the schemes must incorporate ESG factors in the investment decision-making process.

Finally, the study further recommends the inclusion of the clean energy financing payment mechanisms as a separate component that complements the clean energy financing structure. This validates a clean energy financing decision, which is anchored on return of investment and cash flow reliability.

Ghana implemented the CWM as a payment mechanism for ECG to address the payment and liquidity risk that threatened the financial sustainability of the company. The CWM ensures that there is an equitable, transparent, and fair basis for making payments by Electricity Company of Ghana. Based on the CWM guidelines and operational manual that the study reviewed, the allocation proportion used as the basis for payment by the CWM is the end user tariff,

[14] The sector of an economy that engages in the production of goods and services in an economy

which is determined and gazetted by PURC. The allocation proportion of the CWM based on the PURC tariff [15] gazette is demonstrated in Table 7.5.

Table 7.5: Cash Waterfall Mechanism

Category	**Customer Class**	**Unit**	**CWM Allocation Proportion (%)**
Generation (Hydro, Thermal, Renewables)	BGC (VRA + IPPs)	GHp/kWh	44.60%
Fuel	Gas and Liquid Fuel Suppliers	GHp/kWh	20.89%
Transmission	TSC 1	GHp/kWh	10.60%
Distribution	DSC 1	GHp/kWh	23.91%
Total	***EUT***	***GHp/kWh***	**100.00%**

Source: Energy Sector Recovery Programme (ESRP) (2022)

Table 7.5.1 presents the 2020 and 2021 actual CWM payments to generating companies. The payments were based on the CWM allocation proportion that is derived from payment of electricity consumed by customers of ECG only.

Table 7.5.1: Cash Waterfall Mechanism – Business as Usual Payments (BAU) to Generators, 2020 & 2021

BAU CWM Payments to Generators		
	2020 (GHS' Million)	**2021 (GHS' Million)**
Renewable Energy (Solar & W2E)	10.34	20.75
Thermal	1,399.93	1,561.00
Hydro	247.72	479.15
	1,657.99	2,060.90

Source: Energy Sector Recovery Programme (ESRP) (2022)

[15] https://www.purc.com.gh/attachment/99840-20210227100230.pdf

Based on the above, the clean energy power plants receive an insignificant proportion of their invoice amount, which presents a challenge of liquidity risk to investors. Now, to improve the clean energy financing system by addressing the liquidity and exchange rate risk, the study further recommends clean energy financing payment mechanisms and further proposes two options for government consideration to deepen clean energy financing as presented below:

Option 1: Comprehensive Affirmative Action for Clean Energy

The options require the CWM to delineate clean energy electricity generation from the broader generation mix and make 100 percent payment of the electricity generated by clean energy sources as it forms 0.39 percent of total generation (GWh), which translates to 1.01 percent of total generation cost (GHS) for the ECG market segment for the full year of 2021.

Table 7.5.2: Positive Affirmative Action 1: CWM Payments to Generators

Category	Customer Class	Unit	CWM Allocation Proportion (%)
Gross Collection from ECG for CWM Allocation			
Generation - Renewables		GHp/kWh	100%
Net Collection Post Payment of Renewables			
Generation (Hydro &Thermal)	BGC (VRA + IPPs)	GHp/kWh	44.60%
Fuel	Gas and Liquid Fuel Suppliers	GHp/kWh	20.89%
Transmission	TSC 1	GHp/kWh	10.60%
Distribution	DSC 1	GHp/kWh	23.91%
Total	**EUT**	**GHp/kWh**	**100.00%**

Source: Author's Own Construct

Based on the analysis of Option 1, the outcome presents an improvement in the pay-out ratio for the renewable energy power producers as explained in Table 7.5.3 below.

Table 7.5.3: Results of Positive Affirmative Action 1: CWM Payments to Generators

Post Affirmative Action1: CWM Payments to Generators		
	2020 **(GHS' Million)**	2021 **(GHS' Million)**
Renewable Energy (Solar & W2E)	53.96	64.50
Thermal	1,362.87	1,527.53
Hydro	241.16	468.88
	1,657.99	2,060.90

Source: Author's Own Construct

Option 2: Partial Affirmative Action for Clean Energy

This option requires the CWM to delineate clean energy electricity generation from the broader generation mix and make partial payment of the electricity generated by clean energy sources to enable the power plant to meet its operations cost and allow them to service financing.

Table 7.5.4: Positive Affirmative Action 2: CWM Payments to Generators – Proportion (%)

Category	Customer Class	Unit	CWM Allocation Proportion (%)
Gross Collection from ECG for CWM Allocation			
Generation - Renewables		GHp/kWh	CAPEX & OPEX
Net Collection Post Payment of Renewables			
Generation (Hydro &Thermal)	BGC (VRA + IPPs)	GHp/kWh	44.60%
Fuel	Gas and Liquid Fuel Suppliers	GHp/kWh	20.89%
Transmission	TSC 1	GHp/kWh	10.60%
Distribution	DSC 1	GHp/kWh	23.91%
Total	**EUT**	**GHp/kWh**	**100.00%**

Source: Author's Own Construct

Assuming the CAPEX and OPEX represents 50 percent of the total invoice submitted, the outcome below presents an improvement in the liquidity position of the power producers, which tends to build a compelling argument to attract new investment to meet the expected penetration by 2030.

Table 7.5.5: Positive Affirmative Action 2: CWM Payments to Generators – Receipts (GHS' Million)

Post Affirmative Action 2: CWM Payments to Generators		
	2020	**2021**
Renewable Energy (Solar & W2E)	26.98	32.25
Thermal	1,385.79	1,552.20
Hydro	245.21	476.45
	1,657.99	2,060.90

Source: Author's Own Construct

In summary, the clean energy payment mechanism has demonstrated an improvement in the credit worthiness of ECG to enhance its attractiveness for clean energy financing.

7.5 Processes for Clean Energy Financial System

The study identified a framework used for clean energy financing based on evidence from the electricity market of Ghana as shown in Figure 7.3.

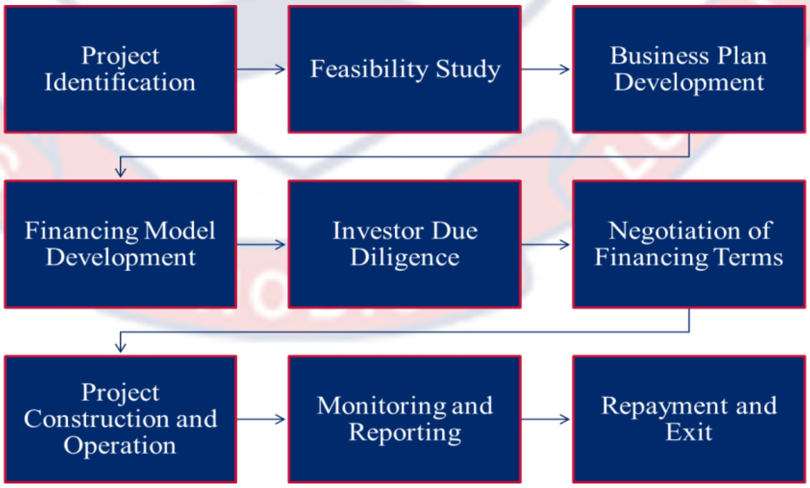


Figure 7.3: Processes for Clean Energy Financial System

Source: Author's Own Construct

Clean energy financing commences with the origination of a clean energy project by a clean energy financing institution, which is classified as Project Identification. At the project identification stage, a summary assessment is made of the technical viability of the project technology, financial viability, commercial agreement review, carbon emission impact of the project, and assessment of sustainable development indices.

The overarching objective of this stage is to ensure that the project is a low carbon emission project, and that it is bankable. The next stage is a feasibility study, which is a deep dive into the project to ascertain the financial and economic viability of the project. It is at this stage that resource potential is identified, as well as technological capability, financial feasibility, market analysis (supply and demand side analysis) and, finally, off-taker credit worthiness.

Based on a viable outcome of the feasibility study, a business plan and a financial model are developed with the objective of presenting it to an investor. Where a project is classified as not feasible, the underlying risk factors threatening the project feasibility is identified for further engagement to explore the options that mitigate the risk identified. Once a bankable project document, such as a business plan and financial model, becomes interesting or attractive to an investor, the clean energy financing institution will then sanction due diligence to be undertaken from the financier's perspective. The due diligence will include: the value proposition and business model; market understanding and analysis; management team; operations & implementation plan; financials; risk mitigation; gender; environmental & social benefits; professionalism in the presentation of documentation; technology; energy access; and number of jobs created once the project obtains the required financing. The due diligence report is then presented to an investment committee for approval: once approval is received the window is then opened for negotiations to get underway between the clean energy financing institution and the clean energy project owner. If the two parties agree to the terms of the financing, this is termed the FC, which is an important stage that allows the project owner to commence construction and operations. It is at FC that we acknowledge that clean energy financing has taken place. When the project attains the COD then the project can commence earning revenues. The financing will be monitored to ensure compliance with standards and regulatory requirements. The final and most important stage for clean energy institutions are repayment and exit of clean energy financing.

7.6 Actors of Clean Energy Financing

The study identified an additional actor, namely clean energy financing NGOs, to the existing actors as identified in the description of the state of clean energy financing and sustainable development in Ghana, to recap: Economic Regulators (PURC), Technical Regulators (EC), Supervisory Authority – (MoEn, MoF, and Ministry of Environment), Central Bank (BoG), SEC, Clean Energy Association, Ghana Standards Authority and GSE. The clean energy sector consists of manufacturers, installers, and dealers who have a vital role to play in assisting households and businesses to install renewable energy systems safely and securely.

Clean energy financing NGOs are non-profit, private-sector institutions dedicated to the promotion of energy efficiency and renewable energy projects and programs. There are active NGOs in Ghana that provide support for clean energy financing through technical assistance, research and development, training, and education in the sector.

7.7 Policy Requirements for Clean Energy Financing System

The study identified that the BoG issued a monitoring guidance and reporting template for banks as part of the implementation process for the Ghana Sustainable Banking Principles & Sector Guidance Notes, which was launched in 2019. Sustainable banking principles are intended to support banks seeking funds and lending to address emerging global issues specific to environmental and climate change actions. Almost all the banks in the country have fully complied with the principle and the regulator is monitoring how the risks of climate change impact the banks' lending or loan portfolio. Since the principle is in its development stage, the regulator has instituted guidelines (such as risk assessment) as part of the environmental impact analysis for all loan appraisals. The seven principles seek to incorporate environmental and social management into lending decisions and support gender equality, extensive financial inclusion, and strong ethical and corporate governance standards. The principles are environmental and social risk management (ESRM), internal ESG in banks operations, corporate governance and ethical standards, gender equality, financial inclusion, resource efficiency, sustainable production, and consumption, reporting towards five sectors: agriculture & forestry, construction & real estate, manufacturing, oil & gas, mining, and power & energy.

The research noted that even though there are well defined laws and policies guiding the activities of clean energy technologies and the technology developers and entrepreneurs in Ghana, it was identified that clean energy financing was relying on existing laws and policies guiding the broader financial system in Ghana. To this end, there are no customized laws and policies specific for clean energy financing.

CHAPTER EIGHT: SUMMARY, CONCLUSION, RECOMMENDATION AND POLICY ACTIONS

8.1 Introduction

This chapter covers the summary of the findings, conclusions from the summaries, recommendations and the policy actions based on the main findings.

8.2 Summary of Findings

The study presents the summary of findings for the various specific research objectives as detailed below:

Electricity generation in Ghana has transitioned from the use of fossil fuel only to the full use of only hydro fuel, and then further transitioned to the use of a blend of hydro fuel and fossil fuel. It is currently using a blend of fuel options, which include hydro, solar, wind and fossil fuel. Electricity generation in Ghana using clean energy technologies has been an integral part of Ghana's electricity development.

Ghana has a dynamic electricity market structure, which has evolved from a monopoly (vertically integrated market) to an unbundled market that allows for competition. The study identified that further steps are being taken to make the market a competitive one with the introduction of the wholesale electricity market.

The classification of the electricity market entails a degree of complexity as the market classification can be a regulated market (comprising of ECG, NEDCo and EPC as separate off-takers of electricity) and a deregulated market (comprising of export and mines & bulk consumers). Price determination of electricity and regulation is key to the classification. The regulator determines the tariff in the regulated market whereas in the deregulated market it is based on bilateral negotiation. This finding was central to the understanding of varied risk profiles of each off-taker in the electricity market, which is key to clean energy financing.

Furthermore, the electricity market of Ghana allows for consumers to procure electricity indirectly through the distribution utilities connected to the grid infrastructure, which the study labelled as grid connection or procuring power directly from a power generator or utilizing other forms of clean energy technologies, which is likewise deemed as off-grid installations.

Ghana has in place regulatory institutions and authorities that spearhead the implementation and operationalization of the policies and regulations. The study identified that improvement in coordination can harness clean energy financing.

The introduction of clean energy financing had a significant impact on sustainable development in Ghana. First and foremost is the drastic cutback in carbon dioxide (CO_2) output. Ghana's dependency on fossil fuels has decreased considerably owing to the country's increased investment in renewable energy sources such as solar, wind, and hydropower. Greenhouse gas emissions in the nation have decreased significantly consequently. This environmental management is in line with global climate targets and strengthens Ghana's resolve to tackle climate change.

A new age of sustainable clean energy has begun in Ghana because of the combination of emission reductions and investment in clean energy. Solar farms, wind turbines, and hydroelectric dams are just a few of the renewable energy projects that have benefited from financial backing and are now in various stages of development and growth. By lowering the country's reliance on non-renewable fossil fuels, these initiatives provide a steady and environmentally favourable supply of energy. Ghana's future energy supply is sustainable and secure thanks to the path established by clean energy funding. Providing new avenues for work is a vital part of this shift.

Recently, the clean energy has become one of the major employers in Ghana. There is a rising need for both expert and unskilled labour as a direct result of the increasing funding for renewable energy projects. The increase in available jobs has helped many Ghanaians improve their standard of living and financial outlook.

Financing for renewable energy has stimulated the economy all around the country. The more the industry grows, the more money flows into it from both at home and abroad. This expansion has far-reaching effects on other sectors of the economy, helping propel growth in Ghana as a whole.

In addition, problems with access to electricity have been resolved, especially in rural and disadvantaged areas, thanks to investments in renewable energy. Communities that had no or limited access to power have gained it via the use of off-grid and mini-grid renewable energy alternatives. This has given locals more agency and encouraged growth by improving living conditions, educational opportunities, and medical care.

In addition, the study identified that clean energy financing resulted in entrepreneurial activities that created jobs as evidenced by the various companies that were licensed by EC to undertake various projects using solar, wind, biomass, hydro, and biogas. The study also identified a relatively high rate of access to electricity in Ghana, which reflected a conscious policy decision and strategy in Ghana. This was driven by Ghana’s goal to attain universal access to electricity. The research used the unemployment trend to explain government macro fiscal decisions that relate to clean energy financing. There exists evidence of clean energy financing in the electricity market of Ghana valued at a minimum of US$ 222 million. A sound macroeconomic environment is critical to making clean energy financing decisions: the macroeconomic environment affects the risk profile and financing structure of projects seeking funding. Although there was evidence of clean energy financing by indigenous financing firms in Ghana, most of the funding was by bilateral and international funding sources.

The findings from the assessment of the determinants of clean energy financing suggest that two variables could significantly influence clean energy financing in Ghana. These variables are the market and infrastructure factors. The findings on the market factors and enabling infrastructure are consistent with the a priori expectation stipulated.

The total electricity demand in Ghana is expected to increase from an estimated consumption of 21,126 GWh as of 2022 to a projected consumption of 40,452 GWh as of 2030.

The study identified that Ghana is endowed with the resource potential for solar power plant development. The Northern Region of Ghana has the relative highest solar irradiation.

Additionally, Keta, Ada, Mampong, Ashanti Akim, Kwahu, Upper Manya and Fanteakwa are specific areas in Ghana suitable for the development of wind farms. The wind speeds in these areas are more than 5.3 m/s, justifying the siting of power plants. Likewise, Ghana has about 14 potential sites for the development of about 740 MW of small-scale hydro dams

The study identified that Ghana is committed to reduce CO_2 emissions emanating from the electricity sector. The electricity market has the potential of integrating 1,358.8 MW of clean energy.

Even though the study was able to identify an optimal level of clean energy technologies that can be integrated into the electricity market, the energy technologies, excluding the large hydro plants, as a proportion of the total dependable capacity was 13.05 percent, whereas including the large or legacy hydro it amounts to 26.21 percent of the total capacity. However, significant growth of clean energy technologies was emanating from the installation of solar PV, which accounts for 91 percent of clean energy technologies as of 2030. The study also affirmed that CO_2 emissions reduced by 12.84 percent as at 2030. The Energy Sector Forecast Model prepared by the study presented results that suggest weak off-take credit worthiness by the distribution utilities (ECG & NEDCo) attributed to high system losses; power sold being less than power purchased resulting in a sector shortfall; and an electricity tariff that is not cost reflective. The risk identified within the regulated electricity market serves as a constraint for clean energy financing.

The study recommended the following options to improve the clean energy financing system. The components of clean energy financing will be enhanced by:

1. Clean energy financing type of procurement: the adoption and integration of competitive procurement of clean energy technologies should be a requirement in the electricity market. To achieve competitive and affordable electricity tariffs, a transparent cost comparison must form a key aspect for procuring power plants. This, in

turn, forms the basis for selecting the most suitable clean energy financing instrument to fund projects. The MoEn together with the EC and the PURC must enforce and operationalize policy on competitive procurement of energy supply and service contracts.

2. Clean energy financing structure: the risk profile of the off-taker is a key precondition to ascertain the bankability of a project and subsequent clean energy financing decisions. There exists a direct relationship between cost of borrowing and collateral requirement. This is explained by strict compliance of collateral requirements set forth by the central bank.
3. Clean energy financing instruments: these should be expanded to include green bonds listed on the GSE.

The clean energy funding source was expanded to include pension funds to allow project owners to access funds that are not exposed to exchange rate risk. The study further recommends the inclusion of the clean energy payment mechanisms as a separate component that complements the clean energy financing structure. This validates the clean energy financing decision, which is anchored on return of investment and cash flow reliability. The study recommended two options: Comprehensive Affirmative Action for Clean Energy, which recommends 100 percent of payment for clean energy electricity generation; and Partial Affirmative Action, where part payment made for clean energy electricity generation allows adequate funding to meet its operations cost and allows them to service financing secured from investors.

The study also identified that financial institutions engaged in clean energy financing are relying on the existing policies and regulations for traditional finance.

8.3 Conclusion

The conclusion of the study relating to each specific objective is detailed below.

1. The electricity market of Ghana is a multiple buyers' market, which characterises a competitive market structure.
2. The electricity market of Ghana has five principal off-takers classified as regulated market (ECG, NEDCo and EPC) and deregulated market (export and mines & bulk consumers).
3. The study identified the evidence of clean energy financing valued at a minimum of US$ 222 million using financial instruments such as debt, grant and equity to finance the deployment of solar, wind, biomass, hydro and mini grids in the electricity market.
4. A sound macroeconomic environment is critical to making clean energy financing decisions.
5. The market factors and enabling infrastructure are the variables that could significantly influence clean energy financing in Ghana.
6. Electricity demand in Ghana is expected to grow by 91.47 percent to 40,452 GWh by 2030. Ghana has resource potential for the development of solar, hydro and wind electricity power plants.
7. The electricity market has the potential of integrating 1,358.8 MW of clean energy.
8. The study also affirmed that CO_2 emissions will be reduced by 12.84 percent as at 2030.

9. Credit worthiness of the distribution utility was a major risk in attracting clean energy financing in the regulated market.
10. The study revised the components of clean energy financing by introducing clean energy financing type of procurement; clean energy financing structure; expanding clean energy financing instruments to include green bonds listed on the GSE; expanding clean energy funding sources to include pension funds; and, finally, the inclusion of the clean energy payment mechanisms as separate components.
11. The study furthermore identified that financial institutions engaged in clean energy financing rely on the existing policies and regulations used for traditional finance.

8.4 Recommendations

The study, based on the conclusions outlined, recommends the following.

1. In view of the varied risk profile of the electricity market of Ghana, active monitoring and reports on the performance of the various off-takers of power will provide the policy and regulatory authority with a comprehensive oversight on key policy and market development. The adoption and integration of an enhanced market surveillance system as part of the MoEn and Regulatory operations will guide policy and regulatory decisions and reviews. A conscious effort needs to be instituted for coordination among the various actors in the sector as well as periodic data synchronization for policy decisions and reviews.
2. In view of the risk established by the market factors and enabling infrastructure, clean energy financing institutions, developers and

entrepreneurs require technical assistance in structuring a bankable project to attract clean energy financing.

3. To find out how much clean energy technology should be integrated into Ghana's electrical market; in-depth economic and financial research should be performed. It is important to consider the effects of different macroeconomic situations on the viability and longevity of clean energy projects in this research. Establishing a special fund or financial mechanism to protect clean energy projects against market volatility like currency exchange rates and inflation is also recommended. If macroeconomic circumstances turn unfavourable, this fund may give financial assistance or incentives to clean energy entrepreneurs, ensuring the sector's continuous development and stability. In addition to giving tax incentives, subsidies, and guarantees to renewable energy investors, authorities should think about establishing a regulatory framework that promotes such investments. By implementing these measures, Ghana will be better equipped to adapt to the changing macroeconomic landscape and advance the development of renewable energy.
4. Existing and yet to be operational payment mechanisms in markets where there exists revenue shortfall should consider the adoption of a payment mechanism that prioritises the payment of electricity generated from clean energy technologies in the electricity market.

8.5 Policy Actions

1. To improve the market surveillance system in the electricity sector, led by the MoEn, it is recommended to establish closer collaboration between MoEn and the MoF. This collaboration should focus on closely monitoring the progress of clean energy technology development and the overall environment for attracting clean energy financing. This joint effort will help ensure effective oversight of the clean energy sector and create a more conducive environment for financing clean energy projects.

2. Achieving sustainable development in Ghana requires the introduction of standards and methods for improving performance in the electricity market. These standards are meant to be used as guidelines for improving overall performance in this sector. The electricity market can pinpoint areas of concern and take preventative action by measuring results against these standards on a regular basis. The market's dependence on fossil fuels may be lowered by establishing objectives for the adoption of renewable energy sources, which in turn reduce CO_2 emissions. This transition to greener energy helps with environmental sustainability and is in line with international agreements like the Paris Accord. Furthermore, criteria for performance improvement might help spur employment growth in the clean energy industry. Employment possibilities in sectors including production, installation, maintenance, and R&D are created as the industry grows and invests in renewable energy projects. The economy

and society both benefit from this increase in employment opportunities.

3. Annual energy sector planning and modelling based on economic and financial feasibility of implementing electricity projects should augment the existing technical planning undertaken by EC and GRIDCo.

4. The MoEn and ECG should integrate the prioritization of payment of clean energy technologies in the CWM and the sector.

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APPENDIX

Appendix 1.1: Donor Partners Support for Clean Energy Financing in Ghana

Country	Agency	Program	Concept	Amount of support *(numbers in brackets indicate the orginal currency of the support)*	Type of financing	Status	Impact Area	Timelines	GoG Stakeholder / Partner / Implementing Agency	Strategy direction
Denmark	DANIDA	China-Ghana-Zambia South-South Cooperation (SSC) On Renewable Energy Technology Transfer Projects (RETT)	Promote RE technology transfer and expertise exchange between China and Ghana	$ 2.72 Million	Grant	Ongoing	RE	Sept 2014 – Dec 2019	UNDP, Energy Commission, MoEN	IPSMP
TOTAL AMOUNT OF SUPPORT				$ 2.72 Million						
European Union		Affordable energy for agro-business in the Upper West Region	Lower tariffs for target group	$ 5.54 Million € 5 Million	Loans	In preparation	RE	Launch of implementation contracts in 2nd half 2020	MoF, MoFA	IPSMP
European Union		Global Climate Change Action (GCCA+) – Support to NDC)	Supporting roof top solar and biogas installations for public buildings	$ 5.54 Million € 5 Million	Loans	In preparation	RE - solar and biogas	Preparatory study to be launched in Q4 of 2019	Environmental Protection Agency, Energy Commission	IPSMP / ESRP
TOTAL AMOUNT OF SUPPORT				$ 11.08 Million	* NOTE: Amount is only an indicator as figure includes multi country allocations. Therefore, exact amount for Ghana only could be established by estimation					
France	AFD	Transmission network expansion	Strenghten Ghanaian transmission network and build interconnection with Burkina Faso.	$ 179.2 million ($ 173.9 million + € 4.8 million)	Non-sovereign loan + Grant	Ongoing	Transmission	Expected completion in 2020	MoEN, GRIDCo, WAPP	IPSMP / ESRP
France	AFD	Retrofit of Kpong dam	Secure clean generation capacities	$ 55 million (€ 50 million)	Non-sovereign loan	80% complete	RE - hydro	Expected completion in Q2 2020	MoF, VRA	IPSMP
France	AFD	SUNREF Green credit lines	Promote green financing (Energy Efficiency and Renewable Energy) from local banks to SMEs.	$ 37.6 million (€ 34 million)	Non-sovereign loan + Grant	Recruitment of technical team by energy commission ongoing	RE	A first credit line has been signed in July 2019 with CalBank.	Energy Commission	IPSMP
TOTAL AMOUNT OF SUPPORT				$ 283.64 million						
Germany	KFW	Green Credit Line	Credit line via Bank of Ghana to foster investments into RE and EE on household level	$ 22.15 million (€ 20 million)	Loan and TA grant	Contract Negotiations	RE	2020-2025	MoF, Bank of Ghana	IPSMP
Germany	KFW	Government goes Solar	financing of PV installations on public buildings to help them reduce the electricity bills	$ 16.6 - 33.2 million (€ 15 - 30 million)	Loan	Feasibility Studies ongoing	RE	2020-2025	MoEN	IPSMP / ESRP
Germany	KFW	Kaleo I – 17 MW	Construct PV systems in Upper West Region (Lawra and Kaleo) to provide cost-effective and ecologically sensitive electricity for Ghana	$ 25.2 million (€ 22.8 million)	Loan	Contracts are signed. Implementation started in October 2019	RE	2012-2021	VRA	IPSMP

Country	Agency	Program	Concept	Amount of support *(numbers in brackets indicate the orginal currency of the support)*	Type of financing	Status	Impact Area	Timelines	GoG Stakeholder / Partner / Implementing Agency	Strategy direction
Germany	KFW	Kaleo II – ~ 12 MW	Construct PV systems in Upper West Region (Lawra and Kaleo) to provide cost-effective and ecologically sensitive electricity for Ghana	$ 16.6 million (€ 15 million)	Loan	Appraisal	RE	2020-2025	VRA	IPSMP
	GIZ	Renewable Energy and Energy Efficiency in the Public Sector (REEEPublic	Increase use of EE and RE in public buildings	$ 7.75 million (€ 7 million)	Technical assistance	Ongoing	RE, EE	07/2019 - 12/2021	Energy Commission, Energy Foundation, others tbd	IPSMP
		Market entry into RE and EE for the productive sector	Improving the preconditions for the utilization of RE and EE solutions for large electricity consumers in the private sector and for utilties	$ 5.54 Million € 5 Million	Technical assistance	Ongoing	RE	06/2019 - 12/2021	MoEN, Energy Commission, Association of Ghana Industries (AGI)	IPSMP
		TVET for RE and EE - (Reform Partnership)	Improvment of the conditions for the demand-oriented education and further training of the skilled workers needed in the sector	$ 5.54 Million € 5 Million	Technical assistance	Ongoing	RE Capacity	06/2019 - 12/2021	COTVET, Energy Commission, MoEN, Ministry of Education	IPSMP / ESRP
		People's Green Energy	Access to renewable energy solutions for rural communities	$ 4.43 million (€ 4 million)	Technical assistance	Ongoing	RE	10/2019 - 12/2022	MoEN, Small holder Farmers, GIDA , GHS, Private Sector	IPSMP
		RE Project Development Program (PDP)	A regional programme in South East Asia and Sub-Saharan Africa, commissioned and funded by the German Federal Ministry for Economic Affairs and Energy (BMWi) under the German Energy Solutions Initiative that supports German companies in creating successful and context-adaptive business partnerships in foreign markets.	$ 22.4 million (€ 20.25 million) for all the 16 different partner countries as it is a global project	Technical assistance	Ongoing	RE	February 2019 until December 2021	Private sector	IPSMP
		Green Cooling Initiative 2 (GCI II)	Aiming at a reduction of emissions from the cooling sectors, Green Cooling combines three approaches: - promoting natural refrigerants, - maximising energy efficiency, - fostering a sustainable approach to private and commercial energy consumption.	$ 4.43 million (€ 4 million)	Technical assistance	Ongoing	Climate Resilience/ Mitigation	05/2017 - 10/2021	MESTI, Environmental Protection Agency, Energy Commission	IPSMP
		Forest Landscape Restoration through a sustainable wood fuel value chain (FLR)	Reduce deforestation and degradation	$ 4.98 million (€ 4.5 million)	Technical assistance	Ongoing	Climate Resilience	04/2019 - 03/2023	MLNR, MOEN, Forestry Commission, Energy Commission, EPA, IUCN	IPSMP
TOTAL AMOUNT OF SUPPORT				$ 141.7million	* NOTE: Amount is only an indicator as figure includes multi country allocations. Therefore, exact amount for Ghana only could be established by estimation					

Country	Agency	Program	Concept	Amount of support *(numbers in brackets indicate the orginal currency of the support)*	Type of financing	Status	Impact Area	Timelines	GoG Stakeholder / Partner / Implementing Agency	Strategy direction
Germany	Norfund	Investments in Renewable Energy, Green Infrastructure, Financial Institutions, Scalable Enterprises in Food, Agribusiness and Manufacturing sectors, and Funds.	Drive development through investments in private sector opportunities.	N/A (Norfund's assets under management globally: approx $2.5 billion)	Equity, debt, hybrid instruments. Also grant facilities alongside commercial capital, where needed.	Ongoing	Investments in Renewable Energy, Green Infrastructure, Financial Institutions, Scalable Enterprises in Food, Agribusiness and Manufacturing sectors, and Funds	Ongoing	N/A	N/A
		TOTAL AMOUNT OF SUPPORT		$ 2.5 Million						
Spain		Contribution to Scaling Up Renewable Energy in Low Income Countries Program (SREP)	Contribution to Scaling Up Renewable Energy in Low Income Countries Program (SREP)	No amount indicated		Ongoing	RE		AfDB	IPSMP / ESRP
		TOTAL AMOUNT OF SUPPORT		No amount indicated						
Switzerland	SECO	Scaling Up Renewable Energy Program in Ghana (SREP) - Solar PV based Net Metering with battery storage	Increase in number of Net Metered PV customers.	$ 12.5 Million	Grant	Pipeline	RE	Tentative duration 2020 - 2024	AfDB,MoEN, NEDCO, ECG, Enclave Power, Energy Commision, PURC, EPA	IPSMP / ESRP
		Ghana Electricity Sector Support Project (GESSP)	Support to the electricity sector in Ghana	$ 21 million	Grant	Ongoing	Grid and Biomass, Renewable energy	2015 - 2021	MoEN, NEDCO, ECG	IPSMP
		TOTAL AMOUNT OF SUPPORT		$ 33.5 million						
Switzerland	SECO	Access to modern electricity services	Transaction advisory and financing facilitation	$ 3 million in Technical Assistance $ 3.3 millon in financing through partial loan guarantee / $ 350 million in export credit finance	Technical assistance (grant)	Closed in 2018	Off-grid energy access	Closed in 2018	MoEN, EC, Ghana Solar companies, MoEN Self-help Program (SHEP)	IPSMP
			Transaction advisory and financing facilitation	$705,000 in Technical Assistance / Ongoing partial loan guarantee $ 169,000 in feasibility studies	Technical assistance (grant)	2018-2022	Off-grid energy access	2018-2022	MoEN, Energy Commission, Ghana solar services providers and mini-grid developers	IPSMP
		Solar power for water pumping for commercial agriculture	Support commercially-viable farming for nucleus farm and small-holder farmers in northern ghana through solar-diesel hybid energy system	$ 2 million	Grant (50% co-financing with private sector)	Closed	RE	Ended in July 2019	Integrated Water & Development Ghana (IWAD)	IPSMP
		Renewable Energy Integration	capacity building and support to RE	$ 1 million	Technical assistance (grant)	Capapcity building related activities with NEDCO and ECG underway	RE	April 2019 - June 2022	GRIDCo, ECG, NEDCo, RE Developers	IPSMP
		Ghana Power Compact - Energy Efficiency and Demand Side Management Project	Offset demand for electricity by developing improved or new efficiency standards for appliances, encouraging education and more EE use among consumers, investing in more efficient Government buildings, and exploring DDM measures, like converting streetlights to more efficient LED technology.	$ 26 million	Grant		EE		MiDA, ECG, Ghana Standards Authority, MoEN, Min Education, MoF, MMDAs	ESRP
		TOTAL AMOUNT OF SUPPORT		No amount indicated						

Country	Agency	Program	Concept	Amount of support *(numbers in brackets indicate the orginal currency of the support)*	Type of financing	Status	Impact Area	Timelines	GoG Stakeholder / Partner / Implementing Agency	Strategy direction
Multilaterals	AfDB	Sustainable Energy Fund for Africa (SEFA)	Support GoG's efforts to overcome technical, financial, regulatory and institutional barriers to renewable energy growth and scale up RE investments	$ 1.5 Million			RE		MoEN	IPSMP
		Ghana Scaling-up Renewable Energy Programme (SREP) Network reliability, Net Metering (NM), Mini-grids and SHS	Net metering through RE generation	No amount indicated			RE		MoEN (SREP Implementation Unit), Energy Commission, SECO	IPSMP / ESRP
		Ghana Scaling-up Renewable Energy Programme (SREP) - Technical assistance	Increase access to energy through RE	$ 1.5 Million	Preparatory grant facility		RE		MoEN (SREP Implementation Unit)	IPSMP
		TOTAL AMOUNT OF SUPPORT		$ 3 Million						
Multilaterals	UNDP	China-Ghana South-South Cooperation on Renewable Energy Technology Transfer project	The project aims to facilitate the development and transfer of renewable energy technologies (RETs) from China to Ghana along with the support required to make the technologies effective, including training and capacity building, transfer of know-how and best practices.	$ 1.7 million	Grant (Denmark)	• Drafting of RE Master Plan completed. Awaiting Parliament's approval. • 30kW hydropower scheme in Tsatsadu (Volta Region) completed and about to be commissioned. • Other South-South Cooperation partnerships are being finalized for institutional cookstoves. • Partnership between Chinese and Ghanaian companies for development of solar PV industry being explored.	RE	2015-2019	MoEN, Energy Commission	IPSMP
		Institutional Support to the Implementation of the SE4All Action Plan	Institutional support to the Energy Commission (EC) from 2013 to 2017 to implement selected activities in Ghana's Sustainable Energy for All (SEforALL) Action Plan and related energy sector interventions.	$ 0.8 million	Grant (UNDP)	Completed	RE EE, Cooking Solutions	2013-2017	Energy Commission	IPSMP
		TOTAL AMOUNT OF SUPPORT		$ 2.5 million						
Multilaterals		GEDAP	Improve the operational efficiency of the electricity distribution system and increase the population's access to electricity	$ 320 million	Budgetary support	Implementation (winding down in 2020)	EE	Project closing: January 2020	MoEN, ECG	IPSMP / ESRP
		Regional Off-Grid Electrification Project – ROGEP	Increase electricity access of households and businesses.	$ 333 million (of which US$ 150 million IDA for 19 countries (IDA, CTF, DGIF)	Development policy financing	Activa	RE	Approved in 2018 Completion report issued in 2019	MoEN	IPSMP
		ECOWAS - Battery Energy Storage Systems and Synchronization	Increase ECOWAS power system capability to secure synchronous operation and enable renewable energy penetration.	$ 299.8 million	Investment project finance	Under preparation	RE	Target date for approval 2020	ECOWAS	IPSMP
		TOTAL AMOUNT OF SUPPORT		$952.8 million						
		GRAND TOTAL		$1.44 billion	* NOTE: Amount is only an indicator as figure includes multi-country allocations. Therefore, exact amount for Ghana only could be established by estimation					

Appendix 1.2A: Clean Energy Financing Funding Classes and their Requirement

Funding	Geographical Focus	Technology Sector Focus	Type of Investment	Investors of Fund	Type of Financing	Technical Assistance /Grant	Debt Mezzanine	Gurantee/ Insurance	Size of Investment	Total Fund Size	Number of Investors	Target Return	Requirements	Target Impact	Detailed Description Of Funding Process Procedure
DEG: Climate Partnerships	All Countries	Solar, Biomass, Hydro	Grant	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Equity	Grants of up to 200.000 EUR	N/A	N/A	Up to £200,000	N/A	N/A	N/A	**Project Requirements:** 1. the private partner would not implement the project without public support 2. the project is not required by law no funds have been provided for the project from the German federal budget yet and if implementation of the project has not yet started. **Co-funding Requirements** DEG bears up to 50% of the eligible project costs, however, not more than EUR 200,000. The company has to contribute at least 50% of the overall project cost.	Promotion of technologies which reduce greenhouse gas emissions.	The company submits a project proposal to DEG. These can be handed in at any time. DEG assesses eligibility of all submitted project proposals according to defined assessment criteria and makes a first selection. DEG submits selected project proposals to the BMUB for approval. In case of a positive decision, the company and DEG will jointly develop a comprehensive project concept, including a cost calculation and time schedule, on the basis of the project proposal. After positive review, an agreement is concluded between DEG and the company. After contract signing, the implementation phase of the project starts. Disbursements are made on a pro-rata basis in accordance with the progress of the project, cost and time schedule. To this end, the project company regularly prepares interim reports to justify the costs incurred.
Benin: Off-Grid Clean Energy Facility	Benin	Wind, Solar, Biomass, Small Hydro	Grant	MCC – Millennium Challenge Corporation	Equity	Grant size ranges from 100,000 USD (Energy Efficiency projects) to 5 million USD (mini grids)	N/A	N/A	$100,000 to $5 M	N/A	N/A	N/A	Project developers are required to propose already tested and proven concepts and are strongly encouraged to take Gender, Social Impact and Environmental aspects into account in their projects design. Project proposals must be in French. A partnership with local organizations is strongly encouraged. **Co-funding Requirements** Project developers shall contribute between 15 % and 50 % of the project's eligible cost.	N/A	DA
The Renewable Energy Performance Platform (REPP)	Sub-Saharan Africa	Run-of-river Hydro, Solar PV and CSP, Geothermal, Waste to Energy	Results-based finance	United Kingdom Department of Business, Energy and Industrial Strategy (BEIS)	Equity REPP facilitates access to equity investors via its REPP Partner Network. REPP provides Result Based Finance which can be structured in various ways.	The REPP has a Technical Assistance facility to provide soft loans and reimbursable grants to project developers.	REPP facilitates access to debt providers via its REPP Partner Network.	REPP facilitates access to risk mitigation providers via its REPP Partner Network.	$0.2-5 M	70m US$		Concessional and market rates	1. Initial screening 2. Project assessment (technical, financial, environmental, and legal evaluation) 3. Project approval 4. Funding/support agreement 5. KYC and due diligence 7. Funds disbursement 8. Monitoring and reporting	REPP seeks to mobilise private sector development activity and investment in small and medium scale renewable energy projects in sub-Saharan Africa.	**Project Requirements:** 1 – 25MW capacity Hydro, Solar, Wind, Geothermal, Waste-To-Energy, Biomass, Biogas. To apply for support, developers should email info@repp-africa.org or fill in a checklist at: www.repp-africa.org/eligibility-checklist **Co-funding Requirements** Developers are expected to co-fund development costs. When providing Result-Based Finance, the REPP expects co-investments in equity and/or debt.
Global Climate Partnership Fund (GCPF)	Global Spread – Sub-Saharan Africa, Latin America, Caucasus, Asia Pacific	Small Hydro, Wind, Solar, Biomass	Debt	Ministry of Foreign Affairs of Denmark, IFC, Deutsche Bank, FMO, KfW ,Department of Business, Energy & Industrial Strategy (BEIS), Development Bank of Austria (OeEB), responsAbility, Ärzteversorgung Westfalen-Lippe, ASN Bank	Equity	In parallel with the GCPF, a Technical Assistance Facility has been established to provide Technical Assistance (TA), primarily to assist investees of the fund in their development and growth as well as to facilitate new and protect existing investments of te Fund. The TA Facility is sponsored by the German Fedral Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and the Development Bank of Austria (OeEB). Activities which could be funded through the TA FAcility include: Business development support; Technical appraisals of potential initiatives; support fnancial institutions in developing their sustainable energy financing portfolio, including the design of dedicated products; improve the social and environmental management systems (SEMS) of GCPF partner institutions; Market research as well as feasibility studies to enable the start-up and planning phases of potential direct investments.	N/A	N/A	$5-20 M	$305 M	N/A	Market rates	**Project Requirements** Requirements for financial institutions: These include local commercial banks, leasing companies and other selected financial institutions. These should: Be willing to initiate or develop further green energy products (renewable energy or energy efficiency projects resulting in a 20% reduction in CO2 emissions) Have a social and environmental risk management system or be willing to implement one Require financing of between USD 10 m and USD 30 m for on-lending to green energy projects Requirements for direct Investments: GCPF makes direct investments in small-scale renewable energy and energy efficiency projects that are commercially viable and have effective risk management structures in place. Energy efficiency projects: these should improve energy efficiency and/or reduce greenhouse gas emissions of buildings, plants or processes by at least 20%. Renewable energy projects: preferred technologies include small-scale solar PV, mini-hydroelectric projects, onshore wind farms and biomass projects. The following restrictions are in place:	Mitigating climate change by contributing to the enhancement of energy efficiency and the fostering of renewable energies globally. The fund will contribute to the economic and social development of the regions in which it invests.	For financial institutions: Initial Screening (review of Business plan, GCPF Portfolio fit assessment. Due diligence inc. on-site visit, financial Evaluation, risk Analysis and more. Preparation of investement proposal. Investment comitee approval. Preparation of financial closing. Monitoring. For direct Investments: Project sourcing from financial institutions, global/local ESCOs, manufacturers and project developers. Project evaluation: portfolio fit assessment, financial, legal environmental and technical evaluation. Project approval and disbursment. Monitoring and reporting.

Funding	Geographical Focus	Technology Sector Focus	Type of Investment	Investors of Fund	Type of Financing	Technical Assistance /Grant	Debt Mezzanine	Gurantee/ Insurance	Size of Investment	Total Fund Size	Number of Investors	Target Return	Requirements	Target Impact	Detailed Description Of Funding Process Procedure
													Solar photovoltaic and solar thermal projects with a capacity of up to 15 MW are eligible. Projects up to 25MW may be considered on a case-by-case basis. Wind power plants up to 50MW are eligible. Small-scale, run-of-the-river hydro projects with a capacity of up to 15MW and a maximum dam height of 15m are eligible. Projects up to 30MW may be considered on a case-by-case Basis.Biomass generation projects up to 15 MW are eligible, including those using biogas, rice husk, wood waste and municipal solid waste. Projects up to 30 MW may be considered on a case-by-case basis. The investment process for financial institutions ranges from 8 weeks to 4-5 months while for direct investments it highly depends on project size and partners CO-FUNDING REQUIREMENTS When investing directly in Projects, GCPF will co-invest with one or more partners.		
Impact Assets Emerging Markets Climate Fund	East and West Africa	Hydro, Wind, Solar, Biomass	Equity or Debt	Calvert Foundation and Private Investors	Equity	N/A	Flexible structure of repayment. Require collateral	N/A	$0.5-5 M	N/A			The venture must have an innovative, profitable, and scalable approach to increased access to energy, or renewable energy generation. The company must also be operational and a pilot phase has already been completed including proof of concept with regards to technology and business model at local level. The company has the management capacity, human resources and know-how to substantially scale their activities. **Co-funding Requirements** Entrepreneur co-investment.	Increased access to energy or reduce CO2 emissions.	Pre-screening review based on business plan and financial statements, to asses the risk in the business. The review is sent to investment committee for initial approval. Screening phase: legal documentation, collateral, compliance checklist based on the sector. The final term sheet must be approved by the investment committee. Both stage takes up to 4 months.
Scaling Up Renewable Energy in Low Income Countries Program (SREP)	Benin, Ethiopia, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Rwanda, Sierra Leone, Tanzania, Uganda, Zambia	Small Hydro Geothermal Wind Solar Biomass	Grant	Climate Investment Fund	Equity	The SREP employs a programmatic approach that builds off national policies and existing energy initiatives: Covering early-stage risks, Enabling investor-friendly environments, Expanding markets.	N/A	N/A	$1-30 M	$796 M	N/A	N/A	**Project Requirements** Support the national energy objectives and strategic plans approved by the World Bank and financed by one of the Multilateral Banks which manage the CIF (AfDB and IFC)	Increased renewable energy generation, and scale up the deployment of renewable energy solutions in the world's poorest countries to increase energy access and economic opportunities.	Online application form, 3 times a year, and then regular due dligence.
Engie: Rassembleurs d'Energies Solidarity Investment Fund	Sub-Saharan Africa	Small Hydro Geothermal Wind Solar Biomass	Equity or quasi-equity investment.	The ENGIE Group offers its employees in France the opportunity to invest their salary-based savings in the ENGIE Rassembleurs d'Energies solidarity fund - a French savings structure for companies, which invest up to 10% of their assets in socially supportive companies.	Equity Minority holding of up to 40% of shares, average investment period: 5-7 years, Representation on governance bodies.	If required, ENGIE also offers grants and technical support provided by Group employee. Codegaz and Energy Assistance, the two NGOs set up by Group employees, can work alongside entrepreneurs in the context of one-off or more long-term missions.	N/A	N/A	€0.1-1 M	N/A	N/A	N/A	5 investment criteria set by GDF SUEZ Rassembleurs d'Energies S.A.S: The relevance of the solution (product or service quality, distribution network structure and maintenance, reproducibility of the financial model, quality of organizational and management structure, market conditions, etc), Social performance, Environmental performance, Project financial value and maturity, Synergies with the ENGIE Group (Involvement of Business Units and entities at local level, experimentation with new business models, etc.)	Social performance: number of beneficiaries, local job creation, variation in available income, reduction of health risks, improvement of education, access to modern information and communication technologies, greater community self-sufficiency, enhancement of the role of women in society, etc.	Engie leverages the Group expertise to assess investment projects and provide help and support to entrepreneurs throughout the investment period. The selection process has the following steps: The entrepreneur or developer submits their online selection by the teams of Engie Rassembleurs d'Energies. Investment Committee which is held 4 times a year gives the investment agreement on selected projects. Study and closing of investments are led by the teams of Engie Rassembleurs d'Energies. Technical support is provided by Engie Rassembleurs d'Energies and other Engie's Business Units during the set up and the follow-up of the investment project throughout the term of the Investment.
Vantage GreenX Fund	South Africa	Geothermal Hydropower Solar Biomass Wind	Debt	South African Pension Funds	Equity	N/A	Senior debt positions, up to 50% of the debt portion	N/A	$5-50 M	$220 M		Market rates	**Project Requirements** To be eligible, a project must meet Vantage financial and environmental social criteria. **Co-funding Requirements** GreenX will only fund up to 50% of debt.	Aside from financial-economic performance, projects are carefully scrutinized in areas such as corporate governance, environmental impact, social policies and practices to ensure the sustainability of the investment (ESG).	There are 2 main steps in the due diligence process. First, Vantage Capital conducts a preliminary screening based on the basic project information (business plan, financial Model, technical specification and so on) to assess general interest of the Fund This information is presented to the investment committee which decides if a due diligence process should be conducted. Once approved, the second stage includes a full due diligence including site visits, legal and technical due diligence, financial analysis and the creation of a term sheet. It usually takes six months to complete from the idea of financing to the signing of contracts.

Funding	Geographical Focus	Technology Sector Focus	Type of Investment	Investors of Fund	Type of Financing	Technical Assistance /Grant	Debt Mezzanine	Gurantee/ Insurance	Size of Investment	Total Fund Size	Number of Investors	Target Return	Requirements	Target Impact	Detailed Description Of Funding Process Procedure
InfraCo Africa – Sub Sahara Infrastructure Fund	DAC Countries, except South Africa	Small Hydro Geothermal Wind Solar Biomass	Equity	Private Infrastructure Development Group (PIDG), European Government	Equity Provides early stage equity, pre-financial close.	N/A	N/A	N/A	$1-3 M	$72 M	N/A	Market rates	**Project Requirements** InfraCo looks for projects with high potential but low professional project development expertise. The company acts as principal, to the point where projects can be successfully financed and sold to private investors. Eligible companies include: start-ups or greenfield developments; Partly developed/abandoned projects and currently operating companies; Privatised or to be privatised projects/companies and Majority state owned projects where the private sector is to participate in a risk sharing capacity. **Co-funding Requirements** Owners Equity expected.	As a part of PIDG, the results monitoring system reports the expected development impact of InfraCo Africa-supported projects, inclduing the environmental, social, and governeance impact of the project, according to the World Bank guidlines. Specifically, PIDG also measures people, women and below the poverty line population expected to benefit from new/better infrastructure , Job creation, both temporary (construction) and permanent (operations) new Jobs.	The business approval processes consist of the following key stages: (i) Identification of new business opportunities and presentation of a long-list of opportunities to the Board (annually or more often, as appropriate). (ii) Annual presentation of a short-list of priority opportunities to the Board and approval by it (including two high developmental value Opportunities) and circulation to the PIDG. (iii) Approval by the Board of the work plan and budget for development of opportunities on the short-list. (iv) Approval by the Board of a proposal for a sale of InfraCo's interest in a project. (v) Approval by the Board of the final terms of a Sale Transaction.
Catalyst Private Equity East Africa Fund (SME)	East Africa	Small Hydro Geothermal Wind Solar Biomass	Equity	DEG, IFC, Proparco, CDC, AfDB, EIB	Equity Typically the fund will take a majority stake, yet some exceptions occur.	N/A	N/A	N/A	$5-20 M	$125M	N/A	20-25 %	**Project Requirements** Expansion and replacement capital, recapitalizations and pre-IPO Investments 4 to 6 year Investment horizon, with Exits via trade and financial buyers, capital markets and self-redeeming instruments. Target 20% to 25% USD cumulative net Returns. High growth and profitability prospects. compelling Expansion, acquisition and regionalisation opportunities. Strong cash flow characteristics or potential. Financial restructuring or recapitalization requirements.	Catalyst follows the IFC environmental, social and governance investment policies. The fund aims to simulate employment and accelerate economic growth across East Africa by improving access to equity financing for emerging companies.	There are 2 main steps in the due diligence process. First, Catalyst conducts a preliminary screening based on the company information it was sent (Financial statements, annual reports, future busines plan and financial model, etc.) to assess general interest of the fund, this information is presented to the investment comitee which decides if a due diligence process should be conducted. Once approved, the second stages includes a full due dilligence including market analysis, interviews with shareholders, clients, employees, financial analysis, legal and technical due diligence, and the creation of a term sheet. It usually takes 3-4 months to complete from the idea of financing to the signing of contracts.
responsAbility – Energy Access Fund	Sub-saharan Africa	Small Hydro Solar Biomass Geothermal Wind	Equity and quasi-equity	IFC, Shell foundation, EIB	Equity Minority stake	The fund is complemented by a Technical Assistance Facility, which is supported by SECO. The technical assistance aims at strengthening the operational capacity of client companies of the fund in order to ensure sustainable business growth and maximize development impact.	N/A	N/A	$0.5-3M	$30M	N/A	Market rates	**Project Requirements** ResponsAbility looks at various stages of the project life cycle (development, construction and operations) with a particular focus on the development stage. While responsAbility Renewable Energy aims to diversify among a variety of technologies (mainly solar, biomass, wind and hydro), its main focus is on small- to medium-scale low-impact run-of-the-river hydropower. ResponsAbility Renewable Energy focuses both on attractive and successful renewable energy businesses and on creating prosperity by providing households and businesses with access to basic necessities for further development and improved living standards.	Access to energy to the 1, 3 off grid/lower income population. Environmental, healt and financial benefits for lower-income users. Job creation in the distribution supply chain in various countries across Africa and Asia.	N/A
Danish Climate Investment Fund (KIF)	Nigeria, Ghana, Kenya, Egypt, South Africa	Small Hydro Geothermal Wind Solar Biomass	Equity	Denmark	Equity Minority stake 20%	TA available side by side	Mezzanine investments follow the same guidelines as equity investment, as long as it is below 10 years. IFU customizes each investment	N/A	€2-50M	€180M	N/A	12% net IRR	**Project Requirements** Renewable energy generation in all technologies. There must be a Danish company involved, either in the developer or the project. **Co-funding Requirements** Prefer a consortium of share-holders so there will be a shared due diligence, with an emphasis on local investor industrial co-investor or local financial institution.	KIF measures impact based IFC guidelines.	The due diligence process follows 2 stages: Initial screening focused on partner country and general merit of the of project. First stage is about a month and ends in approval in board meeting. The second stage is proving due diligence of all the information, including a site visit. The full process can take 6-12 months until disbursement.
Proparco FISEA : Invest and Support Fund for Businesses in Africa	Sub-Saharan Africa	Small Hydro Geothermal Wind Solar Biomass	Equity	AFD	EQUITY Minority equity investments, either indirect (in other investment funds) or direct (in banks, microfinance institutions, businesses and infrastructure projects).	A grant of €5M has been earmarked for technical assistance to companies in its investment portfolio.	N/A	Own equity and additional investors - Proparco will only take a minority stake.	€1-10M	€250M	N/A	Market rates	**Project Requirements** The activity financed must be mainly located in Sub-Saharan Africa, the recipient entity must be managed by a skilled and experienced team. The financed project must be sustainable. The project must have a convincing business plan and be profitable in the medium term. The recipient entity must comply with international	Proparco's objective is in line with AFD's strategic orientations and the priorities of the French cooperation policy: To promote the emergence of a dynamic, innovative and responsible private sector in developing and emerging countries, which contributes to building sustainable economic growth, job creation, the provision of essential	Client Reliability: All financing decisions are based on an in-depth analysis of the various risk factors (financial, legal and technical) related to its client and its project: Reliability of accounts, quality of in-house governance, etc. Proparco also assesses the capacity of the companies it finances to withstand and recover from potential shocks (resilience), which is essential to

Funding	Geographical Focus	Technology Sector Focus	Type of Investment	Investors of Fund	Type of Financing	Technical Assistance /Grant	Debt Mezzanine	Gurantee/ Insurance	Size of Investment	Total Fund Size	Number of Investors	Target Return	Requirements	Target Impact	Detailed Description Of Funding Process Procedure
													environmental, social and anti-money laundering standards. FISEA's financial exit is conceivable in the long term.	goods and services and, more generally, to poverty reduction and the fight against climate change. Proparco excludes certain production sectors and activities (IFC exclusion list).	ensuring that its investments are relevant and viable. The application must be submitted to a Proparco or AFD local office or to Proparco's headquarters. The project is put before the Identification Committee of Proparco. Once the Committee has granted approval, the person in charge of the appraisal analyzes the application with the project promoters to ensure it complies with various criteria (financial, technical, legal, environmental and social, anti-money laundering), then puts the project before a Project Committee. The allocation decision is made by FISEA's Chairman after he has obtained advisory opinions from FISEA's Investment Committee, which is mainly made up of independent members and AFD members. The duration of the entire appraisal process varies depending on the complexity and maturity of the project, between 2 and 6 months.
Vital Capital II	Sub-Saharan Africa except South Africa	Small Hydro Geothermal Wind Solar Biomass	Equity	Private Investors	EQUITY Vital Capital prefers majority equity stake in the investment.										
FMO Infrastructure Development Fund/ Direct Investment	Sub-Saharan Africa	Small Hydro, Geothermal, Wind Solar, Biomass	Debt and Equity	Dutch Ministry of Development Cooperation	EQUITY Up to 25% of the equity portion of the project.	There are various TA and capacity development windows available from FMO side by side to investment. FMO can support some early-stage project developers secure grant and seed capital for structuring feasible and bankable projects through SNV and FMO grant schemes.	Senior debt positions, up to 50% of the debt portion	N/A	€5-50M	€362M	N/A	20-25% for equity, 15-20% for debt	**Project Requirements** To be eligible, a project must meet FMO's financial and environmental social criteria. **Co-funding Requirements** FMO will only fund up to 25% of the equity required or 50% of debt. As such developers should bring co-investors and provide some portion of the equity. Local banks are prefered as partners. To assess eligibility, FMO reviews investment plans, market analyses, due diligence studies, expected returns and the commitment level of management and co-financiers. To complete an investment, FMO requires proper project documentation including business plan, signed PPA, signed construction and EPC agreements, and other legal project documentation and EIA reports.	Aside from financial-economic performance, projects are carefully scrutinized in areas such as corporate governance, environmental impact and social policies and practices to ensure the sustainability of the investment (ESG).	There are two main steps in the due diligence process. First, the asset manager conducts a preliminary screening based on the basic project information (business plan, financial model, technical specification and so on) to assess general interest of FMO. This information is presented to the investment committee which decides if a due diligence process should be conducted. Once approved, the second stages includes a full due diligence including site visits, legal and technical due diligence, financial analysis and the creation of a term sheet. It usually takes six months to complete from the idea of financing to the signing of contracts.
DfID Impact Fund	Sub-Saharan Africa	Small Hydro Geothermal Wind Solar Biomass	Equity	UK Government	EQUITY A minority stake in the company.	N/A	N/A	N/A	$5-15M	$82M	N/A	Market rates	By helping existing impact investors to secure demonstrable social impact with their money and encouraging greater commitments to impact investment, more enterprises will be created or strengthened with more poor people having access to jobs, incomes and affordable goods and services suited to their needs.	N/A	N/A
DEG Feasibility Study Financing	Sub-Saharan Africa	mall Hydro Geothermal Wind Solar Biomass	Grant	German Ministry for Cooperation and Development (BMZ)	Grant	DEG will finance feasibility studies intended for the preparation of realistic investments, in particular those related to new technology, processes and services in developing countries. The study can be completed or supported by qualified external consultants with proven professional competency in the sectors related to the project. The feasibility study must be completed within 12 months and costs are reimbursed in two stages.	N/A	N/A	Up to €200K	Revolving	N/A	N/A	Requirements for receiving the grant include: The project being assessed must be financially viable and fit the development requirements of DEG. The feasibility study must support a future investment in the project, that is suitable for DEG.The company must have the capacity to follow up on the study, if it is positive, and continue to develop the project The feasibility study would not be carried out if public funding wasn't available. EG provides a maximum of 50% of the costs for each feasibility study. The proposing company bears a minimum of 50% of the costs for the study and is responsible for its orderly implementation	DEG follows the IFC Performance Standards and the stipulations of the Environmental, Health and Safety Sector Guidelines of the World Bank Group. Projects should have a developmental impact that follows DEG prioirities, for example: securing and creation of jobs, goods for basic needs, climatic and environment protection, introduction and elevation of standards, broad and structural effects, sustainability, and others	The application should include: Financial description of the proposed investment which the study supports, details on the development impact of the project, the costs and operational plan for the study, financial statements of the company. Once the application form is completed along with all the required documentation, DEG will typically review and reply within 6 weeks.

Funding	Geographical Focus	Technology Sector Focus	Type of Investment	Investors of Fund	Type of Financing	Technical Assistance /Grant	Debt Mezzanine	Gurantee/ Insurance	Size of Investment	Total Fund Size	Number of Investors	Target Return	Requirements	Target Impact	Detailed Description Of Funding Process Procedure
DEG Upscaling	Sub-Saharan Africa	Small Hydro Geothermal Wind Solar Biomass	Re-payable Grant	German Ministry for Cooperation and Development (BMZ)	Grants	If the venture is not successful, the funds will be viewed as a grant and do not need to be repaid.	The funding should be dedicated towards scaling up operations and helping projects reach financial close. If the venture is successful, the funds must be repaid within 5 years (with no interest) based on pre-defined financial criteria such as cash flow, revenue or profit.	N/A	€500K	Revolving	N/A	Market rates	The SME must have an innovative and scalable business approach with a high developmental impact. The company must also be operational and a pilot phase has already been completed including proof of concept with regards to technology and business model at local level. The planned investment generates positive returns. The company shows high growth potential owing to the size of the market and the target group. The company has the management capacity, human resources and know-how to substantially scale their activities. **Co-funding Requirements** DEG will commit a maximum of 50% of the total investment volume. The entrepreneur must contribute a substantial share of equity (at least 25%).	DEG follows the IFC Performance Standards and the stipulations of the Environmental, Health and Safety Sector Guidelines of the World Bank Group. Projects should have a developmental impact that follows DEG prioirities, for example: securing/creation of jobs, goods for basic needs, climatic/environment protection, introduction/elevation of standards, broad and structural effects, sustainability, and others. The full DEG environmental and social requirements can be found here.	After the application form and supporting documents are submitted, DEG performs an initial screening to asses the general fit of the investment and decide if to begin a due diligence process. This stage should take approximately 6 weeks. The due diligence comprises a rigorous appraisal of the company and its potential. The full information is submitted to DEG credit committee for decision. The full process should take 3-6 months, depending on the quaility of the information the company submits.
GuarantCo	Sub-saharan Africa	Small Hydro Geothermal Wind Solar Biomass	Guarantee	Governments (UK, NL, Swiss) KfW, FMO, SBSA, Standard Charter	Equity	N/A	N/A	GuarantCo can provide up to 100% cover but this will only be available in limited circumstances and when dictated by the market. Typically, the financing covered by a guarantee will be up to three times the size of the guarantee (30% to 70% cover), although this can be significantly more for securitisation transactions. GuarantCo can cover debt and subordinated or mezzanine financing but not equity.	$10-40M	$300M	N/A	Commercial Rates (minus political risk)	GuarantCo will support the construction of new facilities or the expansion or refurbishment of existing facilities. In addition, GuarantCo can support the refinancing of existing facilities where cross border debt is replaced by local financing. **Co-funding Requirements** Local financial institutions should be part of the transaction.	GuarantCo follows IFC ESG principles. GuarantCo aims to support the development of capital markets while supporting infrastructure projects that promote economic growth and reduce poverty, benefit broad-based population groups, address issues, of equality and participation, promote social, economic and cultural rights.	GuarantCo has a flexible investment approval process, comprising three stages: Initial review and submission by FMFM to New Business Committee. Due diligence and negotiation of a term sheet by FMFM with the client, followed by submission to Credit Committee and Board.
OFID – Energy Poverty Program	Sub-Saharan Africa (without Nigeria and Gabon)	Small Hydro Wind Solar Biomass	Grant	OPEC	Equity	Grants of up to 50% of project value.	N/A	N/A	$0.1- 2M	N/A	N/A	N/A	**Project Requirements** Innovative Business Models for Energy Access. **Co-funding Requirements** N/A	Increase access to electricity for energy poverty populations.	N/A
Energy and Environment Partnership South & East Africa	Botswana, Burundi, Kenya, Lesotho, Mozambique, Namibia, Rwanda, Seychelles, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe	Solar PV Solar thermal Geothermal Biomass, Waste-to-energy Solid biomass Wind power Waste to energy Hydropower Cookstoves Biogas Biofuels liquids Energy Efficiency A combination of the above	Grants	Ministry of Foreign Affairs of Finland (lead donor), The Austrian Development Agency (ADA) and the UK DFID, Nordic Development Fund	Equity	EEP Africa is a trust fund providing early stage grant, repayable grants and catalytic financing to innovative clean energy projects, technologies and business model	N/A	N/A	$0.2-1 M	$60 M	N/A	N/A	**Applicant Requirements** EEP Africa aims to fund Private companies including start-ups; non-profit and social enterprises; Research Institutes. All applicants must be registered legal entities. Individuals and mainstream government entities e.g. government ministries and national/provincial/district departments are not eligible. **Project Requirements** EEP Africa provides funding to Feasibility Studies or Pilot, Demonstration, Replication, or Scale-up Projects. All proposed projects should be aligned with national development planning, including the Nationally Determined Contributions (NDCs), of the country of operations, as well as with EEP Africa's cross-cutting objectives: climate change, poverty reduction, development effectiveness, inclusive development, gender equality and human rights. **Co-funding Requirements** The EEP Innovation Window considers financing requests in the range of EUR 200,000 — 1,000,000 with a progressive co-financing share of minimum 30% of the total project budget. Financing requests below EUR 500,000 will in most cases be treated as a grant. Any amount of financing exceeding EUR 500,000 will automatically be considered as a repayable grant and require a minimum 50% co-financing share.	The immediate objective for EEP Africa is to enhance development, investment and access to clean energy in the Southern and East Africa region with particular focus on impacting and benefiting poor and underserved groups.	The timeline, specific eligibility criteria and application guidelines are specific to each call for proposal. In principle, any type of organization can participate; excluding government entities' (e.g. ministries) and individuals. The project duration is between 6 and 24 months. An applicant has to register and submit the application form online. Submitted applications are evaluated and selected projects have to submit a full proposal. Applications can only be submitted during the announced call for proposals with detailed guidelines and forms published online, together with the call for proposals. Calls for proposals are published continuously and need to be reviewed regularly online.

Appendix 1.2B: Clean Energy Financing Requirement by Local Commercial Banks in Ghana

Bank requirement		
item	**Bank A**	**Bank B**
1	Updated request Letter indicating the amount, purpose of the facility and proposed duration of the facility	Formal letter from Sponsor with request for financing;
2	Company profile detailing; a. your shareholders, b. directors, c. management structure, d. profile of key management personnel, e. operational structure, etc.	Certificate of company incorporation and good standing with the authorities (for Vendor and/or Sponsor, i.e. end-user)
3	The submission of the Form 3, Certificate to Commence Business, Certificate of Incorporation, ID cards of the directors and shareholders and the company regulations	Audited accounts of the Sponsor (one year);
4	Submission of valuation reports over proposed collateral	Background information of Sponsor’s management team, company profile and documentation on banking relationships;
5	Audited Financials for 2018, 2019, 2020 and 2021 Management Account	Financial model containing financial projections of revenues of the project, detail on cost components (O&M, CAPEX, taxes and financing assumptions);
6	Bank Statement for at least six (6) months from other banks. (Full disclosure on existing banking relationships.)	Credit analysis of the Sponsor;

7	Soft copy of Cashflow projections with key assumptions	Credit analysis of the end-user(s) to be served by Sponsor in instances where Sponsor will be delivering power to other off-takers (i.e. in case of mini-grids and PayGo installation of solar home systems) (including a credit bureau report where possible for commercial/industrial off-takers);
8	Aging analysis for both payables and receivables	Collateral that would be provided by the Sponsor, with report from Collateral Registry showing that collateral offered is not encumbered;
9	Tax Clearance Certificate	Equipment supplier/Vendor/EPC – Confirmation of creditworthiness and proven equipment supply and O&M support agreement.
10	Detailed Project description including breakdown according to contracts executed.	
11	Details of suppliers/ manufactures	
12	Project Cost and financing plan for the project	
13	Copy of existing contracts (where applicable)	
14	A list of your current suppliers (where applicable)	
15	Such additional information as the Bank may reasonably request	

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants														
Plant	**Fuel Type**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Large Scale Renewable (Hydro Power Plants)														
Akosombo	Hydro	1020	1020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020
Kpong	Hydro	160	160	160	160	160	160	160	160	160	160	160	160	160
Bui	Hydro					400	400	400	400	400	400	404	404	404
Sub-total of Hydro Power Plants		**1,180**	**1,180**	**1,180**	**1,180**	**1,580**	**1,580**	**1,580**	**1,580**	**1,580**	**1,580**	**1,584**	**1,584**	**1,584**
Grid Connected Thermal Power Plants														
Takoradi Power Company (TAPCO)	LCO / NG / Diesel	330	330	330	330	330	330	330	330	330	330	330	330	330
Takoradi International Company (TICO)	LCO / NG / Diesel	220	220	220	220	220	220	330	340	340	340	340	340	340

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants

Plant	Fuel Type	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Tema Thermal 1 Power Plant (TT1PP)	LCO / NG / Diesel	110	110	110	110	110	110	110	110	110	110	110	110	110
Tema Thermal 2 Power Plant (TT2PP)	NG / Diesel		49.5	49.5	49.5	49.5	49.5	49.5	49.5	80	80	87	87	87
Cenit Energy Ltd	LCO / NG	0			110	110	110	110	110	110	110	110	110	110
Kpone Thermal Power Plant	Oil / DFO								220	220	220	220	220	220
Ameri Plant	NG					0	0	0	250	250	250	250	250	250
Takoradi T3	NG					132	132	132	0	0	0	0	0	0
Osagyefo Power Barge	NG					125	0	0	0	0	0	0	0	0
Sunon Asogli Power (Ghana) Ltd 1	NG		200	200	200	200	200	200	200	200	200	200	200	200
Sunon Asogli Power (Ghana) Ltd 2	NG								180	360	360	360	360	360
Karpowership	HFO							250	250	470	470	470	470	470
Trojan	Diesel / NG								25	44	44	44	0	44
Mines Reserve Plant (MRP)	NG / Diesel	80	80	80	80	40	80	80	80	0	0	0	0	0
Amandi	NG / LCO											203	203	203
AKSA	HFO										370	370	370	370

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants														
Plant	**Fuel Type**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Cenpower	LCO / Diesel										360	360	360	360
Early Power / Bridge	NG/LPG												144	144
Genser (Grid Connected)	NG/LPG										22	22	22	22
Sub-total of Grid Connected Thermal Plants		**740.0**	**989.5**	**989.5**	**1,099.5**	**1,316.5**	**1,231.5**	**1,591.5**	**2,144.5**	**2,514.0**	**3,266.0**	**3,476.0**	**3,576.0**	**3,620.0**
Thermal Embedded Generation														
Genser (Embedded)	NG / LPG					5	0	0	20	22	73	73	73	133
Sub-total of Embedded Thermal Plants		**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**	**0.0**	**20.0**	**22.0**	**73.0**	**73.0**	**73.0**	**133.0**
Sub-total of Thermal Plants		**740.0**	**989.5**	**989.5**	**1,099.5**	**1,321.5**	**1,231.5**	**1,591.5**	**2,164.5**	**2,536.0**	**3,339.0**	**3,549.0**	**3,649.0**	**3,753.0**
Renewable Energy														

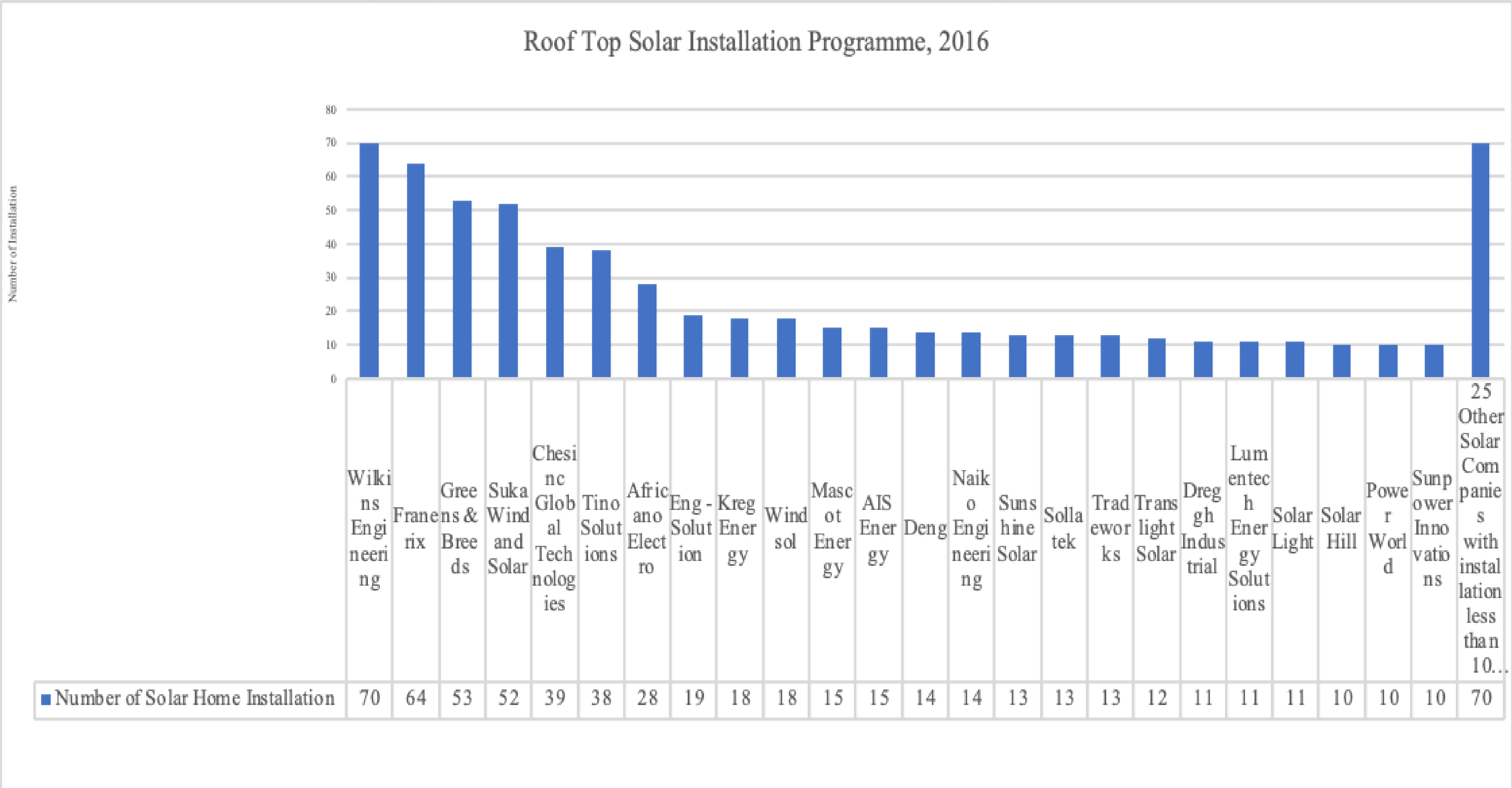
Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants														
Plant	**Fuel Type**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Embedded Renewable Energy Plants														
VRA Solar (Navrongo)	Solar					2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
VRA Solar (Lawra)	Solar												6.54	6.54
VRA Solar (Kaleo)	Solar													13
BXC Solar	Solar							20	20	20	20	20	20	20
Meinergy	Solar										20	20	20	20
Safisana Biogas	Waste to Energy (Biogas)							0.1	0.1	0.1	0.1	0.1	0.1	0.1
Tsatsadu Hydro	Hydro												0.045	0.045
Sub-total of Embedded Renewable Energy Plants		**0**	**0**	**0**	**0**	**2.5**	**2.5**	**22.6**	**22.6**	**22.6**	**42.6**	**42.6**	**49.185**	**62.185**
Roof Top Renewable Energy Installation														
Distributed Solar PV	Residential Solar Roof Top & C&I					0.4946	0.9374	1.6375	4.2638	8.5297	17.9703	24.4408	30.9198	30.9198

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants														
Plant	**Fuel Type**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Sub-total Roof Top Renewable Energy Installation		**0**	**0**	**0**	**0**	**0.4946**	**0.9374**	**1.6375**	**4.2638**	**8.5297**	**17.9703**	**24.4408**	**30.9198**	**30.9198**
On-grid Renewable Energy Plants														
Bui Solar	Solar												10	51
Sub-total on-grid connected RE		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**10**	**51**
Mini-grid (Off - grid) Renewable Energy Plants														
Wayokope (GoG)	Solar							0.03	0.03	0.03	0.03	0.03	0.03	0.03
Atigagorme (GoG)	Solar							0.0405	0.0405	0.0405	0.0405	0.0405	0.0405	0.0405
Kudorkope (GoG)	Solar							0.054	0.054	0.054	0.054	0.054	0.054	0.054
Perdiatorkope (GoG)	Solar							0.05	0.05	0.05	0.05	0.05	0.05	0.05
Aglakope (GoG)	Solar							0.054	0.054	0.054	0.054	0.054	0.054	0.054

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants														
Plant	**Fuel Type**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
MOEN (GoG)	Solar							0.0275	0.0275	0.0275	0.0275	0.0275	0.0275	0.0275
Black Star (Private)	Solar								0	0.0583	0.0583	0.0583	0.0583	0.0583
Wind	Wind							0.011	0.011	0.011	0.011	0.011	0.011	0.011
Sub-total of mini-grid (off-grid) RE Plants		**0**	**0**	**0**	**0**	**0**	**0**	**0.267**	**0.267**	**0.3253**	**0.3253**	**0.3253**	**0.3253**	**0.3253**
Off-grid Renewable Energy Plants														
Solar (Off-grid)	Solar						1.35	5.3527	6.591	7.26943	7.42444	7.42444	7.42444	7.42444
Wind (Off-grid)	Wind							0.02	0.02	0.02	0.02	0.02	0.02	0.02
Sub-total Off-grid Renewable Energy		**0**	**0**	**0**	**0**	**0**	**1.35**	**5.3727**	**6.611**	**7.28943**	**7.44444**	**7.44444**	**7.44444**	**7.44444**
Total Renewable Energy Power Plants	Solar, Hydro, Waste to Energy (Biogas), Wind	0	0	0	0	2.9946	4.7874	29.8772	33.7418	38.74443	68.3401	74.8105	97.8746	151.875
Total Electricity		**1,920.00**	**2,169.50**	**2,169.50**	**2,279.50**	**2,904.49**	**2,816.29**	**3,201.38**	**3,778.24**	**4,154.74**	**4,987.34**	**5,207.81**	**5,330.87**	**5,488.87**

Appendix 1.3: Installed Capacity of Grid Connected and Off Grid Electricity Generation Plants														
Plant Power Plants (All In)	Fuel Type	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total Electricity Power Plants (Excluding Off -Grid))		1,920.00	2,169.50	2,169.50	2,279.50	2,904.49	2,816.29	3,201.11	3,777.97	4,154.42	4,987.01	5,207.49	5,330.55	5,488.55
Total Electricity Power Plants (Excluding Off -Grid & Embedded Generation)		1,920.00	2,169.50	2,169.50	2,279.50	2,896.99	2,813.79	3,178.51	3,735.37	4,109.82	4,871.41	5,091.89	5,208.36	5,293.36

Appendix 1.4: Roof Top Solar Installations (2016)



Appendix 1.5: Details of Energy Demand Drivers – Business as Usual

Details of Energy Demand Drivers – Business as Usual-Residential

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Residential	7,933.4	8,602.8	9,298.3	10,020.2	10,728.9	11,327.5	11,876.3	12,425.6	12,969.2
Urban	5,781.6	6,205.5	6,654.2	7,128.9	7,594.3	8,085.6	8,604.1	9,151.2	9,705.2
Metro Urban	3,025.5	3,247.7	3,482.0	3,729.1	3,969.8	4,223.3	4,490.3	4,771.3	5,055.0
Cooking	18.5	16.8	14.8	12.5	12.7	12.8	12.9	13.0	13.1
Lighting	741.3	784.2	828.4	873.8	896.1	918.4	940.6	962.7	982.3
Refrigeration	1,086.2	1,165.4	1,249.1	1,337.8	1,435.2	1,538.3	1,647.2	1,762.4	1,879.6
Space cooling	144.0	168.4	194.7	223.0	253.1	285.4	319.8	356.6	394.8
Water heating	22.5	27.0	31.8	37.1	42.6	48.6	55.0	61.8	69.0
Clothes Washing	19.6	23.4	27.4	31.7	36.3	41.3	46.5	52.2	58.1
Dish Washing	3.0	3.9	4.9	5.9	7.1	8.3	9.7	11.1	12.6
Air circulation	227.4	242.1	257.6	273.9	290.8	308.6	327.3	346.9	366.7
TV	139.6	151.5	164.1	177.6	191.7	206.8	222.8	239.7	257.1
Miscellaneous	623.5	665.2	709.3	755.8	804.1	854.9	908.4	964.8	1,021.7
Other Urban	2,756.0	2,957.8	3,172.2	3,399.9	3,624.5	3,862.3	4,113.9	4,379.9	4,650.3
Cooking	8.7	8.9	9.1	9.3	9.5	9.7	9.9	10.1	10.3
Lighting	1,096.6	1,155.1	1,216.0	1,279.4	1,330.8	1,383.5	1,437.8	1,493.6	1,547.3
Refrigeration	552.3	620.4	694.8	775.8	862.9	957.4	1,059.7	1,170.2	1,286.6
Space cooling	9.6	11.6	13.8	16.1	18.6	21.2	24.0	26.9	30.0
Water heating	3.0	3.6	4.3	5.0	5.8	6.6	7.5	8.4	9.3
Clothes Washing	2.7	3.2	3.8	4.3	4.9	5.5	6.2	6.9	7.7
Dish Washing	0.7	0.9	1.1	1.3	1.5	1.7	2.0	2.3	2.6
Air circulation	314.6	331.2	348.6	366.6	385.1	404.3	424.2	445.0	465.5
TV	182.8	193.2	204.1	215.4	227.1	239.2	251.9	265.1	278.3
Miscellaneous	585.1	629.6	676.7	726.6	778.4	833.1	890.7	951.3	1,012.8
Rural	2,151.8	2,397.3	2,644.1	2,891.2	3,134.6	3,241.9	3,272.2	3,274.4	3,264.0
Coastal	546.3	575.9	605.6	635.3	664.0	692.4	720.2	723.4	723.9
Electrified HH	546.3	575.9	605.6	635.3	664.0	692.4	720.2	723.4	723.9

Forest	1,011.7	1,150.4	1,289.7	1,429.0	1,566.2	1,568.1	1,567.9	1,565.5	1,557.2
Electrified HH	1,011.7	1,150.4	1,289.7	1,429.0	1,566.2	1,568.1	1,567.9	1,565.5	1,557.2
Savanna	593.8	671.0	748.8	827.0	904.4	981.4	984.1	985.4	982.9
Electrified HH	593.8	671.0	748.8	827.0	904.4	981.4	984.1	985.4	982.9

Details of Energy Demand Drivers – Business as Usual-Services

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Services	3,748.7	4,031.0	4,319.8	4,615.1	4,916.9	5,224.8	5,539.0	5,859.1	6,185.0
Formal	3,748.7	4,031.0	4,319.8	4,615.1	4,916.9	5,224.8	5,539.0	5,859.1	6,185.0
Offices	404.5	412.6	420.8	429.1	437.4	445.8	454.3	462.8	471.3
Government	141.0	144.6	148.4	152.2	156.1	160.1	164.2	168.4	172.7
Private	263.5	268.0	272.5	276.9	281.4	285.7	290.1	294.4	298.6
Lodging	362.1	378.3	395.2	412.6	430.7	449.4	468.8	488.9	509.7
Hotels	245.9	257.3	269.0	281.2	293.9	307.0	320.7	334.8	349.5
Budgets	90.9	94.2	97.6	101.2	104.9	108.6	112.6	116.6	120.8
Guest Houses	5.7	5.8	5.9	6.1	6.2	6.4	6.5	6.6	6.8
Hostels	19.6	21.1	22.6	24.1	25.7	27.4	29.1	30.8	32.6
Health Facilities	347.5	359.5	371.9	384.8	398.0	411.7	425.8	440.4	455.4
Hospitals	234.6	243.2	252.1	261.4	270.9	280.8	291.0	301.6	312.6
Poly_Clinics	55.2	57.0	58.8	60.7	62.7	64.7	66.8	68.9	71.1
MatHealth Centres	44.1	45.1	46.0	47.0	47.9	48.8	49.8	50.7	51.6
Others	13.6	14.2	15.0	15.7	16.5	17.3	18.2	19.1	20.1
Educational facilities	716.2	794.2	875.5	960.1	1,048.3	1,140.1	1,235.6	1,335.0	1,438.3
Tertiary	524.3	597.4	673.6	753.3	836.4	923.1	1,013.6	1,107.8	1,206.0
Secondary	68.6	69.0	69.3	69.5	69.7	69.9	70.0	70.1	70.1
TechVoc	11.1	11.4	11.8	12.1	12.5	12.8	13.2	13.5	13.9
Basic	112.1	116.4	120.8	125.2	129.7	134.2	138.9	143.5	148.3
Special	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Retail Facilities	649.4	752.0	856.4	962.4	1,069.8	1,178.3	1,287.9	1,398.1	1,508.8
Accra Shopping Mall	179.5	176.3	172.9	169.3	165.6	161.6	157.5	153.1	148.6

Other Shopping Malls	288.3	377.8	469.1	561.9	656.2	751.7	848.3	945.7	1,043.7
Supermarket	95.6	111.5	127.7	144.2	160.9	177.8	194.9	212.1	229.3
Cold stores	13.1	14.0	14.9	15.9	16.8	17.7	18.7	19.6	20.6
Others	73.0	72.4	71.7	71.1	70.3	69.5	68.6	67.6	66.6
Restaurants and Eateries	279.4	297.6	316.3	335.3	354.7	374.5	394.5	414.8	435.3
Restaurants	117.0	133.0	149.6	166.8	184.5	202.7	221.4	240.7	260.3
Chop bars etc	162.4	164.6	166.7	168.6	170.3	171.8	173.1	174.1	175.0
Others	233.6	227.7	221.7	215.8	209.9	203.9	198.0	192.0	186.1
Electricity all uses	233.6	227.7	221.7	215.8	209.9	203.9	198.0	192.0	186.1
Street lighting	756.0	809.0	862.0	915.0	968.0	1,021.0	1,074.0	1,127.0	1,180.0
Electricity	756.0	809.0	862.0	915.0	968.0	1,021.0	1,074.0	1,127.0	1,180.0
Informal	-	-	-	-	-	-	-	-	-
Electricity all uses	-	-	-	-	-	-	-	-	-

Industry

	2022	2023	2024	2025	2026	2027	2028	2029	2030
Industry	6,499.7	7,008.9	7,480.3	8,035.2	8,486.2	14,943.5	17,443.5	17,913.3	18,390.4
Water production	434.4	493.5	552.5	611.6	670.6	729.7	788.7	847.8	906.8
Water production	434.4	493.5	552.5	611.6	670.6	729.7	788.7	847.8	906.8
Electricity	434.4	493.5	552.5	611.6	670.6	729.7	788.7	847.8	906.8
Mining and Quarrying	4,040.1	4,255.9	4,435.3	4,699.3	4,889.0	5,085.1	5,323.8	5,532.1	5,747.1
Gold	3,998.7	4,172.2	4,351.8	4,537.5	4,729.6	4,928.2	5,133.4	5,345.4	5,564.2
AGC Obuasi mines	1,197.3	1,300.8	1,409.2	1,522.6	1,641.2	1,765.1	1,894.5	2,029.5	2,170.3
Surface gold	2,801.4	2,871.4	2,942.6	3,014.9	3,088.4	3,163.1	3,238.9	3,315.9	3,393.9
New underground	-	-	-	-	-	-	-	-	-
manganese	15.1	14.7	14.2	13.8	13.4	12.9	12.5	12.1	11.6
Electricity all uses	15.1	14.7	14.2	13.8	13.4	12.9	12.5	12.1	11.6
diamonds	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Large scale	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Small scale	-	-	-	-	-	-	-	-	-
bauxite	-	41.3	40.2	117.6	114.5	111.4	144.4	140.3	136.2
electricity all uses	-	41.3	40.2	117.6	114.5	111.4	144.4	140.3	136.2
quarrying	23.3	24.8	26.1	27.3	28.5	29.5	30.4	31.3	32.0

electricity all use	23.3	24.8	26.1	27.3	28.5	29.5	30.4	31.3	32.0
salt	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8
Large scale	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.8	0.8
Small scale	-	-	-	-	-	-	-	-	-
Iron	-	-	-	-	-	-	-	-	-
Limestone	-	-	-	-	-	-	-	-	-
Construction	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3
Building Construction	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3
Electricity all uses	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.3
Road Construction	-	-	-	-	-	-	-	-	-
Electricity all uses	-	-	-	-	-	-	-	-	-
Manufacturing	2,023.8	2,258.1	2,491.1	2,722.9	2,925.2	9,127.3	11,329.5	11,532.0	11,735.1
formal	2,023.8	2,258.1	2,491.1	2,722.9	2,925.2	9,127.3	11,329.5	11,532.0	11,735.1
Pig Iron Production	-	-	-	-	-	-	-	-	-
Steel Production	-	-	-	-	-	-	-	-	-
Steel Milling	58.4	68.9	79.4	89.8	98.5	107.3	116.0	124.7	133.4
Clinker Production	-	-	-	-	-	-	-	-	-
Cement Milling	176.7	232.5	286.7	339.3	390.5	440.0	488.0	534.5	579.4
Alumina Production	-	-	-	-	-	6,000.0	8,000.0	8,000.0	8,000.0
Gold refinery	-	-	-	-	-	-	-	-	-
Textiles	84.8	94.6	104.2	113.6	122.7	131.5	140.2	148.5	156.6
Plastics	83.6	83.2	82.7	82.3	81.8	81.4	80.9	80.4	79.9
Wood processing	140.8	148.2	155.3	162.2	168.1	173.8	179.2	184.5	189.6
Beverages	110.3	125.2	139.8	154.0	162.8	171.5	179.8	187.9	195.8
Food processing	296.8	346.0	394.0	440.8	473.4	505.1	535.8	565.7	594.6
Paper and Paper Products	72.5	84.6	96.4	107.9	115.8	123.5	131.0	138.2	145.2
Chemicals and chemical products	113.4	132.3	150.7	168.7	181.1	193.2	204.8	216.2	227.1
Lubricating oils	1.8	2.0	2.1	2.3	2.5	2.6	2.8	3.1	3.3
Fabrication of metals	50.5	54.5	58.5	62.5	66.5	70.5	74.5	78.5	82.5
Other	834.2	886.2	941.2	999.6	1,061.4	1,127.0	1,196.4	1,269.9	1,347.7

VALCO, Agriculture and Transport

	2022	2023	2024	2025	2026	2027	2028	2029	2030
VALCo	2,889.9	2,880.9	2,868.9	2,854.0	2,836.1	2,815.4	2,791.6	2,765.0	2,735.4
Electricity for smelting	2,889.9	2,880.9	2,868.9	2,854.0	2,836.1	2,815.4	2,791.6	2,765.0	2,735.4
Agriculture	41.3	51.5	62.4	74.0	86.3	99.3	113.1	127.6	142.8
Irrigation	18.1	23.5	29.8	36.7	44.4	52.8	62.0	71.9	82.6
Net Irrigation	18.1	23.5	29.8	36.7	44.4	52.8	62.0	71.9	82.6
Electric pumps	18.1	23.5	29.8	36.7	44.4	52.8	62.0	71.9	82.6
poultry	22.8	27.4	32.0	36.6	41.1	45.7	50.3	54.8	59.4
poultry farms	22.8	27.4	32.0	36.6	41.1	45.7	50.3	54.8	59.4
electric all uses	22.8	27.4	32.0	36.6	41.1	45.7	50.3	54.8	59.4
Land ploughing	-	-	-	-	-	-	-	-	-
Tractor_EV	-	-	-	-	-	-	-	-	-
Crop harvesting	-	-	-	-	-	-	-	-	-
Harvester_Electric	-	-	-	-	-	-	-	-	-
post harvest processing	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
driers	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
electricity	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
Fishing	-	-	-	-	-	-	-	-	-
Inland	-	-	-	-	-	-	-	-	-
Canoe_Electric	-	-	-	-	-	-	-	-	-
Transport	13.5	15.0	16.6	18.3	20.1	22.0	24.1	26.3	28.7
Passenger	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-
Intracity	-	-	-	-	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-
Electric train	-	-	-	-	-	-	-	-	-
Freight	13.5	15.0	16.6	18.3	20.1	22.0	24.1	26.3	28.7
Road	-	-	-	-	-	-	-	-	-
Local	-	-	-	-	-	-	-	-	-
Rail	-	-	-	-	-	-	-	-	-
Electric Train	-	-	-	-	-	-	-	-	-

Pipelines	13.5	15.0	16.6	18.3	20.1	22.0	24.1	26.3	28.7
Crude oil Pipeline	1.7	1.9	2.0	2.2	2.4	2.6	2.8	3.0	3.3
Petroleum products pipeline	11.8	13.1	14.5	16.0	17.7	19.4	21.3	23.3	25.4
Road Transport Detailed	-	-	-	-	-	-	-	-	-
Passenger Cars	-	-	-	-	-	-	-	-	-
Electric	-	-	-	-	-	-	-	-	-
Light Commercial Vehicles	-	-	-	-	-	-	-	-	-
Electric	-	-	-	-	-	-	-	-	-
Heavy Duty Vehicles	-	-	-	-	-	-	-	-	-
Electric	-	-	-	-	-	-	-	-	-
Urban Buses	-	-	-	-	-	-	-	-	-
Electric	-	-	-	-	-	-	-	-	-
Motorcycles	-	-	-	-	-	-	-	-	-
Electric	-	-	-	-	-	-	-	-	-

Appendix 1.6: Research Matrix

Specific Objective	Dominant Variables	Data Type and Sources	Data Collection Method	Data Processing	Data Analysis: Framework of Analysis	Data Analysis: Techniques of Analysis
1. To describe the state of clean energy financing and sustainable development in Ghana.	Electricity market of Ghana	Data Type: Electricity Market Data Source: Primary Data & Secondary Data	Quantitative data from secondary sources (Energy Commission, Ghana Grid Company Ltd-GRIDCo Ministry of Energy and Public Utilities Regulatory Commission-PURC)	Excel combined with SPSS	Description	Descriptive Statistics
	Clean energy technologies in the electricity market of Ghana	Data Type: Clean Energy technologies Data Source: Primary Data & Secondary Data				
	Sustainable development • Entrepreneurial participants in clean energy & Skills Development, Access to electricity, Employment and Economic Development Sustainable development indicators in the electricity market of Ghana • CO_2 emission, energy per capita, electricity tariffs, payment obligations of government, access to electricity and Energy use per unit of Efficiency, Fuel shares in GDP, Supply energy and electricity, Renewable energy share in electricity market of Ghana	Data Type: Sustainable development indicators Data Source: Primary Data & Secondary Data				
	Evidence of clean energy financing and financing institutions in Ghana	Data Type: clean energy technology Data Source: Primary Data & Secondary Data				

Specific Objective	Dominant Variables	Data Type and Sources	Data Collection Method	Data Processing	Data Analysis: Framework of Analysis	Data Analysis: Techniques of Analysis
2. To assess the determinants of clean energy financing in Ghana.	Policy and regulations (Regulatory uncertainty and Contractual)	Data Type: Policies and Regulations Data Source: Primary Data & Secondary Data	Data Request & quantitative responses from Project development and financiers	Excel and SPSS	Correlation	Binary Logistic Regression Analysis
	Local administrative capacity (Licensing and permitting, Land acquisition and Strict local content requirements)	Data Type: Local Capacity Data Source: Primary Data & Secondary Data				
	Revenue (Energy purchase, Volume, Measurement, reporting and verification, Contract renegotiation and Price)	Data Type: Revenue Data Source: Primary Data & Secondary Data				
	Enabling infrastructure (Evacuation infrastructure and Grid flexibility)	Data Type: Infrastructure Data Source: Primary Data & Secondary Data				
	Technology (Technology maturity and Performance)	Data Type: Technology Data Source: Primary Data & Secondary Data				
	Market (Interest rate and Exchange Rate)	Data Type: Market Data Source: Primary Data & Secondary Data				
	Financing (Availability of appropriate finance)	Data Type: Financing Data Source: Primary Data & Secondary Data				

Specific Objective	Dominant Variables	Data Type and Sources	Data Collection Method	Data Processing	Data Analysis	
					Framework of Analysis	Techniques of Analysis
3. To estimate an optimal level of integrating clean energy in the electricity market of Ghana.	Least Cost of Energy	Data Type: generation cost of power plants to meet current and future demand in Ghana	Secondary Data from (Energy Commission, Ghana Grid Company Limited - GRIDCo, Ministry of Energy and Public Utilities Regulatory Commission-PURC, Energy Sector Recovery Programme)	Long-Range Energy Alternatives Planning (LEAP) model Clean Energy Emission Reduction tool (CLEER) Excel	Optimization	Modelling
		Data Source: Secondary Data				
	Energy Security	Data Type: Current and Future Peak demand of energy				
		Data Source: Secondary Data				
	Environmental Sustainability (Low CO_2 Emissions)	Data Type: CO_2 Emissions by power plants				
		Data Source: Secondary Data				

<table>
<tr><th rowspan="2">Specific Objective</th><th rowspan="2">Dominant Variables</th><th rowspan="2">Data Type and Sources</th><th rowspan="2">Data Collection Method</th><th rowspan="2">Data Processing</th><th colspan="2">Data Analysis</th></tr>
<tr><th>Framework of Analysis</th><th>Techniques of Analysis</th></tr>
<tr><td rowspan="6">4. To synthesize an improved system of clean energy financing for enhanced sustainable development in Ghana.</td><td rowspan="2">Components of the clean energy financial system
a. Off-Grid Financing
b. On-Grid Financing
i. Commercial Banks
ii Investment Banks
iii Pension Funds
iv Private Equity
v Donor Funds from Development Partners</td><td>Data Type: Actors within the clean energy finance system</td><td rowspan="6">Data Request
&
Solicit quantitative responses</td><td rowspan="6">Excel</td><td rowspan="6">Synthesis</td><td rowspan="6">System Improveme nt</td></tr>
<tr><td>Data Source: Primary Data and Secondary Data</td></tr>
<tr><td rowspan="2">Actors within the clean energy financial system
a. Economic Regulators
b. Technical Regulators
c. Supervisory Authority - Ministry of Energy, Environment & Finance
d. Central Bank
e. Securities and Exchange Commission
f. Clean Energy Association
g. Standards Authority
h. Ghana Stock Exchange</td><td>Data Type: Policy framework of clean energy system</td></tr>
<tr><td>Data Source: Primary Data and Secondary Data</td></tr>
<tr><td rowspan="2">Standards for clean energy technologies
a. Hardware: Specifications
b. Software: tools and skills
Processes for Standards</td><td>Data Type: Specifications of clean energy finance system</td></tr>
<tr><td>Data Source: Primary Data and Secondary Data</td></tr>
</table>

Appendix 1.7: Research Instrument

CLEAN ENERGY FINANCING AND SUSTAINABLE DEVELOPMENT:

EVIDENCE FROM THE ELECTRICITY MARKET OF GHANA

You have been invited to take part in an academic research survey. Before you commence to provide responses, please take time to read the following information carefully.

WHAT IS THE RESEARCH ABOUT?

Ghana signed on to the Paris Agreement following COP 21(21st Conference of the Parties - COP) and subsequently affirmed its commitment to reduce CO2 and other greenhouse gas emissions by issuing its policy directive called the Nationally Determined Contribution (NDC). Ghana has set renewable energy targets to aid its energy transition and achievement of low carbon emissions by 2030.

It is unequivocal that the electricity sector of Ghana forms an integral part of the actions under the NDC and a major sector for Ghana to achieve her climate goals. While the electricity sector is an engine growth for industrialization, it is material to note that the sector significantly contributes to the sustainability of development.

The primary objective of this study is to analyse clean energy financing, and to synthesize an improved system of clean energy financing system for sustainable development in Ghana.

The study is purely academic-oriented, as such the researcher would like to assure you that your responses would not be used for any other purpose other than those stated before.

For the purposes of improving the quality of the study, we humbly request you to take your time to read and understand the items on this instrument before you respond to them.

WHAT DOES MY PARTICIPATION IN THE RESEARCH INVOLVE?

You will be asked to answer a series of questions exploring your beliefs, opinions, and views about clean energy financing and sustainable development in Ghana.

WHY HAVE I BEEN CHOSEN?

This survey is aimed at professionals aged 18 and above who meet at least one of the following criteria:

1. Expert scientific knowledge of clean energy financing and sustainable development issues in Ghana
2. Relevant professional experience in clean energy finance in Ghana
3. Relevant professional experience in electricity market in Ghana and in the renewable energy sector in Ghana.

WHAT WILL HAPPEN TO MY PERSONAL INFORMATION IF I TAKE PART IN THE SURVEY?

Your identification as a participant in this survey will be classified and by treated as anonymous. Once the survey is completed, all participants' details will be pseudonymised to "Respondent 1", "Respondent 2", "Respondent 3" etc, and all information will be deleted and removed from our records. All information that is collected about you during the course of the research will be kept on a password protected database and is strictly confidential. Any identifiable information you may give will be removed and anonymised.

HOW WILL THE COLLECTED DATA BE STORED?

The data that is collected will be stored and secured in line with all relevant privacy laws in Ghana (Data Protection Act, 2012, Act 843)

WHAT WILL HAPPEN AFTER I COMPLETE THE SURVEY?

The information you provide in this survey will be analysed and will be used to produce research output(s). The research findings may also be published in scientific journals or presented at academic conferences or similar events. These findings will also be available on the world wide web and made accessible to all participants upon request. Your participation is greatly valued. Your responses will not only contribute to developing academic knowledge but will also aid to synthesize an improved system of clean energy financing for enhanced sustainable development in Ghana.

WHAT IF I AGREED TO TAKE PART AND LATER CHANGE MY MIND?

You can withdraw from the study at any time, without giving a reason. If you wish to withdraw after having completed the survey and submitted your responses, please let us know and we will immediately withdraw you and your responses from the research and permanently delete all information related to you from our records.

WHAT IF I HAVE A COMPLAINT?

The lead researcher conducting this study is Jeffrey Kenneth Baiden, PhD student at the Institute of Development and Technology Management affiliated to the University of Cape Coast. If you have any complaints, please contact the study lead by email at jkbaiden@gmail.com.

DATA COLLECTION APPROACH

Data Collection will be undertaken using a three progue approach

1. Approach 1: Questionnaire
2. Approach 2: Information Request fact Sheet
3. Approach 3: Interview Questions

Approach 1: Questionnaire

SECTION A

Background of Respondent

What is your Profession/Occupation/Position	Option	
	Developer/ Entrepreneur	
	Strategic Partner / Investor	
	Energy Consultant	
	Financier	
	Individual	
	End User	
	Other	

If Respondent is an Individual, State the Gender of the Respondent	Option	
	Male	
	Female	
	Prefer not to disclose	

How many years have you been working as the option selected above	Option	
	1 to 5 years	
	6 to 10 years	
	11 to 15 years	
	Above 15 years	

If the Respondent is an entrepreneur, can you give an estimate of the people working in your firm	Less than 5 employees	
	5 to 29 employees	
	30 to 99 employees	
	100 and more employees	

SECTION B- Determinants of Clean Energy Financing in Ghana

>> Based on the respective scales provided, kindly circle a number that best represents your opinion on each statement. *Using a scale of 0 to 10; where 0=strongly disagree; to 10= strongly agree; to what extent do you agree or disagree with the statements.*

Policy and regulations Factors	0	1	2	3	4	5	6	7	8	9	10
Is regulatory uncertainty a challenge in Ghana's energy sector											
Do you perceive unexpected, retroactive or frequent changes in law/regulation affect clean energy financing in Ghana											
Risk allocation between parties is not optimal or unclear in financing or developing clean energy in Ghana											
The process of contracting renewable energy service companies (installers) in Ghana is very transparent.											
Local administrative capacity Factors	0	1	2	3	4	5	6	7	8	9	10
It is expensive to procure a land for clean energy projects.											
Overlapping permits, fragmented ownership and unregistered land come with a lot of complications.											
The local content requirements for clean energy project approvals are very high in Ghana.											
What is your recommended share of local content ownership											
Revenue Factors	0	1	2	3	4	5	6	7	8	9	10
There are delays in the payment for power, fuels or energy services by counterparty, which is often related to the overall financial performance of the counterparty.											
These factors can affect the financials of a clean energy company: Load curtailment, low demand, underperformance of technology.											
Lack of maintenance, meteorological variations can affect the operations of a clean energy plant.											
There is establishment of a reliable baseline and processes for measuring, reporting and verifying energy savings.											
The electricity market in Ghana is exposed to variable wholesale market pricing with limited ability to manage price fluctuations with hedging instruments.											

Enabling infrastructure Factors	0	1	2	3	4	5	6	7	8	9	10
It is difficult to connect to the national grid or a local grid.											
The national grid is not capable of accommodating variability in electricity generation sources.											
The national grid is not capable of accommodating variability in electricity demand.											
Power purchase agreements have flows, which can lead to unreliable dispatch or affect provision of electricity services.											
There exists a secondary market through net metering mechanism to sell excess energy to the grid in Ghana.											
Technological factors	0	1	2	3	4	5	6	7	8	9	10
There is uncertainty over the performance of clean energy technologies traded in Ghana without a track record and wide demonstration at a global level.											
Technicians or installs are not familiar with clean energy technologies.											
Financial Institutions in Ghana understand how structure funding instruments for clean energy technologies.											
Clean energy technologies have outputs or performance at less than rated specifications.											
Clean energy technologies have unforeseen maintenance or outages challenges.											
Market Factors	0	1	2	3	4	5	6	7	8	9	10
There are unexpected changes in the interest rate for a loan in Ghana											
Inflation and exchange rate are very unpredictable in Ghana.											
The local capital markets in Ghana are underdeveloped.											
There are currency convertibility restrictions and restrictions to repatriate capital in Ghana.											
The end user tariff for clean energy is expensive for the consumer.											
Clean Energy Financing	0	1	2	3	4	5	6	7	8	9	10
There are limited long-term financing opportunities for clean energy financing.											
There are limited interest rate for clean energy financing											
It is expensive to finance clean energy.											
The local banks in Ghana have limited capacity to conduct due diligence and value projects.											

Other Issues

Please, give any comment on any key issue in respect of the subject matter that you see as relevant but not addressed by the questionnaire………
……
……
……
……………………………………………………………

Approach 2: Information Request Fact Sheet

SECTION A - Clean Energy Financing and Sustainable Development in the Electricity Market of Ghana

This section of the questionnaire sought to describe clean energy financing and sustainable development within the electricity market of Ghana

Metric	**Year**								
Electricity consumption	2013	2014	2015	2016	2017	2018	2019	2020	2021
Consumption									
On-grid installed capacity	2013	2013	2015	2016	2017	2018	2019	2020	2021
Hydro									
Renewables									
Solar									
Wind									
Biomass									
Biogas									
Off-grid installed capacity			2015	2016	2017	2018	2019	2020	2021
Hydro									
Renewables									
Solar									
Wind									
Biomass									

Biogas									

Electricity Generation Capacity			2015	2016	2017	2018	2019	2020	2021
Installed Capacity									
Dependable Capacity									

Clean energy technologies in the electricity market of Ghana

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
No of Clean Technology Developers									
Solar									
Wind									
Biomass									
Biogas									
No of Clean Technology Financial Institutions									
Banks									
Equity									
Donor									
Development Finance Institution									

Sustainable development indicators in the electricity market of Ghana

Metric	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
CO2 emission									
Energy per capita									
Electricity tariffs									
Payment obligations of government									

Access to electricity									
Renewable energy share in energy and electricity									
Energy use per unit of Efficiency									
Fuel shares in GDP									
Supply energy and electricity									

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
No. clean energy financing institutions									
Evidence of Clean Energy Financing (GHC)									

SECTION B - Optimal Level of Integrating Clean Energy in The Electricity Market of Ghana

Assess an optimal level of integrating clean energy in the electricity market of Ghana.

Least Cost of Energy	2015	2016	2017	2018	2019	2020	2021
Generation Cost per Plant							
Future Demand of Energy							
Future Supply of Energy							
Present Demand							
Present Supply							
Energy Security	2015	2016	2017	2018	2019	2020	2021
Current Peak demand of energy							
Future Peak demand of energy							
Environmental Sustainability (Low CO2 Emissions)	2015	2016	2017	2018	2019	2020	2021
CO_2 Emissions by power plants							

SECTION C -The effects of clean energy financing on sustainable development in Ghana

Metric	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Growth in Entrepreneurial participants in clean energy (%)							
Growth in Skills Development or Human Capital for clean energy (%)							
Access to affordable energy source							
Women empowerment and job creation (No. Women employed)							
Wealth Creation (income)							
Industrial Development (No. clean energy industries created)							

Approach 3: Interview Questions

Background of Respondent

Profession/Occupation/Position	Developer	
	Strategic Partner	
	Energy Consultant	
	Financier	
	Other	
Number of years working in your sector	1 to 5 years	
	6 to 10 years	
	11 to 15 years	
	Above 15 years	

SECTION A: QUESTIONS FOR NON-FINANCIERS

1. What are the types of renewable energy sources used to generate electricity in Ghana?
2. What are some of the most important factors to consider appraising a renewable energy project?
3. How does net metering enhance the credit viability of renewable energy project?
4. What is the process of evaluating the financial viability of a renewable energy project?
5. What is the process of evaluating the technical viability of a renewable energy project?
6. Kindly provide examples of renewable energy project you have supported and provided financing.

7. Kindly describe the financial instruments used to finance the projects
8. Is access to finance a challenge? If so how?
9. Which regulatory license is required to operationalize a renewable energy project in Ghana?
10. Describe your role in process.
11. What is the process of the environmental impact assessment undertaken for renewable energy projects?
12. Were there any estimated cost savings compared to grid connect source?
13. What is your assessment of the regulations and policies related to renewable energy in Ghana?

SECTION B: QUESTIONS FOR FINANCIERS

1. Do you provide debt finance to renewable energy projects in Ghana?

   If YES:
2. What tenor of loans do you provide – Short, Medium or Long term?
3. How do you assess the credit viability of a renewable project?
4. What entails in your contractual agreement for a renewable project loan?
5. Challenges in providing credit financing for renewable projects applicants?
6. Do you build the capacity of loan applicants?