RENEWABLE ENERGY CHALLENGES AND OPPORTUNITIES. THE PROSPECT OF ADOPTING A NEW POLICY AND LEGAL PARADIGM IN GHANA

A thesis submitted for the degree of Doctor of Philosophy in Law

by

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ABSTRACT

Global consumption of fossil fuels has wreaked havoc on the environment through anthropogenic greenhouse gas emissions. Meeting the ever-increasing demand for energy and limiting its impact on the environment are the two intertwined issues that confront the world. Against this backdrop, national and international stakeholders have been called to transition to renewable energy (RE) to provide energy security and stem climate change. As such, governments around the world have been formulating legal and policy frameworks to encourage the deployment of RE along with technological innovations. However, poor legal frameworks and policies, insufficient financial support, and incentives have rendered the adoption of RE technologies, especially in developing countries, woefully inadequate and Ghana is no exception.

In Ghana, various legal and policy frameworks have been deployed for the development of hydro and non-hydro RE. However, the contribution of non-hydro RE (solar and wind) to the country's electricity generation mix is paltry due to various challenges. The research uses desktop analysis, empirical research, and comparative analysis to critically examine the existing Renewable Energy Act, 2011 (Act 832) and policies on RE in Ghana to ascertain the extent to which they effectively address energy security challenges. The results reveal many challenges as follows: a general poor implementation of the provisions of the Act, poor funding, obsolete grid network, transmission and distribution losses, and bureaucratic processes in licence acquisition to be responsible for the paltry diffusion of non-hydro RE in Ghana whose share was 0.3% in 2020. The research recommends that the government of Ghana (GoG) reviews the existing Renewable Energy Act, policies, and regulatory frameworks currently in operation to address deployment constraints. The thesis concludes by calling on the GoG to focus on specific legal and policy frameworks that would promote solar photovoltaic deployment as the country is endowed with abundant solar energy.

Key Words: Ghana; Renewable Energy; Renewable Energy Act, Renewable Energy Policy

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DEDICATION

I dedicate this thesis in honour of my parents, the late Mr Nyimakan Koln and madam Mmoyok Naomi Nyimakan. Though not having formal education, they however spent their meagre resources to send me to school. I would forever remain grateful for this singular gesture that they have bestowed upon me.

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CHAPTER ONE

INTRODUCTION

1.1 Background

Energy is one of the driving forces of the global economy, and most developed countries have explored and exploited it to their benefit. Since the industrial revolution, oil, gas, and coal have provided the primary fuel that drives modern economies' development. This trend has continued to the present day. However, we live in times of great flux as the demand for energy continues to rise, especially this is the case with newly developing countries now seeking new energy wealth. The paradox is that this massive energy demand is happening at a time in the world's history when we have to reduce our carbon emissions caused by fossil fuels and stem the effects of climate change. As such, countries are enquiring and changing to environmentally friendly and sustainable alternatives that are renewable and can sustain the ever-increasing demand for energy. Renewable energy (RE) offers the hope for our sustainable energy future to provide our energy needs and reduce greenhouse gas (GHG) emissions to mitigate climate change and provide energy security (ES). How to reconcile these two often demands is where energy law becomes pivotal. The introductory part of the thesis gives the background of the problem and discusses the purpose of the research. It also covers the aim and objectives, research questions, justification, conceptual framework, scope, literature review, contribution to knowledge, sustainable development, research methodology, and the layout of the thesis.

There has been an increase in the demand for energy to drive economic growth and improve living standards.[1] Humankind initially was dependent on RE from the beginning, but this soon changed in favour of fossil fuels.[2] As mentioned earlier, oil, natural gas, and coal have been the fuels that have driven the growth of the global economy, especially in the developed countries to improve living standards. With an increase in population growth, the demand for fossil fuels will continue to rise.[3] It has therefore become clear that reliance on fossil fuels has caused much havoc to our planetary system and brought in its wake some challenges. Fossil fuels have been responsible for environmental degradation, health hazards, global warming, and climate change. All these are a result of humans' anthropogenic activities, which occur through the burning of fossil fuels which release GHG emissions into the atmosphere, which has brought changes in the weather pattern.[4]

The reality is that the world cannot continue to rely on fossil fuels, even though it has helped propel the global economy, especially in the developed countries, which reflects in high GDP per capita, which has improved the living standards of many people worldwide. The following global issues, such as climate change, ES, depleted fossil fuel sources, and environmental

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[1] Iñaki Arto and others, 'The Energy Requirements of a Developed World' (2016) 33 Energy for Sustainable Development 1 <http://dx.doi.org/10.1016/j.esd.2016.04.001> accessed 12 May 2019

[2] Selim Jürgen Ergun, Phebe Asantewaa Owusu and Maria Fernanda Rivas, 'Determinants of Renewable Energy Consumption in Africa' [2019] Environmental Science and Pollution Research 15390 < https://doi.org/10.1007/s11356-019-04567-7> accessed 12 June 2019

[3] XF Wu and GQ Chen, 'Global Primary Energy Use Associated with Production, Consumption and International Trade' (2017) 111 Energy Policy 85 <https://doi.org/10.1016/j.enpol.2017.09.024> accessed 15 July 2019

[4] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri, and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 <https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf> accessed 10 July 2019

degradation, have alerted the world to change trajectory. The above concerns have helped push through law and policy to increase the integration of renewable energy sources (RES).[5] Several studies have demonstrated that fossil fuels have dwindled, and uranium scarcity indicate that there is no going to be cheap energy any longer and this even makes it compelling to consider renewables. Scholars have unanimously agreed that the use of renewables is good for the environment as well as economic and social development.[6]

The International Energy Agency (IEA) in 2007 forecast that RE (solar, wind, wave, geothermal and tidal) with an annual average growth rate of 6.7% is going to be the fastest-growing sector in the energy industry covering the period 2005 to 2030.[7] According to the latest IEA forecast, indeed RE is growing at a fast rate, and, it is forecast that RE generation capacity will rise in 2021 to 290 GW and by 2026 global RE electricity generation is projected to reach over 4,800 GW.[8] Security of energy supply and climate change appear to be some of the driving forces behind RE policies high in the political space of both the individual country and at the international stage which is driving the fast rate.[9] Furthermore, Russia invasion of Ukraine brings to sharp focus, the dangers on the continuous dependence on fossil fuels. Many countries are caught up in the security of supply shortfalls following the imposition of sanctions on Russia which has sent prices for oil and gas skyrocketing in the international market. A time to reflect on focusing on RE adoption which is the panacea to our energy challenge.

In light of these concerns, the world has identified that new alternative energy sources have to be explored to satisfy humans' insatiable demand for energy. The alternative is RE; RE is energy obtained from non-depleting sources.[10] Sources that are sustainable and can provide ES and help stem climate change. RES include biomass, wind, ocean energy, hydropower, solar, geothermal, and waste-to-energy. However, meeting the energy needs of their citizens without compromising economic growth and the environment has become a herculean task for governments worldwide.

Many strategies have been deployed to aid the change from a conventional regime to a non-conventional one. Renewable energy technologies (RETs) are emerging to help in the switch, but these technologies alone cannot ensure the successful deployment and development of RE, and this is where the law comes to the fore.[11] The law is therefore needed to establish the technologies and provide them with the enabling environment in which they can function successfully to boost investors' confidence. In the developing countries, law and policy have just begun to gain thrust, and a growing number of countries have set RE targets to increase

[5] Raphael J Heffron and Kim Talus, 'The Evolution of Energy Law and Energy Jurisprudence: Insights for Energy Analysts and Researchers' (2016) 19 Energy Research and Social Science 1 <http://dx.doi.org/10.1016/j.erss.2016.05.004> accessed 12 August 2019

[6] Ortzi Akizu-Gardoki and others, 'Decoupling between Human Development and Energy Consumption within Footprint Accounts' (2018) 202 Journal of Cleaner Production 1145<https://doi.org/10.1016/j.jclepro.2018.08.235> accessed 10 September 2019

[7] International Energy Agency, 'World Energy Outlook 2007' (IEA, 2007) < http://projects.mcrit.com/foresightlibrary/attachments/World_energy_outlook_2007.pdf> accessed 10 October 2019

[8] International Energy Agency, 'Renewable Electricity Growth is Accelerating Faster than ever Worldwide, Supporting the Emergence of the New Global Energy Economy' (IEA, 1 December 2021) <https://www.iea.org/news/renewable-electricity-growth-is-accelerating-faster-than-ever-worldwide-supporting-the-emergence-of-the-new-global-energy-economy> accessed 19 March 2022.

[9] Romain Mauger, 'The Voluminous Energy Transition Legal Framework in France and the Question of Its Recognition as a Branch of Law' (2018) 122 Energy Policy 499 <https://doi.org/10.1016/j.enpol.2018.08.013>.accessed 16 August 2019

[10] Ghana's Renewable Energy Act, 2011 (Act 832).

[11] Thomas Von-Danwitz, 'Regulation and Liberalization of the European Electricity Market – A German View' (2006) 27 Energy Law Journal 423 <http://www.eba-net.org/assets/1/6/7-423-450.pdf> accessed 16 June 2019

their generation.[12] As such, many countries across the globe have formulated RE strategies and policies that would help in the deployment and development of RE. In the developed world, there are already well-established laws and policies on RE that have been implemented to increase their integration into their energy mixes.[13]

Some of the many of such policies include feed-in tariffs (FIT), renewable portfolio standard (RPS), mandatory green power option (MGPO) fuel generation disclosure requirement, retail choice, and public benefits fund. In developing countries, the creation of legal frameworks both in terms of regulation and policy has just begun, as earlier mentioned, and this is seen in the literature. The setting of targets is a trend that is gaining currency as this has caught the attention of many scholars. In addition, the literature on renewable energy law and policy is building more scholarly works that contribute to the much bigger energy law as a whole.

Like any other African country south of the Sahara, Ghana is endowed with both conventional and RES, and this gives the country the opportunity to explore and exploit these resources to ensure ES and to support economic activities in the country.[14] Yet, Ghana has experienced numerous challenges in electricity generation and supply in recent times.[15] This situation led to calls by Ghana's development partners, industry experts and concerned citizens for the government to explore other viable options which include off-grid energy systems and to invest in green or clean energy to expand its generation mix.[16] This led the government to explore the addition of non-hydro RE into the energy mix and set a target of incorporating a 10% share of solar or wind into the national electricity generation mix in the year 2020 which was missed.[17] Official estimates from the Ministry of Energy of Ghana states that the government will have to invest about US $1 billion in RE from 2012 to 2020 in order to achieve the target.

The government went ahead to demonstrate its commitment to incorporating RE into the energy mix by enacting Ghana's Renewable Energy Act, 2011 (Act 832) (RE Act).[18] The Act required that 10% of the energy generated should come from RES (excluding wood fuels and large hydro) in the year 2020.[19] The government then kicked-in its action plan in 2012 to attract more than US $1 billion from private investors for eight years to the target year 2020. Despite these interventions, it was revealed in a study conducted by Obeng-Darko that Ghana was

[12] Kaveri K Iychettira, Rudi A Hakvoort and Pedro Linares, 'Towards a Comprehensive Policy for Electricity from Renewable Energy: An Approach for Policy Design' (2017) 106 Energy Policy 169 <http://dx.doi.org/10.1016/j.enpol.2017.03.051> accessed 9 October 2019

[13] Emmanuel Hache and Angélique Palle, 'Renewable Energy Source Integration into Power Networks, Research Trends and Policy Implications: A Bibliometric and Research Actors Survey Analysis' (2019) 124 Energy Policy 23 <https://doi.org/10.1016/j.enpol.2018.09.036>.accessed 1 July 2019

[14] NDPC, 'Ghana Shared Growth and Development Agenda (GSGDA) 2010-2013 Volume 1: Policy Framework Final Draft Government of Ghana' (2013) I 2010 <http: eeas.europa.eu/delegations/ghana/documents/eu_ghana/ghana_shared_growth_and_development_agenda-en.pdf> accessed 12 September 2019

[15] Isaac Malgas and Anton Eberhard, 'Hybrid Power Markets in Africa: Generation Planning, Procurement and Contracting Challenges' (2011) 39 Energy Policy 3191 <https://doi.org/10.1016/j.enpol.2011.03.004> accessed 10 October 2019

[16] Leslie Nsakie-Kassim, 'Ghana Needs Nuclear Now!' (Energygh blogspot, 8 April 2011) <http://energygh.blogspot.com/2011/04/ghana-needs-nuclear-now.html> accessed 17 September 2019

[17] Energy Commission of Ghana, 'Strategic National Energy Plan 2006-2020: Main Report' (EC, July 2006) <http://www.energycom.gov.gh/files/snep/MAIN REPORT final PD.pdf>.accessed 10 June 2019

[18] Ghana's Renewable Energy Act, 2011 (Act 832).

[19] ibid

only able to achieve 0.5% in 2017 out of the 10% target set for 2020, and he concluded that the country was set to miss its target.[20]

In light of this development, the thesis has set forth to investigate what has gone amiss since the launching of the Strategic National Energy Plan in 2006, the National Energy Plan in 2010, the enactment of the RE Act, the regulatory frameworks and other policy interventions in the RE subsector in Ghana. The thesis will critically examine government policies to ascertain their effectiveness in addressing ES. After reviewing the existing legal instruments, the work will probe further to see whether a policy shift or modification is needed. The research has become necessary to appraise the RE legal regime to see whether it is on course to meet the objectives set to address ES challenges. The research also aims to conduct a comparative analysis of RE policies deployed in Australia and Cape Verde to the RE policies of Ghana. Comparison is to identify successful policies that have been implemented in the two jurisdictions and whether Ghana can emulate these successful policies to bring about improvement in the government's quest to develop its RE policies for successful implementation. But the thesis would not be calling for direct policy transplant from one jurisdiction to the other as such transplants do not work due to the socio-economic, political, and cultural differences of each country.[21]

1.2 Background to the Research in the Ghanaian Context

Energy is an essential commodity that plays a significant role in the economic prosperity of any country. Developed nations have exploited it to the benefit of their economies, which has positively impacted the daily lives of their citizens. Energy can be used for many things, including cooking, transport, lighting, heating, and communication. Indeed, energy has become crucial and indispensable in our daily lives in the 21st century. Most developed countries depend on fossil fuels for their energy supply, but fossil fuels have depleted. As of 2000, available statistics estimate that conventional oil reserves will last for 50 years to satisfy global demand whilst gas will meet world consumption for 80 years.[22] Conventional energy sources are not replenishable when compared to other forms.[23] In its 2006 report, the IEA estimated that world demand for energy would increase substantially demanding huge investments to over US $20 trillion to build the infrastructure to meet demand, however, investment in RETs can bring the cost far lower than the estimated cost.[24] Conventional sources have become expensive and associated with GHG emissions widely believed to cause climate change. These concerns have caught the world's attention that action is needed to address the issue.

As such, countries are turning their attention to RES to solve their energy problems and reduce GHG emissions to mitigate climate change and improve their ES. "Renewable energy is energy from naturally replenishing sources and are virtually inexhaustible in duration but

[20] Nana Asare Obeng-Darko, 'Why Ghana Will Not Achieve Its Renewable Energy Target for Electricity. Policy, Legal and Regulatory Implications' (2019) 128 Energy Policy 75 <https://doi.org/10.1016/j.enpol.2018.12.050>.accessed January 2020

[21] Otto Kahn-Freund, 'On Uses and Misuses of Comparative Law' (1974) 37 Modern Law Review 1 <https://heinonline.org/HOL/P?h=hein.journals/modlr37&i=25> accessed 20 October 2019

[22] Michael Jefferson, 'Accelerating the Transition to Sustainable Energy Systems' (2008) 36 Energy Policy 4116 < https://doi.org/10.1016/j.enpol.2008.06.020> accessed 12 October 2019

[23] Michael Carley and Ian Christie. *Managing Sustainable Development* < https://doi.org/10.4324/9781315091525>

[24] International Energy Agency, 'The World Energy Outlook,2006' (IEA, November 2006) < https://www.iea.org/reports/world-energy-outlook-2006> accessed 5 October 2019

limited on the amount of energy available per unit of time".[25] RE is a clean and less polluting source of energy that can solve the problem of dwindling fossil fuels supply and GHG emissions. RE can also save the environment by mitigating climate change. The big test for the RE subsector will be to develop and deploy technology that can compete favourably with the benefits offered by fossil energy which many people regard as reliable and affordable. To this, the sector needs to develop RE infrastructure around the world to power future energy requirement. The infrastructure needed can be built by constructing wind farms, solar farms, and electrical grid upgrades. Being a member of the comity of nations, Ghana has joined the campaign and turned its attention to RES.

Ghana initially relied on hydro from large dams and recently on thermal that uses fossil fuels. However, for two decades on, the country has been experiencing a severe shortfall in generation and supply. Energy generation in Ghana has gone through different phases. It started with diesel generators and stand-alone electricity supply systems owned by industrial mines and factories. The Gold Coast (Ghana's colonial name) Railway administration established the first public electricity generation system in 1914 to provide electricity to run the operations of the railways in Sekondi.[26] Takoradi got electricity in 1928, with further extension to other major cities like Accra, Kumasi, Tema, Tamale, Bolgatanga by Public Works Department (PWD) then in-charge of the electricity sector. Following this period, in 1947, an electricity department was created under the Ministry of Works and Housing, which took over electricity management from PWD and the railways' administration, thus consolidating the two under the new department to coordinate all electricity matters in the Gold Coast. At this early stage of electricity supply and extension, diesel generating plants were those used before independence.

After Ghana gained independence in 1957, the Volta River Authority (VRA) was established in 1961 with the mandate to see to the construction of the Akosombo dam. The country moved to the hydro phase following the construction of the Akosombo Dam in 1965.[27] Then to the thermal phase fired by natural gas or light crude oil and the recent addition of non-hydro RE into the electricity generation mix which excludes the large hydro dams.[28] Up until this point, Ghana had enjoyed reliable, clean, cheap energy mainly generated from hydro sources namely: Akosombo dam, Kpong dam and Bui dam (which has recently come on stream). Demand soon increased from 540 GWh in 1968 to 3917 GWh by 1976.[29] This fell due to some economic shocks but soon picked up again, leading to the construction of the Kpong Dam, which was commissioned in 1982 to augment the existing dam. The Bui dam came on stream in 2012 when the latest round of crisis begun.

The first energy crisis was experienced in 1984 following a prolonged drought in 1983, which brought about low levels of water in the reservoir of the Akosombo dam. The total water inflow into the dam was less than 15% of the needed total.[30] This triggered power rationing even to the neighbouring countries like Togo and Benin, who relied on Ghana for their power supply. Another crisis was re-recorded in 1998, and this was attributed to the poor rainfall pattern,

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[25] U.S. Energy Information Administration, 'Renewable Energy Explained' (U.S IEA, June 2022) <www.eia.gov/energyexplained/?page=renewable_home> accessed 5 January 2023

[26] Ebenezer Nyarko Kumi, 'The Electricity Situation in Ghana: Challenges and Opportunities' [2017] University of Energy and Natural Resources, Sunyani, Ghana 30 < https://www.cgdev.org/sites/default/files/electricity-situation-ghana-challenges-and-opportunities.pdf>. accessed 10 June 2019

[27] Volta River Development Act, 1961 (Act 46).

[28] William Gboney, 'Policy and Regulatory Framework for Renewable Energy and Energy Efficiency Development in Ghana' [2009] Climate Policy <https://doi.org/10.3763/cpol.2009.0636> accessed 10 July 2019

[29] Maame Esi Eshun and Amoako-Tuffour, 'A review of the trends in Ghana's Power Sector'. Energy, Sustainability and Society (2016) <https: doi:10.1186/s13705-016-0075-y> accessed 10 August 2019

[30] ibid

which saw little water accumulated in the Volta Lake, culminating in another power rationing. There was another crisis from 2006 to 2007, which also received the same reasons as the earlier ones as to the causes of the crisis.[31] Another gargantuan one began in 2012 and persisted to 2017. The new crisis is known as 'dumsor' meaning off and on in the local parlance. At this juncture, it became clear that demand had far outstripped supply, and this trend has been on the ascendency over the following years till date.

Ghana, from the outset, developed its energy supply from hydropower, as stated earlier. The hydro dams generated electricity to meet domestic and industrial needs. However, uncertain rainfall patterns diminished the prospects for hydropower as less water was accumulated in the reservoirs of the dams.[32] This means power shortages are inevitable anytime water levels fell. On the other hand, energy demand has risen due mainly to economic growth, urbanisation, population growth, and industrial activities.[33] In 2007, electricity accounted for 9% of the country's energy consumption, and consumption over a decade has since doubled. Another factor is the low tariff regime; this does not allow for full cost recovery, and the generating plants operate at an annual financial loss. As a result, it inhibits capacity expansion leading to a shortage in the generation capacity, which does not meet the growing demand. Furthermore, the country's population is growing at a fast rate of 2.15%, which has implications for energy demand. The population stands at 30,8 million in 2021 which is higher when compared to the population a decade ago.[34] Thus, with increased power demand, for how long can hydroelectric power be depended upon to meet the power needs of the country?

These factors mentioned above have contributed to the country moving from a surplus generation to a deficit. The government, in reaction, then introduced thermal into the energy mix. These plants use natural gas, and they complement hydro. The first of such plants are located at Aboadze, in the country's Western region, and many soon followed at different locations. As observed by Kilinc-Ata, countries with increasing population growth, energy use and energy demand tend to follow traditional energy solutions (fossil fuels) instead of renewables.[35] This is the route the Ghanaian government has taken; thus, the addition of more thermal into the energy mix and now thermal has surpassed hydropower.[36] But the addition of thermal into the energy mix did not solve the problem.

Many factors account for this. As most thermal plants depend on fossil fuels, thus natural gas and light crude oil to burn, they have become expensive and not readily available. Ghana signed a contract with the Nigerian government to deliver gas through the West African Gas Pipeline (WAGP). The gas supply through this deal has not been delivered as expected, and that can be attributed to many factors, which include lack of finance, sabotage, and the Nigerian authority's non-fulfilment of its contractual obligation.[37] Also, the extension of the national grid to the rural areas of the country since the inception of the national electrification scheme in 1988. Furthermore, the transmission and distribution infrastructure has since

[31] Centre for Policy Analysis, 'The Energy Crisis and Growth Performance of the Economy' (CEPA No:15, 2007) < https://searchworks.stanford.edu/view/7873290> accessed 16 July 2019
[32] Eshun and Amoako-Tuffour (n 29).
[33] Samuel Gyamfi, Mawufemo Modjinou and Sinisa Djordjevic, 'Improving electricity supply in Ghana-The potential of renewable energy' (2015) 43 Renewable and Sustainable Energy Reviews <http://dx.doi.org/10.1016/j.rser.2014.11.102> accessed 26 June 2019
[34] Ghana Statistical Service, 'Ghana 2021 Population and Housing Census' < https://census2021.statsghana.gov.gh/> accessed 25 November 2022
[35] Nurcan Kilinc-Ata, 'The Evaluation of Renewable Energy Policies across E.U. Countries and U.S. States: An Econometric Approach' (2016) 31 Energy for Sustainable Development 83 <http://dx.doi.org/10.1016/j.esd.2015.12.006>.accessed 10 May 2019
[36] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022
[37] Mike Fulwood, 'Opportunities for Gas in Sub-Saharan Africa' [2019] Oxford Energy Insight <https://www.oxfordenergy.org> accessed 16 October 2019

deteriorated over time, due to lack of investment and maintenance. The network has become obsolete, adversely affecting the efficient delivery of energy leading to losses in transmission and distribution, which are estimated to be over 34.7%.[38] Ghana will have to improve its grid network infrastructure, expand, and diversify its installed capacity to improve supply and reliability. The above factors have rendered the dependence on large hydro dams and thermal unreliable and insecure. The country has considerable potential in RES, including hydro, wind, solar, biomass, and ocean energy but these resources are left untapped.[39]

Ghana is confronted with many challenges, including a deficit in power generation, ES, and reliance on depleted and expensive fossil fuels. How to meet its international obligation of combating climate change and meeting its commitment to fulfill U.N SDG 7 by 2030 are the issues the country is grappling with.[40] To overcome these challenges, the government initially set a target for itself to integrate a 10% share of non-hydro RE into the electricity generation mix in 2020 which was missed.[41] Ghana has therefore turned its attention to RES such as solar, wind, biomass, biofuel, landfill gas, sewage gas, geothermal and ocean energy. The Strategic National Energy Plan (2006 to 2020), through this policy document, the Government of Ghana (GoG), through the Energy Commission (EC), for the first time, set a target it wanted to achieve when it started to exploit its RES. This target is seen as a vehicle through which government could use to accelerate the utilisation of its RES. The target that was set was to incorporate a 10% share of non-hydro RE into the electricity generation mix in 2020 as stated above.[42]

The RE integration plan will start at 0.05% in 2007 and gradually increased to 10% in 2020, the generation capacities were to come from mini hydro plants, biomass, wind, and solar.[43] The government started to explore these sources to contribute to overcoming the challenges and brought in changes in the energy sector to include non-hydro RE in the electricity generation mix. Like Ghana, other countries have set targets for electricity generation from RES; The E.U. set a target of 20% of electricity to be generated from RES in 2020.[44] In the U.S.A Oregon set a target of 25% of electricity to be generated from RES by 2025.[45]

However, meeting these targets will be difficult without first appraising the existing RE policy instruments and their impact on RE development, as observed by Klinc-Ata.[46] Hence this thesis evaluates the existing RE legislation and policies on RE development in Ghana to ascertain their effectiveness in addressing ES.

With this ambitious target, law and policy will feature prominently in this shift to provide the right environment for the promotion and deployment of RE.[47] The RE Act was therefore enacted to back the government's determination to find the solution to the challenges. These

[38] Energy Commission of Ghana (n 36).
[39] Gboney (n 28).
[40] SDG 7 stands for U.N. Sustainable Development Goal 7.
[41] Non-hydro RE refers to solar, wind, biomass, mini-hydro, waste-to-energy, ocean energy, but excludes hydro from the large hydro dams that Ghana has already exploited.
[42] Energy Commission of Ghana, 'Strategic National Energy Plan 2006-2020: Main Report' (EC, July 2006) <http://www.energycom.gov.gh/files/snep/main report final pd.pdf> accessed 16 June 2019
[43] ibid
[44] Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources.
[45] Magali A. Delmas and Maria J. Montes-Sancho, 'US State Policies for Renewable Energy: Context and Effectiveness' (2011) Energy Policy, Forthcoming, <https://ssrn.com/abstract=1739301> accessed 21 December 2019
[46] Kilinc-Ata (n 35).
[47] Richard L. Ottinger and Fred Zalcman, 'Legal measures to promote renewable and energy efficiency resources' in Adrian J. Bradbrook and Richard L. Ottinger (eds). Energy law and Sustainable Development (IUCN, Gland, Switzerland and Cambridge, UK)

new policies and regulatory frameworks are envisaged to increase the share of non-hydro RE in the country's electricity generation mix. Some of the measures employed include taxes and duty waivers, and subsidies, but these are utilised albeit to a limited extent. Despite these government measures, the problem still lingers, as Sakah and others concluded.[48] The introduction of renewable energy law in China, for instance, witnessed an increase of about 22.16% in RE share in the energy mix for all resources, including hydro.[49]

So, what has gone wrong with the Ghanaian RE law? The enactment of the RE Act was a good starting point. A clear demonstration of GoG's commitment to harness its RES to address ES and climate change challenges, as many countries are yet to enact laws solely for the development of RE. The target that was set was considered achievable. However, the country was bound to miss it, as alluded by the minister of energy.[50] Indeed, the target was missed in 2020 and now shifted to 2030 as concluded by Aboagye and others.[51] So, the questions to ask are: what went wrong with these laudable policies, tools and regulatory frameworks set out in the Act? What are the challenges that the RE subsector is facing? How effective are the laws and policies that have been implemented? Among many guesses about this state of affairs is that the existing legal and policy frameworks are not effective enough to bring about the necessary adoption of RETs. This is because maybe the legal and policy frameworks are too reliant on government budgetary allocation and donor support which are not forthcoming, or the provisions of the RE Act are partially or poorly implemented. Against this backdrop, the thesis sets to investigate and assess whether the legal and regulatory frameworks and policies in place are effective in addressing the challenges.

The literature has centred on either analysing the primary legislation or the policies. However, this thesis seeks to holistically examine the legal regime governing the development of RE in Ghana to ascertain the effectiveness of the policies or otherwise. The contention is that the feed-in tariff is not working as expected and is incapable of expanding RE capacity in the country, which has now been repealed in 2020.[52] Additionally, some provisions of the RE Act have also been ineffective. Efforts have been concentrated on developing and promoting conventional energy sources to overcome the ES crisis to the neglect of RE. As such, RE policies are drawn in a narrow view, framed to serve in a complementary role. This can be gleaned from the government's approach to solving the challenge by introducing more and more thermal into the energy mix and spending millions of cedis building the infrastructure. However, little is spent on RE, and the RE Act is crafted to attract investors, and some of the provisions/policies in the Act are not investor friendly.

1.3 Research Aim and Objectives

The thesis' aim is to critically examine the RE Act and policies in Ghana to ascertain their effectiveness in the development of RE. The objectives are as follows:

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[48] Marriette Sakah and others, 'Towards a Sustainable Electrification in Ghana: A Review of Renewable Energy Deployment Policies' [2017] Renewable and Sustainable Energy Reviews. < https://doi.org/10.1016/j.rser.2017.05.090> accessed 15 June 2020

[49] Yongxiu He and others, 'A Regulatory Policy to Promote Renewable Energy Consumption in China: Review and Future Evolutionary Path' (2016) 89 Renewable Energy 695 <http://dx.doi.org/10.1016/j.renene.2015.12.047>.accessed 01 November 2019

[50] Boakye Agyarko, 'Ghana to Miss the Ten Percent Target' The Business and Financial Times Accra, 5 June 2017)

[51] Bernard Aboagye and others, 'Status of Renewable Energy Resources for Electricity Supply in Ghana' (2021) 11 Scientific African e00660 <https://doi.org/10.1016/j.sciaf.2020.e00660>. 3 March 2022

[52] Ghana's Renewable Energy (Amendment) ACT, 2020 (Act 1045).

Based on the examination, the research wants to critically review the existing legislation and policies on RE in Ghana to ascertain their effectiveness in addressing ES challenges.

To further probe to ascertain whether the existing legislation and policies on RE have stimulated and provided the enabling environment for the development of RES in Ghana.

To conduct a comparative analysis of the RE laws, regulatory measures and policies deployed in Australia and Cape Verde to the RE law and policies in Ghana. The comparative analysis is done to identify successful policies that have been implemented in the two jurisdictions to discuss their possible replicability in Ghana.

To make policy recommendations on specific policy features derived from the results of the comparative analysis of the RE laws and policies of Australia and Cape Verde and to make further recommendations based on the research findings.

1.4 Research Questions

The main question raised in the thesis is:

To what extent do the existing legislation and policies on RE in Ghana effectively address ES challenges?

Specifically, the following supporting questions were considered, the supporting sub questions are:

(i) What main constraints have impeded the successful implementation of the RE Act and policies in Ghana since coming into force in 2011?

(ii) Do the existing legal and policy frameworks deployed for the development of RE in Ghana provide the enabling environment for the successful harnessing of solar energy in the country to address ES challenges?

(iii) How likely will Ghana be able to achieve the 10% target set in the Renewable Energy Master Plan by 2030?

(iv) Do the Renewable Energy Act and policies currently in operation in Ghana need review?

Effectiveness is defined as, the ability of a policy instrument to reach a RES electricity target.[53] It is one element used in measuring the performance of a policy, there are others that are going to be discussed alongside it in chapter three- under section 3.12 and subsections 3.12.1 to 3.12.2

1.5 Justification of the Research

From the review of the literature, it has been discovered that Ghana is in dearth of studies evaluating the effectiveness of the existing RE Act, regulatory frameworks, and policies to

[53] Pablo Del Río and Emilio Cerdá, 'The Policy Implications of the Different Interpretations of the Cost-Effectiveness of Renewable Electricity Support' (2014) 64 Energy Policy 364 <http://dx.doi.org/10.1016/j.enpol.2013.08.096> accessed 12 November 2019

address ES challenges.[54] This justifies the significance of the study because the researcher has set forth to review/appraise the existing RE law and policy frameworks for their effectiveness taking into cognizance the best practices of other jurisdictions. A similar study to this research is that of Sakah and others (2017), which assessed the impact of Ghana's RE policy in relation to the deployment and development of sustainable energy technologies using the SWOT analysis.[55] Zoundi's work in 2016 also touched on the effectiveness of RE policies, but that was done on twenty-five African countries whilst this thesis focuses solely on the effectiveness of the existing legislation and policies on RE in Ghana primarily, to address ES challenges.

The thesis will focus more on ES because the GoG, when it enacted the RE Act, stated that it was for ES and climate change challenges that it was turning to these resources. The discussion will be less detailed on climate change, sustainability, and competitiveness as they are equally broad indicators which cannot be discussed exhaustively in this thesis. This research will further identify the causes of the failure of the RE policies in Ghana. The thesis uses a combination of methods as the methodology, thus doctrinal, desktop analysis, empirical research, and comparative analysis. This approach will be explained further in the section under methodology.

Under conventional energy uses ES concerns have overshadowed RE. This is the case even when ES concerns have been addressed through legal frameworks. The attention has often been given to conventional energy sources, whereas little attention is given to RE policies and technologies. The thinking behind this sometimes could be that RETs are seen as tools designed to play a complementary role to conventional energy in ensuring ES, to the total neglect of their role in combating environmental degradation and reducing carbon emissions. Even though evolving legal instruments have helped develop RETs so far, they can be seen to be woefully inadequate.

A critical examination of the RE Act and policies is needed to ascertain their effectiveness in addressing ES challenges. The assessment will investigate the challenges of RE development and what remedies can be provided as the panacea to the problems. When a policy or law is implemented, it needs a periodic appraisal to ascertain its effectiveness; by doing so, the researcher can gain an insight into its success to see if it has achieved the objectives for which it was enacted. The thesis will focus on substantive issues that emanate from the RE Act and not on monitoring and enforcement of its provisions. Many RE laws and policies are being implemented around the world, some successful others have failed. A study like this can identify the best and most successful ones that can be emulated with some adjustments to suit Ghana's peculiar situation. The research further explores policy features and mechanisms that support successful RE policies that have been successfully deployed worldwide for emulation by Ghana, as seen in the comparative analysis. It must be stated that Ghana, from the outset, built three hydroelectric dams, and their combined installed capacity is 1,584 MW according to EC in 2021. Hydro is recognised and classified as RE but what is most often referred to in the literature has a very small installed capacity and these include solar, wind and others which are the main focus of the RE Act and thesis.

1.6 Theoretical- Conceptual Framework

RE has become an important issue in the current drive by the international community to combat climate change. RE is adopted for ES and climate change mitigation purposes in

[54] For example, the works of Ackah and Asomani (2015), Zoundi (2016), Solarin and others (2017) Sakah and others (2017), Obeng-Darko (2019), Ergun, Owusu and Rivas (2019).
[55] SWOT stands for Strengths, Weaknesses, Opportunities and Threats.

Ghana. Based on this background, the call is to transition from fossil fuels-dominated energy system to RE to stem the degradation of the environment and exploit energy resources in tandem with the concept of sustainable development. This section looks at the philosophical underpinnings of this research on RE and the legal and policy frameworks that aid its development in Ghana. The theories that lay the foundation for this research are captured in the transition theory, and energy justice. In developing the RE legal frameworks for RETs in Ghana, there is the need to carefully design policies that can be implemented to deliver the desired results. This section aims to establish how these theories help lay the foundation for the research and to ascertain the effectiveness of the legal and policy frameworks deployed to address ES challenges in Ghana.

1.6.1 The Transition Theory

Energy transition refers to the shift from one dominant energy resource-or a set of resources to another, e.g., transitioning from wood to coal during the industrial revolution. In modern times it is characterised by a decline in the use of fossil fuels like coal, oil, and natural gas to renewables like hydro, solar, and wind.[56] Rotmans and Loorbach have discussed persistent problems and how they affect society. They observed that the problems are complex, challenging to manage and involve a host of actors and are deeply rooted in societal structures.[57] As these persistent problems develop, their symptoms become more visible. Their emergence indicates failures in the system which cannot be solved with the current policies or market-related measures being deployed. The central topic for this thesis, the energy problem is an excellent example of a persistent problem. Geels and Schot opine that countering these system failures requires the restructuring of our systems, it calls for exploring new ideas and values alongside times of uncertainty, fear, and turmoil.[58] This is what transition constitutes. The theory has been studied for several decades across different disciplines.

Transition brings about changes within structures closely related to society and culture, making it a complex phenomenon. The structural changes are radical and bring about an evolution in economic, cultural, technological, ecological, and institutional developments at different scale levels.[59] Furthermore, transition causes sudden changes that go beyond the economy and bring about nonlinear changes, for example, creating new institutions.[60] Research on transition has expanded to different areas of interest, thus technological revolutions, technological transitions, and regime transformation. There are two main reasons for energy transition; to secure energy supply to meet demand, thereby reducing import dependency and responding to GHG emissions concerns to mitigate climate change. The world is called upon to transition from fossil fuels to RE that emits no or less carbon and is built on the energy trilemma.

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[56] Sanya Carley and David M Konisky, 'The Justice and Equity Implications of the Clean Energy Transition' (2020) 5 Nature Energy 569 <http://dx.doi.org/10.1038/s41560-020-0641-6> accessed 20 December 2021

[57] Jan Rotmans and Derk Loorbach, 'Complexity and Transition Management' (2009) 13 Journal of Industrial Ecology 184 < https://doi.org/10.1111/j.1530-9290.2009.00116.x> accessed 10 June 2021

[58] Frank W. Geels and Johan Schot, 'The Dynamics of Transitions: A Socio-Technical Perspective' in John Grin, Jan Rotmans and Johan Schot (eds), *Transitions to Sustainable Development: New Directions in the Study of Long-term Transformative Change* (Routledge 2010).

[59] Rotmans and Loorbach (n 57).

[60] Kwok L Shum, 'Renewable Energy Deployment Policy: A Transition Management Perspective' (2017) 73 Renewable and Sustainable Energy Reviews 1380 <http://dx.doi.org/10.1016/j.rser.2017.01.005>.accessed 15 June 2021

1.6.2 Other Perspectives of Transition Theory

There are many perspectives of looking at the transition theory, and the five going to be discussed include Socio-technical, Energy Trilemma, Energy Quadrilemma, Energy Justice, and Multi-level Perspective (MLP) framework.

1.6.2.1 Socio-technical Perspective

If analysed from a socio-technical perspective, technological transition would come from a well-informed analysis of the technology's studies, including more context and background. The thesis applies the socio-technical approach as espoused by Geels and Schot, and this perspective is founded on a contextual understanding of the technology. The context in technological development allows for the addition of the different elements which are necessary for knowledge building, resource mobilisation, regulatory framework, social networking, and market adaptation.

Further, technological advancements and regimes need to be better understood since there are endless questions on the effects of technology that go beyond its production and consumption. In this case, policymakers and social groups put in efforts that demonstrate attempts to either control the effects of new technologies or pursue their expansion whilst praising their essential social benefits.[61] Berkhout, Smith and Stirling have explained that the history of technology has shown that there exists an active process of structuring technology and its social context.[62] They noted a strong connection between technological and social aspects, which is illustrated by the ongoing interest in applications and effects of technology. There is an increasing pursuit to have social control over technology, which can be seen in the industrialised countries. The methods used by public entities and civil society to understand and manipulate technological changes have varied in time but have always remained the same to the present.[63] Therefore if the energy problem is re-considered with this knowledge background, the need for transition becomes more crucial.

Part of the transition requirements are identified as: rethinking and re-establishing per capita energy levels to provide adequate human quality of life, a significant increase in energy efficiency, an increase in low carbon energy supplies such as RE and sound regulatory policymaking.[64] Socio-technical transition focuses on developing sustainable energy systems that can contribute to the limiting of temperature rise per the Paris Agreement 2015. This intervention needs the deployment of RE that still depends on policy and regulatory instruments to grow; some of these instruments include subsidies, feed-in tariffs, auctions, and renewable portfolio standards.[65]

1.6.2.2 Energy Trilemma

The discussion on energy transition is to see how the global energy industry impacts the environment. The focus of this subsection is going to be on the energy trilemma. The

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[61] Frans Berkhout, Adrian Smith and Andy Stirling, *Socio-technological regimes and transition contexts. System innovation and the transition to sustainability: theory, evidence and policy* (Edward Elgar, Cheltenham 2004) 48

[62] ibid

[63] Frans Berkhout, Adrian Smith and Andy Stirling, Socio-technological regimes and transition contexts. System innovation and the transition to sustainability: theory, evidence and policy (Edward Elgar, Cheltenham 2004) 48

[64] Reinhard Haas, Jim Watson, and Wolfgang Eichhammer, 'Transitions to Sustainable Energy Systems-Introduction to the Energy Policy Special Issue' (2008) 36 Energy Policy 4009 < https://doi.org/10.1016/j.enpol.2008.06.015> accessed 19 June 2019

[65] Shum (n 60).

subsection would provide highlights, as it acts as a framework for resolving the challenges in transitioning from fossil fuels to RE.

The World Energy Council (WEC) coined "energy trilemma" in order to provide an understanding of the issues that confront the world in relation to energy use and the protection of the environment.[66] The definition of energy trilemma now has several variations, but all address the fundamental challenges called the three pillars which comprises economic competitiveness (affordability), energy security (politics) and environmental sustainability (carbon emissions).[67] Energy trilemma has a three-prong approach to the challenges thus, energy security at the apex of the triangular model and the bases are concerned with affordability and environmental sustainability issues as shown in the World Energy Trilemma Index 2021.[68] Energy trilemma also refers to the emerging trade-offs between ES, economics and the environment.[69] Furthermore, in recent times the challenge of accessibility has arisen in the case of developing countries this is because it could be available but not accessible when this is considered it makes it altogether unavailable which leads to energy poverty. For instance, Ghana is endowed with a lot of RES especially solar energy, but these available resources are left untapped leaving 13% of the population without access to electricity though available, access has become a constraint. As such at the national level ES cannot be discussed in isolation without including all other energy issues which are fundamental.[70] Knowing the role energy consumption plays in the climate change menace proffering solutions to energy trilemma becomes a complex issue. This is the case as fossil fuels have impacted the environment, but it is ironic that the global energy systems are still dominated by them for the world's energy supply and their continuing use is still ongoing into the foreseeable future as projections depict.[71]

In contrast the U.N sustainable development goal 7 has urged the world to change trajectory by jettisoning fossil fuels in favour of sustainable ones like RE. This goal, however, faces practical challenges as the so-called cheap energy like the fossil fuels trio are damaging to the environment and sustainable energy like RE has some limitations which have been discussed already in the thesis. RE deployment is not on a scale that can satisfy global insatiable thirst for energy leading to the continuous consumption of fossil fuels for energy security. The discussion on energy trilemma is important as it highlights both the problem and provides the framework that can help deliver the needed energy transition to make RE energy systems a success and a reality. It ensures that energy decision-making take on board

[66] World Energy Council, 'World Energy Trilemma Index' 2015 Benchmarking the sustainability of national energy systems (WEC, 2015) <https://www.worldenergy.org/assets/downloads/20151030-Index-report-PDF.pdf > accessed 10 January 2023

[67] Raphael J Heffron, Darren McCauley and Benjamin K Sovacool, 'Resolving Society's Energy Trilemma through the Energy Justice Metric' (2015) 87 Energy Policy 168 <http://dx.doi.org/10.1016/j.enpol.2015.08.033>.accessed 20 June 2021

[68] World Energy Council, World Energy Trilemma Index (WEC, 2021) <https://www.worldenergy.org/assets/downloads/WE_Trilemma_Index_2021.pdf?v=1634811254> accessed 2 January 2023

[69] Elena De Luca and others, 'Explaining Factors Leading to Community Acceptance of Wind Energy. Results of an Expert Assessment' (2020) 13 Energies 1.<https://doi.org/10.3390/en13082119> accessed 07 January 2023

[70] BW Ang, WL Choong and TS Ng, 'Energy Security: Definitions, Dimensions and Indexes' (2015) 42 Renewable and Sustainable Energy Reviews 1077.<http://dx.doi.org/10.1016/j.rser.2014.10.064> accessed 05 January 2023

[71] International Energy Agency, 'Perspective for the Energy Transition: The Role of Energy Efficiency' (IEA, 2018) <https://iea.blob.core.windows.net/assets/d9090f84-fd5a-464b-976a-99c7905c9c57/PerspectivesfortheEnergyTransition-TheRoleofEnergyEfficiency.pdf> accessed 5 January 2023

competing interests and decisions should not be premised on making profits or the need to provide ES but should rather focus on an energy mix dominated by RE which is the panacea to climate change mitigation.

1.6.2.3 Energy Quadrilemma

The energy quadrilemma adds a fourth strand which is the social dimension of energy which focuses on people which has to do with their involvement, participation and acceptance of decisions emanating from the energy industry. The people centred dimension concerns itself with providing energy in a just and sustainable manner. These emerging social issues have necessitated the coming into being of the energy quadrilemma. The people may like green energy but is it socially acceptable? Take for instance the installation of a wind turbine to generate RE, on some occasions, people have opposed the RE infrastructure on grounds that it would change their landscape, devalue their property, a malfunctioning blade could fall and cause injuries if someone is in close distance and the spinning blades can also kill migrating birds. These agitations have led to the popular phrase not in my backyard and form the basis for not accepting the wind turbine. This has led to the stalling of many RE infrastructure even though most people are now aware of the environmental externalities caused by fossil fuels. The energy quadrilemma is somewhat generally referred to as energy justice which is concerned with identifying where injustice has occurred in the energy system and how law and policy can remedy it.[72] Energy quadrilemma incorporates the concept of energy justice as it is fundamental in the understanding of the complex trade-offs that energy policy making generally embodies as shown by the competing needs of ES, energy equity and environmental sustainability.[73] It is important to state at this point that there is no energy source as yet that fully meets all the conditions of energy trilemma or clearly socially accepted as 'justice neutral.[74]

To achieve more. sustainable outcomes in the relationship that exists between energy and the environment experts need to collaborate to address energy trilemma and energy quadrilemma.[75] Examining the two frameworks from law and policy perspective, understanding the challenges raised, the energy trilemma and quadrilemma can be used to formulate legislation, policy, and regulation in the future to address these challenges to mitigate climate change and protect the environment. When all these things are put in place, they would help in achieving SDG 7 thus to ensure access to affordable, reliable, sustainable, and modern energy for all and provide ES.

1.6.2.4 Energy Justice

Energy justice is centred around the notion that all humans should have access to energy which is affordable, sustainable, safe and be able to maintain a decent lifestyle; it as well involves participating in energy decision making processes with the authorities to bring about

[72] Heffron, McCauley and Sovacool (n 67).
[73] De Luca and others (n 69).
[74] Paul Munro, Greg van der Horst and Stephen Healy, 'Energy Justice for All? Rethinking Sustainable Development Goal 7 through Struggles over Traditional Energy Practices in Sierra Leone' (2017) 105 Energy Policy 635 <http://dx.doi.org/10.1016/j.enpol.2017.01.038>.accessed 3 January 2023
[75] Rebecca Lunn, 'Independent Experts Needed to Help Solve 'Energy Quadrilemma'' The Herald (Scotland, 1 August 2019) <https://www.heraldscotland.com/news/17809085.professor-rebecca-lunn-independent-experts-needed-help-solve-energy-quadrilemma/> accessed 5 January 2023

change.[76] Energy justice can be grouped into three main categories namely: distribution, recognition, and procedure. Distributional justice calls for fairness in the distribution of energy resources in terms of the positive and negative impacts in the provision of energy regardless of demographics like age, race, social status or educational attainment.[77] Recognition justice evaluates why and how specific individuals in the society get the most negative or the positive impact of energy systems than the rest of the people.[78] Procedural justice deals with socially and spatially differentiated groups in the decision-making processes in the provision of energy to ensure equitable outcomes for all.[79] Restorative energy justice has emerged as the fourth tenet and it focuses on remediation measures that can mitigate the occurrence of energy injustices.[80] Furthermore, if injustice can be tackled one need to understand and identify the concern (distribution), identify who it affects (recognition) and finally identify the approaches for remediation (procedure).[81] In energy transition to RE, there are winners and losers in the process, which impact the lives of individuals. The winners are those who are going to benefit from RE; thus, clean air, reduced emissions, and employment, whilst the losers are those who will bear the burdens or may have limited opportunities in the process.[82] Energy justice evaluates where injustices exist, which individuals in society are affected or ignored and what processes are available for remediation to reveal and reduce such injustices.[83]

1.6.2.5 Implication of Energy Justice in Energy Transition

As indicated above, those who miss out on the energy transition shoulder many burdens (individuals, communities, and households) across the globe. In effect bearing the burden too much or getting less of the opportunities that come with energy transition is an affront to energy justice. In developed and developing countries, poor, lower-income earners, and rural dwellers bear much of these burdens.[84] One example is that communities that live close to highways are more likely to inhale much-concentrated exhaust pipe emissions. Also, in Ghana, the grid extension has been concentrated in the cities and urban areas, whilst the rural areas receive more negligible extension compared to the cities. National access is 87%, rural access is 50%, whilst urban access is 91%.[85] RETs also produce negative externalities that will affect people disproportionately, as seen above, especially those located near the infrastructure. Examples are noise pollution from wind turbines, pollution from landfill installations and unpleasant

[76] Morgan Bazilian, Smita Nakhooda and Thijs Van De Graaf, 'Energy Governance and Poverty' (2014) 1 Energy Research and Social Science 217 <http://dx.doi.org/10.1016/j.erss.2014.03.006>. accessed 10 January 2022
[77] ibid
[78] Darren McCauley and others, 'Energy Justice in the Transition to Low Carbon Energy Systems: Exploring Key Themes in Interdisciplinary Research' (2019) 233–234 Applied Energy 916 < https://doi.org/10.1016/j.apenergy.2018.10.005> accessed 20 June 2021
[79] ibid
[80] M Lacey-Barnacle, R Robison, and C Foulds, 'Energy Justice in the Developing World: A Review of Theoretical Frameworks, Key Research Themes and Policy Implications' (2020) 55 Energy for Sustainable Development 122 <https://doi.org/10.1016/j.esd.2020.01.010>.accessed 10 August 2021
[81] McCauley and others (n 78).
[82] Sanya Carley and David M Konisky, 'The Justice and Equity Implications of the Clean Energy Transition' (2020) 5 Nature Energy 569 <http://dx.doi.org/10.1038/s41560-020-0641-6>. accessed 20 December 2021
[83] Kirsten Jenkins and others, 'Energy Justice: A Conceptual Review' (2016) 11 Energy Research and Social Science 174 <https://doi.org/10.1016/j.erss.2015.10.004> accessed 20 June 2021
[84] Spencer Banzhaf, Lala Ma, and Christopher Timmins, 'Environmental Justice: The Economics of Race, Place, and Pollution' (2019) 33 Journal of Economic Perspectives 185 <https:// doi.org/ 10.1257/jep.33.1.185> accessed 10 April 2022
[85] Ephraim Bonah Agyekum, Vladimir Ivanovich Velkin and Ismail Hossain, 'Sustainable Energy: Is It Nuclear or Solar for African Countries? Case Study on Ghana' (2020) 37 Sustainable Energy Technologies and Assessments 100630 <https://doi.org/10.1016/j.seta.2020.100630>.accessed 12 April 2022

smells. It is found that in the case of wind, more of the brunt is borne by poor rural and less educated populations.

In contrast, a large share of the benefits is enjoyed by urban dwellers.[86] However, with this development, some studies point to the fact that if the local people are involved in the processes leading to the siting of the turbines and see the planning process as fair, they are most likely to perceive the positive benefits of the turbines.[87] Despite these negative externalities, it is still worth transitioning from fossil fuels to renewables. Transmission and distribution losses are high in Ghana; GRIDCo makes transmission losses of 5%, whilst ECG, NEDCo and EPC together make distribution losses of 29.7%.[88] These losses occur due to poor grid network and other inefficiencies from the companies. However, these losses are charged into the energy bills of customers, an affront to the distribution dimension of energy justice.

1.6.2.6 The Renewable Energy Policy of Ghana and Energy Justice

This section will probe whether Ghana's legal and policy frameworks deployed have contributed to promoting energy justice, thus distributive, recognition, and procedural dimensions. Using Jenkins and others as follows:[89] The researcher wants to assess the degree to which distributive justice has been incorporated into Ghana's energy policy framework. It will be assessed in terms of access and its fair distribution, which is demonstrated by specific policies for energy access to rural areas via grid connection or mini-grids or standalone systems. It also assesses the degree to which recognition of energy justice is applied. In addition, this assessment considers whether the policy framework has taken into account the energy needs of people who come from vulnerable segments of society, such as people who reside in remote regions, i.e., Island communities and disabled people. Finally, an assessment is made on the policy framework and whether it contributes to procedural justice thus democratic processes (the rule of law).

So, in Ghana, in reference to distributive justice in the case of access, the National Electrification Scheme began in 1988; it was a policy by the GoG to extend electricity to every part of the country by the year 2020. As seen earlier in the chapter (section 1.2), though the target was not met, significant progress was made as the access rate was 87% at the end of 2021. The RE Act re-affirmed the government's determination, as captured in the object of the Act 1 (2) (d) to improve access to electricity through the use of RES. Ghana envisages transitioning to RE whilst recognising the incorporation of energy justice in its policies. As such, Ghana's energy policy framework incorporates market-based and justice-oriented features in order to benefit from both, as seen in the RE Act.[90] The Act, to a large extent, relies on investors to fund the RE agenda, and GoG seeks to attract investors using incentives like tax rebates.

The Ghana policy framework has considered the needs of some vulnerable people by making combatting energy poverty a priority, thus accounting for the recognition dimension of energy justice. The recognition justice is manifested in policies tailored toward groups like low-income

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[86] Carley and Konisky (n 82).
[87] Sarah Banas Mills, Douglas Bessette and Hannah Smith, 'Exploring Landowners' Post-Construction Changes in Perceptions of Wind Energy in Michigan' (2019) 82 Land Use Policy 754 <https://doi.org/10.1016/j.landusepol.2019.01.010>.accessed 10 April 2022
[88] Energy Commission of Ghana (n 36).
[89] Kirsten Jenkins and others, 'Energy Justice: A Conceptual Review' (2016) 11 Energy Research and Social Science 174. <https://doi.org/10.1016/j.erss.2015.10.004> accessed 14 January 2022
[90] Franziska Müller and others, 'Assessing African Energy Transitions: Renewable Energy Policies, Energy Justice, and SDG 7' (2021) 9 Politics and Governance 119 <https://doi.org/ DOI: 10.17645/pag.v9i1.3615> accessed 10 April 2022

earners and the poor, who are classified into low tariff categories in which they pay less for their energy consumption.[91]

The Ghana energy sector is governed by a plethora of laws that give direction to the pathways the GoG wants to go. The Parliament of Ghana enacts all these laws for implementation. This approach fulfils the procedural justice dimension. The laws provide guidance as to what can be done or what cannot be done, e.g., the RE Act was passed in 2011, and it gives guidance as to what is needed to operate in the RE subsector in Ghana. Institutions that function in the energy sector and RE subsector came into existence by an Act of parliament.

1.6.2.7 Multi-level Perspective (MLP) Framework

The Multi-Level Perspective (MLP) framework can be used to describe and analyse socio-technical transitions; MLP conceptualises transitions as a combination of processes. They interact at three levels where they have influence and interfere with one another; the three levels are: innovation (niche), structure (regime) and trends (landscape).[92] The levels are functional and can therefore be used to showcase the functional relationships that exist between actors and structures.

The understanding of MLP applied in transitions has been increased by the contribution of Grin, Rotmans and Schot, who state that: it constitutes a process theory in which transitions are reached and gained by diverse groups in society.[93] During the transition process, actors can change interests and even identity; the specific timing of events determines the type of transition pathway that can be followed; MLP is layered by nature, likewise are the system descriptions provided by it and is based on event sequences; MLP is a general approach that can be applied to different case studies because it is versatile.[94]

Under MLP, the three levels are explained as follows:

(1) The micro level is where the niches are, where radical changes occur, allows research and development, encourages the development and establishment of support networks and investment in new technologies like those of RE.[95]

(2) At the meso level, the regimes are found; this level provides the space for actors related to a technology to interact. They are the "rule-set" or grammar embedded in the complex engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them are embedded in institutions and infrastructure".[96] The preceding captures what goes on at this level.

(3) Macro level is where the landscape is found, which forms the external structure or context for the interaction of actors. Factors such as environmental concerns, climate change issues, oil prices, and economic issues are prevalent here, and these factors are slow to change, e.g., transitioning from fossil fuels to RE. Changes at the landscape level can reinforce the

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[91] Public Utilities Regulatory Commission, 'Publication of Electricity Tariffs' ((PURC,16 December 2020) <https://www.purc.com.gh/attachment/642643-20210225110236.pdf> accessed 10 April 2022

[92] T. Steward, 'A Brief Introduction to Multi-Level Perspective (MLP)' <http://projects.exeter.ac.uk/igov/wp-content/uploads/2012/12/DOWNLOAD-Multi-Level-Perspectives.pdf> accessed 01 July 2021

[93] John Grin, Jan Rotmans, Johan Schot, *Transitions to Sustainable Development: New Directions in the Study of Long-Term Transformative Change* (Routledge 2010) < https://doi.org/10.4324/9780203856598> accessed 10 June 2021

[94] ibid

[95] Steward (n 92).

[96] Shum (n 60).

prevailing trajectories or can put pressure on the regime. This pressure exerted can result in the destabilisation of the structures of the regime and create windows of opportunity where radical innovations can breakthrough.[97]

The benefit of MLP is that it allows a historical view of each trajectory and provides independent analysis of the trajectories, it focuses on the dynamic processes that have been created by the interactions of the trajectories and actions, tensions and 'windows of opportunity'.[98] The drawback of the MLP framework according to some scholars like Geels is that, it is still a complex perspective that requires more qualitative data, the socio-technical regimes are broad units of analysis which makes it difficult to draw precise boundaries.[99] Genus and Coles have also re-echoed the same sentiments by saying that MLP underplays the effects of social and cultural aspects that co-evolve with technologies in transition.[100] However, in response to these criticisms, recent Strategic Niche Management literature has made a distinction between market niches, technological niches and social niches to cater for the pitfalls raised by the critics.[101]

1.6.3 Technology and Policy Transfer Overview

Doci, Vasileiadou and Petersen have observed that the MLP framework has enhanced a better understanding of socio-technical transitions, it shows how innovations emerge and cause a shift in the incumbent regime, which is dominated by fossil fuels, toward sustainability (RE).[102]

Dolowitz and Marsh define policy transfer as ''a process in which knowledge about policies, administrative arrangements, institutions in one time/or place is used in the development of policies, administrative arrangements, and institutions in another time and place''.[103]

It is what this research attempts to do by echoing the call for Ghana to transition from a fossil fuel-dominated energy mix to an RE dominated energy mix; the research also seeks to compare the policies of other countries to derive the best policy for a possible policy transfer for Ghana to adopt. Dolowitz and Marsh further opine that the most important thing in policymaking is to learn lessons.[104] A policymaker can learn the two most important things from the international arena. First, political systems that have already experimented with new policies and the successful adoption of policies deployed in other jurisdictions. Second, Dolowitz and Marsh have emphasised a strong focus on context analysis in applying policy learning.[105] Whether a policy transfer is voluntary or coercive, there exist modes in which a policy can be adopted.

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[97] Frank W Geels, 'Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-Level Perspective and a Case-Study' (2002) 31 Research Policy 1257 < https://doi.org/10.1016/S0048-7333(02)00062-8> accessed 02 July 2021
[98] Geels and Schot (n 58).
[99] Geels (n 97).
[100] Audley Genus and Anne Marie Coles, 'Rethinking the Multi-Level Perspective of Technological Transitions' (2008) 37 Research Policy 1436 <https://doi.org/10.1016/j.respol.2008.05.006> accessed 01 July 2021
[101] Marten J Witkamp, Rob PJM Raven and Lambèr MM Royakkers, 'Strategic Niche Management of Social Innovations: The Case of Social Entrepreneurship' (2011) 23 Technology Analysis and Strategic Management 667 < https://doi.org/10.1080/09537325.2011.585035> accessed 01 July 2021
[102] Gabriella Dóci, Eleftheria Vasileiadou and Arthur C Petersen, 'Exploring the Transition Potential of Renewable Energy Communities' (2015) 66 Futures 85 < ttp://dx.doi.org/10.1016/j.futures.2015.01.002> accessed 28 June 2021
[103] Dolowitz, David, and David Marsh. 'Who Learns What from Whom: A Review of the Policy Transfer Literature.' (1996) 44 (2) Political Studies 343–57. <https://doi.org/10.1111/j.1467-9248.1996.tb00334.x> accessed 30 June 2021
[104] ibid
[105] ibid

Williams and Dzhekova present five policy transfer modes that can be adopted; these include copying, adaptation, hybridisation, synthesis, and inspiration.[106] The choice of a policy transfer mode depends on the context and the country which influences the success or failure of the transfer. It is important to note that policy transfer is a complex process that success is not easy to achieve. But there are three failing transfers that policymakers, including Ghanaian policymakers, should avoid, as noted by Williams and Dzhekova.[107]

(1) An 'uninformed transfer' comes about when the country adopting the policy does not have enough knowledge about the policy,

(2) An 'inappropriate transfer' happens when the transferred policy is incompatible with the political, social, economic, and cultural contexts that exist between the source country and the destination country and

(3) An 'incomplete transfer' occurs when all the key features of a policy which make it successful in the source country are not being implemented.

1.6.4 Assessment of the Prospect of Transition Theory in the Ghanaian Context

The adoption of the transition theory in this thesis is to have a better understanding of the transition process, especially moving from a well-established fossil energy system to a more sustainable energy system fueled by renewables. From the above discussion, it is appropriate at this point to assess whether there has been any energy transition in Ghana or not and, if any, is it from fossil fuels to RE or vice-versa. In making this assessment, there are some indicators gleaned from the literature which can be used to assist in the drawing of the conclusion. The indicators include a change in energy source type; this refers to the transition in the energy source type, e.g., from fossil fuels (coal, oil, and natural gas) to RE (solar, wind and hydro). It also involves a change within the same energy category, for instance, coal to oil or oil to natural gas, as all these come from fossil fuels; also, in this category is moving from biomass to liquefied petroleum gas as in the case of Ghana and some other developing countries.[108] Change in energy ownership and management involves a change in the ownership or management of the country's energy system. For example, from state ownership to private ownership or change from a localised system to a centralised system; this has also been termed as democratisation of energy.[109] Furthermore, ECG and NEDCo, who are state-owned distribution companies, now share the distribution with Enclave Power Company Ltd, a private company. Transition to green vehicular transportation refers to the use of electricity for vehicular power transportation in the country. It is particularly important because the transport sector is one of the major consumers of energy in Ghana.[110]

From the foregoing, transition in its broad sense has taken place in the energy sector in Ghana. It has taken the form of a transition from an exclusive hydroelectricity to a combination of hydro-thermal mix and non-hydro RE. Thermal now dominates, and the current mixture is hydro (34.1%), thermal (65.3%), and non-hydro RE (solar, wind) (0.55%) in the electricity

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[106] Colin C. Williams and Rositsa Dzhekova, 'Evaluating the Cross-National Transferability of Policies: a Conceptual Framework' (2014) 19(4) Journal of Developmental Entrepreneurship <https://doi.org/10.1142/S1084946714500228 > accessed 09 July 2021

[107] ibid

[108] Paul Osei-Tutu, Samuel Boadi, and Vincent Kusi-Kyei, 'Electrical Energy Transition in the Context of Ghana' (2021) 11 Energy, Sustainability and Society 1 <https://doi.org/10.1186/s13705-021-00322-4>.accessed 10 January 2022

[109] Matthew J Burke and Jennie C Stephens, 'Political Power and Renewable Energy Futures: A Critical Review' (2018) 35 Energy Research and Social Science 78 <https://doi.org/10.1016/j.erss.2017.10.018>.accessed 08 January 2022

[110] Osei-Tutu, Boadi, and Kusi-Kyei (n 108).

generation mix.[111] Also, there has been a transition from an entire state-owned generation and distribution to a state and Independent Power Producers generation and distribution mix. For example, VRA is a state-owned generation company, but there are private generation companies like Bui Power Authority and KAR Power, which now dominate the supply mix. With distribution, ECG and NEDCo are state-owned distribution companies but now share distribution with Enclave Power Company Ltd, a private distribution company.[112]

Furthermore, the transition to electric vehicles has not occurred in the transport sector due to the continuous use of fossil fuels. Most of the current fleet of automobiles used in the country consumes either diesel or petrol. No infrastructure has been built in readiness to switch to the use of electric cars, and there is less public awareness of the benefits of switching to the use of electric cars in the transport sector in Ghana. The transition of interest in this research is the transition from a fossil fuel- dominated energy mix to an RE dominated energy system. Nevertheless, the current situation is that fossil fuels dominate both the primary energy supply and electricity generation mix, and there is no sign of any change in this trajectory. Based on this, the transition that has occurred cannot be said to be a transition to RE. Therefore, it can be concluded that sustainable energy transition has not happened in the Ghanaian context. For this reason, the research has set forth to investigate the legal and policy frameworks deployed in Ghana to ascertain whether they promote RE development and effectively address ES challenges or otherwise. This is because Ghana is endowed with enormous RES and has deployed many laws and policies for RE development.

1.7 Issues Outside the Scope of the Research

The thesis is focused on electricity and the RE subsector and how the sector can generate power using RES. Further, the review of the legal and policy frameworks has been limited to the legal instruments governing the RE subsector. It thus sees the following issues as lying outside the scope of the research: grid connection, technical construction of RETs, installation and their functions, infrastructure, manufacture of RE equipment like solar panels, setting of tariffs, power purchase agreements, monitoring, and enforcement issues. Therefore, the discussion will be centred on RE law, policies, and strategies and not based on conventional energy sources. Furthermore, the focus will be on adopting RE to address ES challenges in Ghana, this is because Ghana after enacting the RE Act stated that it was for ES challenges that it was turning its attention to non-hydro RES.[113] Other important challenges such as climate change, sustainability, and competitiveness will be considered in detail in future research. Also, the thesis focuses on the supply side of ES and leaves the demand side of ES which has not been covered and it will, therefore, be a topic for future research.

Finally, the limitation regarding the empirical research is seen in terms of the time available to interview many experts. More interviews would have further enriched the results of the thesis. However, the time required to go and collect data from Ghana, transcribe and analyse and provide the results was limited, given that the Covid 19 Pandemic had already delayed the trip by one year, which should have taken place in May 2020. Furthermore, plenty of time is required to process the enormous data generated from the in-depth interviews, which is a constraint in dealing with a large dataset as earlier envisaged. Another constraint was the recruitment of participants, as some of them who were contacted appeared to be too busy and could not commit to an interview. The Covid 19 restriction (social distancing) made face-to-

[111] Energy Commission of Ghana (n 36).
[112] ibid
[113] Ghana's Renewable Energy Act, 2011 (Act 832).

face interviews impossible and complicated matters for the researcher and participants. All interviews had to take place online or by telephone.

1.8 Literature Review

Renewable Energy has attracted much attention in recent years and has been recognised as a viable alternative for energy access and climate change mitigation.[114] A thorough literature review is regarded as 'the foundation and inspiration for substantial, useful research'.[115] The purpose of a literature review in this research is to fulfil three requirements. The first is, it provides an examination of existing scholarly work, which is the starting point to identify information and terminologies used in the field, that is relevant to one's research and to get familiarised with the subject area.[116] Secondly, it affords the researcher the opportunity to evaluate the quality of existing works critically and to know the best techniques and approaches used by scholars in the field.[117] Thirdly, literature review helps to shape and focus one's research by setting it apart from the works of other scholars thereby allowing a gap to be addressed and making an original contribution to knowledge in the subject area.

The purpose of reviewing the literature connected to the topic is to identify scholarly works and academic commentary in the field of RE, and how these can help narrow the scope of the research. It sets the framework for identifying the main themes/issues of the study. Scholarly works done by others have been used to lay the foundation for framing the research questions for the thesis. The literature review has been conducted to get an insight into the literature in order to assist in answering the research questions.

Following this, it is essential to look at the methodology and strategies that the scholars in the field have used in their works.[118] This is done to specifically identify whether these techniques and methodologies support the outcomes of the conclusions reached. Finally, the literature review seeks to identify the importance of work done by other scholars in the subject area and to show how this study will differ from existing scholarly works.

The literature has often focused on renewable energy technologies (RETs) and the means to transfer them and their capacity building. However, little attention has been given to the law; thus, the legal and policy frameworks that are pivotal in their implementation.[119] The thesis examines the role the law plays in the promotion and development of RE and assesses the effectiveness of the policies already deployed. This area has been surprisingly left unattended until recently, when attention has been drawn to it.

The thesis will first review the literature that deals with the factors that contribute to a successful RE policy deployment. Omri and Nguyen stated that the identification of the

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[114] Intergovernmental Panel on Climate Change, Special Report on Renewable Energy Sources and Climate Change Mitigation (Eds Core Writing Team, O. Edenhofer, R. Pichs-Madruga, Y. Sokona) (2011) <https://www.ipcc.ch/pdf/special-reports/srren/SRREN_FD_SPM_final.pdf>.accessed 19 August 2019

[115] David Boote and Penny Beile, 'Scholars Before Researchers: On the Centrality of the Dissertation Literature Review in Research Preparation' (2005) 34 (6) Educational Researcher < https://doi.org/10.3102/0013189X034006003> accessed 16 August 2019

[116] David Thomas and Ian Hodges, *Doing a Literature Review in Designing and Managing your Research Project* (Sage 2010) 105

[117] ibid

[118] Boote and Beile (n 115).

[119] Richard Ottinger, 'Legal Frameworks for Energy for Sustainable Development' in Adrian J. Bradbrook, Rosemary Lyster, Richard L. Ottinger and Wang Xi (eds), The Law of Energy for Sustainable development (Cambridge University Press 2005).

determinants of RE use in a developing country is imperative in order to aid any policy decisions that would increase the adoption of RETs.[120] The review will begin with the literature from Ghana and then proceed to the international stage.

Ackah and Asomani did a study on RE demand in Ghana using the automatic variable selection (autometrics) model to estimate the drivers of RE demand in Ghana. The data were collected from the World Bank Development indicators. The study used the following predictors to conduct the analysis: price, income, carbon emissions, labour, and energy resource depletion. The results of the study showed that both economic and non-economic factors influenced the demand for RE consumption in Ghana. An increase in income has shown to be a driver of energy demand. Also, the increase in population is a significant contributor to the rise in demand for RE. The results also confirmed the lack of efficient way RE was consumed during the study period. Autometrics is used in that it applies a tree search for the removal of unimportant variables in the selection of the final model so to allow valid inference to be drawn from the specification.[121] The study may have encountered some challenges in the sourcing of the data due to the unavailability of accurate or up-to-date information in a developing country like Ghana.

Adom and Bekoe studied modelling electricity demand elasticities in Ghana before 1983 and after 1983. It is a time-varying investigation of electricity demand before and after the economic recovery programme in Ghana. The study grouped electricity demand into three sample periods viz pre-reform (1971 to 1983), post-reform (1983 to 2008) and whole period (1971 to 2008). They used these classifications for their analysis. The data for the studies were collected from 1971 to 2008. Data were collected from EnerData Global Energy and carbon dioxide Data Research Services and World Development Indicators (2011 edition). The authors used the fully modified Philip-Hansen ordinary least squares (OLS) model in the analysis. The full-sample period result indicates that electricity demand, in the long run, is affected by real capita GDP, industrial efficiency and industry value-added. However, the rate of urbanisation did not have any significant effect in the long run on the demand for electricity.[122] Furthermore, the findings demonstrate that technological change before 1983 was centred more on energy savings whilst post 1983 has been about more on energy consumption. One disadvantage of OLS is that variables included have a constant mean and variance. As such, when there is a variable change in the means and variances over a period of time, the OLS is rendered invalid as such OLS results become false. The cointegration models allow the covering of the short-run and long-run effects of the variables when it comes to explaining electricity demand. The title of the article does not look clear because it does not capture the different sample periods that have become the pillars that the article hinges on.

Sakah and others conducted a study to review RE deployment policies, thus the regulatory framework, some provisions of Ghana's RE Act and financial incentives. The work critically assessed the policy's strengths, weaknesses, opportunities, and threats. In addition, it used a comparative analysis approach to review the success and failure of similar policies that have been implemented in other jurisdictions so that the country can draw worthwhile lessons. Finally, the study also appraised the effect of the policy on project development. The background to their work stems from the fact that Ghana has been experiencing perennial power shortages due to factors such as rapid urbanisation, population growth and the

[120] Anis Omri and Duc Khuong Nguyen, 'On the Determinants of Renewable Energy Consumption: International Evidence' (2014) 72 Energy 554 <http://dx.doi.org/10.1016/j.energy.2014.05.081>.accessed 12 September 2019

[121] Ishmael Ackah and McCmari Asomani, 'Empirical Analysis of Renewable Energy Demand in Ghana with Autometrics' (2015) 5 International Journal of Energy Economics and Policy 754. <https://dergipark.org.tr/en/download/article-file/361537> accessed 12 September 2019

[122] Philip Kofi Adom and William Bekoe, 'Modelling Electricity Demand in Ghana Revisited: The Role of Policy Regime Changes' (2013) 61 Energy Policy 42. <http://dx.doi.org/10.1016/j.enpol.2013.05.113> accessed 17 July 2019

expansion of the economy. In the face of these challenges, the country is endowed with many RES, which have been left untapped. These resources include solar, wind, mini hydro, biomass, geothermal, and ocean energy. When these resources are successfully exploited in an environmentally sustainable way, they can ameliorate the problem.

Therefore, the government set the target of reaching 100% universal coverage of providing electricity to its populace in 2020. It also set a target of increasing the share of non-hydro RE by 10% in the electricity generation mix in 2020. They observed that despite the deployment of many policies, including the RE Act, the current penetration of non-hydro RE in the national electricity generation mix is less than 1%, This is the case because the right mix of policies is necessary for the achievement of the targets, and they are insufficient hence the need for a review. The findings of the review revealed that the renewable energy policy on grid-connected electricity did badly looking at the target.[123] The reasons for the poor performance are attributed to the incomplete implementation of the policies, weak grid network, lack of financial support schemes, bad strategies development, poor pricing policy frameworks. This study contradicts earlier findings that Ghana was poised to achieve the 10% ambitious policy target in 2020, as concluded by Gboney.[124] Their work revealed that Ghana only managed a less than 1% penetration as of 2017. In the conclusion section of the article, the authors stated that they have provided a critical examination of the effectiveness of Ghana's RE policy in the deployment of RETs. However, this assertion is not reflected in either the title or introduction. Furthermore, the subtitle of the article does not explicitly state the purpose of the review of the RE deployment policies.

Gyamfi, Modjinou and Djordjevic writing on the potential of RE to improve electricity supply security in Ghana, observed that the country enjoyed an abundant supply of cheap hydropower many decades ago. However, in recent times this has changed due to many factors, including the rapid growth of the economy, shortage of water in the hydropower dams, urbanisation, and population growth. These factors have contributed to the increase in demand for energy which leaves the country to rely on fossil fuel-based power plants for supply which comes at a high cost. The VRA, the company that generates electricity, found that it was challenging to keep up with the high demand and could not generate enough power to satisfy all sectors of the economy. Therefore, the country has to undergo a load shedding timetable at the peak of the power crisis. These challenges have led the government to explore other alternatives. It led to the introduction of other forms of RE such as solar, mini hydro, wind, biomass, waste-to-energy, and ocean energy into the electricity generation mix. Therefore, the study reviewed the potential of RE in the energy landscape of Ghana and attempted to identify the barriers to their successful exploitation. The findings confirm that Ghana is indeed endowed with the above RES that can be exploited for electricity generation.[125] Their penetration is currently low, but it is envisaged that they will increase rapidly over the following decades, given the legal and policy frameworks that are being deployed. It is worth noting that recent similar reviews have demonstrated that RES uptake is not increasing rapidly enough, as predicted by the authors. Instead, their increase is relatively too slow with little penetration, as concluded by Obeng-Darko's recent study in 2018.[126]

Solarin and others investigated the pollution haven hypothesis (PHH) in Ghana using carbon emissions as an indicator of air pollution covering the period from 1980 to 2012. The variables

[123] Marriette Sakah and others, 'Towards a Sustainable Electrification in Ghana: A Review of Renewable Energy Deployment Policies' (2017) 79 Renewable and Sustainable Energy Reviews 544 <http://dx.doi.org/10.1016/j.rser.2017.05.090> accessed 11 October 2019
[124] Gboney (n 28).
[125] Samuel Gyamfi, Mawufemo Modjinou and Sinisa Djordjevic, 'Improving Electricity Supply Security in Ghana - The Potential of Renewable Energy' (2015) 43 Renewable and Sustainable Energy Reviews 1035 <https://doi.org/10.1016/j.rser.2014.11.102> accessed 16 July 2019
[126] Obeng-Darko (n 20).

used in the study include renewable energy consumption, gross domestic product (GDP), fossil fuel energy consumption, GDP square, foreign direct investment, trade openness, institutional quality, and urbanisation. The data for total carbon emissions from energy consumption and carbon emissions from the use of petroleum were collected from the U.S.A Energy Information Administration database, whilst the data for other determinants were collected from World Development Indicators of the World Bank. They employed different time models and utilised the autoregressive distributed lag (ARDL) method and augmented it with a structural break to inquire into the long-run relationship between the determinants to reach the goals of their study. The results show a cointegration and that there is a long-run relationship between the determinants. Furthermore, foreign direct investment, urban population, financial development, GDP, and international trade have shown a positive effect on carbon emissions whilst institutional quality reduces carbon emissions in Ghana.[127]

The results, therefore, do not validate PHH predictions in Ghana. Under the discussion section, the authors made some unsubstantiated statements which cast doubts on their veracity. “Air pollution in Accra is almost twice the regional average in Africa, and even higher than the average pollution level in Chinese cities".[128] The authors have failed to back this statement with references for any reader to verify their assertion. It can be argued further that though foreign direct investments have increased carbon emissions, especially those in the extraction industries like oil, it has also provided the necessary capital for the country to embark on its RE journey. As can be seen, these investments have helped establish the three hydropower dams in the country, which generate electricity for the country's energy needs. Furthermore, foreign investments have helped the country to build a strong capital development which has linked the local market with the international market.

Kemausuor and others reviewed policies and plans to increase energy access in Ghana with the primary focus on RE, cooking fuels and electricity. The authors argue that even though past and present governments have had energy access and extension high on the national development agenda, past and current policies and plans have not delivered the intended results; as such, energy access to the villages around the country is limited where the rural folks are in dire need of such services.[129] They identified some challenges that militate against the efforts to achieve national energy targets and goals. Some of the challenges include an increase in demand for energy but without a corresponding increase in investments to match the demand, the inefficient operations of utilities that lead to high power losses, the under exploitation and utilisation of RES and over-reliance on woodfuels as the primary energy for households, which is a threat to the country's forest reserves. The authors have made some recommendations to address the afore-mentioned challenges. First, a well-formulated national energy policy should be drawn with specific targets to be achieved with clear guidelines on how to achieve the targets. Government should support universities in undertaking research and development of RETs.

Mohammed and Ackah writing on Ghana's RE law as a catalyst to keep the lights on have examined the extent to which the RE Act can intervene in mitigating the electricity crisis. According to Mohammed and Ackah, in the 1970s, Ghana had an excess electricity generation. However, over the past decades, the country has gradually descended from an excess regime to a deficit regime due mainly to the severe droughts of the 1980s and the over-reliance on hydropower. The government has been trying different approaches to find

[127] Sakiru Adebola Solarin and others, 'Investigating the Pollution Haven Hypothesis in Ghana: An Empirical Investigation' (2017) 124 Energy 706 <http://dx.doi.org/10.1016/j.energy.2017.02.089>.accessed 28 July 2019

[128] ibid

[129] Francis Kemausuor and others, 'A Review of Trends, Policies and Plans for Increasing Energy Access in Ghana' (2011) 15 Renewable and Sustainable Energy Reviews 5143 <http://dx.doi.org/10.1016/j.rser.2011.07.041>.accessed 10 October 2019

solutions to the challenge, and one of them is the harnessing of its RES. To demonstrate its commitment government enacted the RE Act with the view of increasing the share of non-hydro RE by 10% in the electricity generation mix in 2020. The authors embarked on examining the extent to which the RE Act can deliver on the objectives for which it was enacted. The method employed is a holistic review of the entire RE Act provisions in line with the best practice of RE deployment worldwide. Following the auditing of the Act, it has been established that the Act holds some promise of ensuring the security of energy supply.[130] Nevertheless, the country would have to go beyond the promise and embark on a radical approach to harnessing all its energy resources in a cost-effective manner and integrate them into the electricity generation mix. If this is done, it will keep the lights on at an affordable price for a very long time to come. The optimism expressed by the authors during their study is faced with the stark reality that the 10% penetration is not going to happen, as observed by Obeng-Darko (2018) in his article, why Ghana cannot achieve the 10% target.[131]

Obeng-Darko did a study on why Ghana cannot achieve its 10% non-hydro RE target by the year 2020. Ghana set an ambitious target of adding 10% share of non-hydro RE into the electricity generation mix in 2020 using RETs and energy efficiency measures to meet the target. At the same time, the government set another target of having 100% national electrification coverage for the whole country. Obeng, in his study, argues that Ghana cannot achieve the target it set. The study revealed that as of December 2017, Ghana had only succeeded in making a penetration of 0.5% of electricity from non-hydro RE, a development that gives an indication that the country is heading towards missing the target.[132] Following from this development, the fact is that Ghana needs 9.5% penetration to meet its target, which from 2018 to 2020 it will become impossible to make up the deficit within the short period of time available to the target year. The country's inability to meet this target stems from the poor implementation of the legal instruments deployed. The regulatory agencies have not been able to come out to formulate policies that would aid the achievement of the target. Another challenge is that the regulatory institutions are not independent as such initiative is stifled. The downside to this reality is that it would make investors lose confidence in the government's ability to meet current and future RE policy targets. It brings about uncertainty in investors' operations, and this will ultimately lead to less investment in RE projects which will affect RE targets set.

Selim, Owusu and Rivas investigated determinants of RE consumption for a panel of twenty-one African countries spanning from the period 1990 to 2013 using a random effect generalised least squares regression. The variables used for the analysis include human development index (HDI), democracy (DEM), GDP per capita (GDPpc), foreign direct investment (FDI) and trade openness (TO). The findings state that countries whose GDP per capita is high coupled with a higher human development index consume less RE.[133] These findings contradict earlier studies for some developed countries that concluded that GDP per capita increased RE consumption, such as the study conducted by Sadosky.[134] Also, another finding indicates that foreign direct investment positively impacts RE consumption. Furthermore, the level of democracy is seen not to affect RE adoption directly. Finally, the

[130] Nasir Alfa Mohammed and Ishmael Ackah, 'Analysing the Utility of Ghana's New Renewable Energy Act as Catalyst for Switching on the Lights for National Development' [2015] SSRN Electronic Journal 1. <http://dx.doi.org/10.2139/ssrn.2681030> accessed 14 July 2019

[131] Obeng-Darko (n 20).

[132] Obeng-Darko (n 20).

[133] Selim Jürgen Ergun, Phebe Asantewaa Owusu and Maria Fernanda Rivas, 'Determinants of Renewable Energy Consumption in Africa' [2019] Environmental Science and Pollution Research 15390.<https://doi.org/10.1007/s11356-019-04567-7> accessed 15 September 2019

[134] Perry Sadorsky, 'Renewable Energy Consumption, CO 2 Emissions and Oil Prices in the G7 Countries' (2009) 31 Energy Economics 456 <http://dx.doi.org/10.1016/j.eneco.2008.12.010>. Accessed 20 September 2019

causality test revealed that there is a bi-directional relationship between the variables except for foreign direct investment, which shows a unidirectional relationship.

On the international stage, Marque and others have analysed the drivers of RE in the European Union (EU). They used a panel data technique called fixed effect vector decomposition (FEVD) to work on data spanning from 1990 to 2006. The focus of the study has been on political factors, country-specific factors and socio-economic factors that affect RE development. The study results concluded that traditional energy sources like natural gas, oil, coal, and carbon dioxide emissions play a significant role in undermining the deployment and development of RE. At the same time, the goal of reducing the dependency on energy from conventional sources has led to the increase in the consumption of RE.[135] The advantage of the panel data they used is that it provides more information on the indicators mentioned above, and much more variability of the data, the collinearity between the variables is less, and there is more efficiency in the estimates.[136] Furthermore, FEVD technique is able to generate more efficient estimates compared to simple fixed effect estimator.[137] Given the time span of the data used for this study, technology development regarding each source of RE can change and alter the results, which can lead to wrong conclusions.

Rafiq and Alam studied the determinants of RE consumption in six emerging economies. Data were collected from these emerging countries (Brazil, Turkey, China, India, Philippines, and Indonesia) for the study. The annual data of the countries were collected between 1980 to 2006 and used for the analysis. They used panel methods such as fully modified ordinary least square (FMOLS), dynamic least square (DOLS) and the time series method autoregressive distributed lag (ARDL). Their study produced results that show pollutant emissions and income are the main determinants of RE consumption in China, Brazil, India, and Indonesia in the long run, whilst income appears to be the only factor in RE adoption in the Philippines and Turkey.[138] With all the countries, oil price appears to have an insignificant negative impact on RE use. Rafiq and Alam used a time series technique called autoregressive distributed lag (ARDL) to analyse the data they collected. The advantage of this technique or model is that it offers more robust results in small samples. It also combines lags on both dependent and explanatory variables in an attempt to overcome data limitation concerns. Furthermore, the ARDL model does not require one to know the order of integration or cointegration ranks of the variables, and therefore avoids the limitations inherent in testing for unit roots before testing for cointegration and can be used in studies where the sample size is small.[139] Looking at the study, the data collected spanned a period of time of about twenty-six years, the authenticity of the records could be problematic in that record-keeping in most of these countries cannot be considered to be robust. As such, using data with wrong entries or not up-to-date records could lead to flawed findings and conclusions.

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[135] António C Marques, José A Fuinhas and JR Pires Manso, 'Motivations Driving Renewable Energy in European Countries: A Panel Data Approach' (2010) 38 Energy Policy 6877 <http://doi:10.1016/j.enpol.2010.07.003 > accessed 20 August 2019

[136] Greene W.H, Econometric Analysis. (5th ed. Prentice Hall. Englewood Cliffs 2003) 1 < https://spu.fem.uniag.sk/cvicenia/ksov/obtulovic/Mana%C5%BE.%20%C5%A1tatistika%20a%20ekonometria/EconometricsGREENE.pdf> accessed 7 July 2019

[137] Thomas PÏmper and Vera E Troeger, 'Efficient Estimation of Time-Invariant and Rarely Changing Variables in Finite Sample Panel Analyses with Unit Fixed Effects' (2007) 15 Political Analysis 124 <http:// doi:10.1093/pan/mpm002> accessed 10 August 2019

[138] Shuddhasattwa Rafiq and Khorshed Alam, 'Identifying the Determinants of Renewable Energy Consumption in Leading Renewable Energy Investor Emerging Countries' (2010) Australian Conference for Economists. <http://hdl.handle.net/10536/DRO/DU:30076927> accessed 25 August 2019

[139] ibid

The types of RE policies chosen also attracted much attention in scholarly works. Close attention will be given to these policies as scholars try to investigate their use in the deployment and development of RE.

Stadelmann and Castro have investigated the domestic and international drivers of RE policies in one hundred and twelve emerging and developing countries employing data from 1998 to 2009. Their work concentrated on four different types of policies, namely feed-in tariffs, framework policies, renewable energy targets and other financial incentives. They used the logit-linked discrete-time events history model to examine the policies. The results of their work concluded that with the domestic drivers, wealth and a larger population of a country have a higher chance of influencing the adoption of RE policies. However, RES endowment is only a factor in some specific cases that governments are encouraged to adopt RE policies whilst hydro resources potential hinders the chance of adopting RE targets. Focusing on the international dimension, membership within the EU and copying peers with similar colonial heritage seems to encourage the adoption of RE policies. Whilst climate finance mechanisms help in the adoption of targets and frameworks but are less influential when it comes to tariffs and incentives.[140] The study has some limitations worth highlighting, the study investigation was divided into domestic and international factors. However, this distinction appears simplistic because domestic and international determinants can interact on many fronts. For example, domestic energy also relies on the price and availability of international energy sources and for international climate funding to make any impact, it will depend on national institutions.[141] In this regard, further studies will be required to delve deeper to gain more insights.

Yoon and Sim, in their study, explored the causes why the South Korean government has not been able to deploy its RE policy successfully. They employed qualitative evaluation methods to unearth the causes. The analysis of both primary and secondary data reveals that fossil fuels domination interests, policy shifts, e.g., from feed-in tariffs to RPS and poor monitoring and feedback are responsible for the policy failure.[142] It can be argued that the political environment in which the policy is being implemented which is predominantly inclined to fossil fuels and nuclear interests has played a significant role in its failure and not the policy itself. It Is worth noting that the policy failure resulted in excessive regulation of RE businesses which invariably stifled initiative. The government's monitoring system of RE programmes was not systematic and timely, which led to ineffective implementation of RE programmes that were not thought-through. One of the methods used to draw their conclusion is the qualitative evaluation method which has some limitations on the robustness of the data collected. Collecting data from respondents is exposed to some bias. It thus can introduce the respondents' subjective views, which has the tendency to affect the quality and reliability of the information gathered.

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[140] Martin Stadelmann and Paula Castro, 'Climate Policy Innovation in the South - Domestic and International Determinants of Renewable Energy Policies in Developing and Emerging Countries' (2014) 29 Global Environmental Change 413 <http://dx.doi.org/10.1016/j.gloenvcha.2014.04.011>.accessed 20 September 2019

[141] ibid

[142] Jong Han Yoon and Kwang Ho Sim, 'Why Is South Korea's Renewable Energy Policy Failing? A Qualitative Evaluation' (2015) 86 Energy Policy 369 <http://dx.doi.org/10.1016/j.enpol.2015.07.020>. accessed 30 May 2019

1.9 Contribution of the Research to Knowledge

A. There is a dearth of knowledge in the literature on the effectiveness of the RE legislation and policies in Ghana. Therefore, the thesis is set apart from the works of others by critically examining and evaluating the existing legislation and policies on RE in Ghana to ascertain their effectiveness specifically to address ES challenges.

B. The research advocates for legislative reforms to support RE deployment and development in Ghana, it particularly calls for the establishment of the RE Fund and Authority. A review is needed in respect to some sections of the licensing process especially the one that grants the Minister of Energy the power to review the terms of the licence but does not issue it, the issuance is made by the EC. As such the determination of both the terms and issuance of the licence can be performed by the EC. It further calls for the enactment of a legislation solely for solar to make it a niche technology as was done for hydro to provide ES.

C. The review has established that the existing legal and policy frameworks currently deployed for RE development have been less effective due to the defects in formulation and implementation. The research has detected that this has resulted in Ghana achieving only 0.3% and missing the target of adding a 10% share of non-hydro RE to the electricity generation mix in 2020.

D. The research has established through the comparative analysis of the RE policies of Australia and Cape Verde, the good policies that Ghana can emulate from the two countries, thus the Australian Solar Rooftop Initiative and the Renewable Energy Development Zones policy of Cape Verde

E. The Research has established that Ghana has a substantial solar energy endowment, which can be harnessed to address the ES challenges of the country and help in climate change mitigation. Therefore, there is a need for the GoG to focus on legal and policy frameworks that would help to promote the adoption of solar PV on a large scale.

1.10 Introduction to the Concept of Sustainable Development

Sustainable Development (SD) is very important for societies to attain, and many efforts are needed in the development of RES that would ensure sustainability in energy policy. This is so because energy is at the centre of the SD paradigm. Our activities, demand and consumption of energy do not meet the SD standard required and this has adversely affected the environment which has led to its damage.[143] SD has been defined by the Brundtland report as, development that meets the needs of the present without compromising the ability of future generations to meet their own needs.[144] Tester and others define sustainable energy as "A dynamic harmony between the equitable availability of energy-intensive goods and services to all people and preservation of the earth for future generations".[145] Providing adequate and reliable energy services at affordable prices in an environmentally friendly way and according

[143] Anna Stanford, 'A Vision of a Sustainable Energy Future' (1997) 10 Renewable Energy 417 < https://doi.org/10.1016/0960-1481(96)00099-7> accessed 20 October 2020

[144] Brundtland Report 1987, 'Report of the World Commission on Environment and Development: Our Common Future' <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf> accessed 14 August 2019

[145] Jefferson W. Tester and others, *Sustainable Energy: Choosing Among Options* (2nd edn, Massachusetts Institute of Technology Press London 2012) 10

to the needs of social and economic development is at the heart of SD.[146] In 2015 U.N member states adopted SD goals to protect the environment and ensure prosperity for all. Out of these goals, goal 7 reflects the theme of this research and it states, to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030.

RES offers opportunities for social and economic development, energy access, climate change mitigation, ES, and limitation of environmental degradation towards SD.[147] SD consists of improving the quality of life in a manner that can be sustained economically and ecologically into the future with the support of the country's institutional structure.[148] SD is hinged on three pillars thus economic, social and environment. The economic components are energy use; generation and supply; energy supply efficiency and end-use energy intensity; energy pricing; taxation and subsidies; ES and energy diversity. The social dimension includes health, affordability, energy supply and demand disparities. The environmental dimension deals with global climate change, carbon emissions, air pollution, water pollution, waste generation, deforestation, and land degradation. However, it must be noted that sometimes the concept of SD is interpreted to mean the development of sustainable energy sources to serve the objective of carbon emissions reduction. However, it should be understood rather in terms of ES.

Sustainability is a complex and a multidimensional concept which tries to create a balance between ecological (environment), social and economic dimensions which now pose challenges of our times.[149] These challenges are addressed through the process of SD that calls on the present and future generations to consume the earth's energy resources for both generations in terms of availability, accessibility, and acceptability. Sustainable energy is energy that is abundant and readily available that can be used for a very long time, it contributes to the reduction of GHG emissions, and helps to protect the environment.[150] It, therefore, means our energy system needs to depend on renewables which should be as well sustainable. Sustainability in energy refers to energy sources which have minimal environmental impact whilst considering social dimension through reliable and affordable energy supplies.[151]

Sustainability can be determined by three dimensions thus environmental sustainability, social sustainability, and economic sustainability.[152] Environmental sustainability implies that it does not harm the environment in our exploitation and consumption of energy and the ability of society to improve its environment over a period of time. Social sustainability involves healthy

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[146] Stefan Dragos Cîrstea and others, 'Evaluating Renewable Energy Sustainability by Composite Index' (2018) 10 Sustainability (Switzerland) < https://doi.org/10.3390/su10030811> accessed 28 November 2020

[147] Samuel Asumadu-Sarkodie and Phebe Asantewaa Owusu, 'Carbon Dioxide Emissions, GDP, Energy Use, and Population Growth: A Multivariate and Causality Analysis for Ghana, 1971–2013' (2016) 23 Environmental Science and Pollution Research 13508 <http://dx.doi.org/10.1007/s11356-016-6511-x>. accessed 18 November 2020

[148] Georgina Ayre and Rosalie Callway, *Governance for Sustainable Development: A Foundation for the Future* (Earthscan London 2005) 25

[149] Jefferey D. Sachs, *The Age of Sustainable Development* (Columbia University Press New York 2015) <https://doi.org/10.7312/sach17314> accessed 24 August 2020

[150] A. Armin Razmjoo, Andreas Sumper and Afshin Davarpanah, 'Development of Sustainable Energy Indexes by the Utilization of New Indicators: A Comparative Study' (2019) 5 Energy Reports 375 <https://doi.org/10.1016/j.egyr.2019.03.006>.accessed 19 October 2020

[151] Satu Pätäri and others, 'Competitive and Responsible? The Relationship between Corporate Social and Financial Performance in the Energy Sector' (2014) 37 Renewable and Sustainable Energy Reviews 142 <http://dx.doi.org/10.1016/j.rser.2014.05.012>. accessed 10 January 2020

[152] Wenhao Qi and others, 'Corporate Governance-Based Strategic Approach to Sustainability in Energy Industry of Emerging Economies with a Novel Interval-Valued Intuitionistic Fuzzy Hybrid Decision Making Model' (2020) 12 Sustainability (Switzerland) 1 < https://doi.org/10.3390/su12083307> accessed 19 September 2020

work conditions and wages for workers; it also entails the provision of enough food and energy for all whilst using planetary resources judiciously and efficiently. Economic sustainability is seen when technology can succeed without subsidies. It can be concluded that fossil fuels are not economically sustainable because they rely heavily on subsidies, whilst RE is less dependent on subsidies and can be described as economically sustainable and can meet the demand for energy into the foreseeable future. To achieve energy sustainability, the adoption of RE is one of the effective ways of transitioning from fossil energy in addition to energy efficiency measures that will help achieve crucial targets in the future to meet sustainability in energy consumption.[153]

The concept of SD plays an integral part in this thesis because it lays the foundational premise of both international and environmental law.[154] From the premise, the concept has a modern reflection of how the present generation should recognise the duty they have towards future generations by the judicious use and preservation of our planetary resources so that they can meet their own needs too. Therefore, the research examines in chapter five how legal frameworks deployed for the development of RETs can ensure economic, social, and environmental development. It affords the opportunity to make an analysis of these technologies and to underscore the vital role they play in achieving the goals of SD for present and future generations. The management of natural resources is closely linked to the conceptualisation of SD. The same applies to the development of a sustainable energy legal framework which is linked to the concept of SD. It will be demonstrated in chapter five that through the use of legal tools, RETs can ensure economic, social and environmental development, which are the three pillars of the concept of SD.

1.11 Methodology

To answer the research questions of this thesis, it is important that the methods and methodology used are up to the task. Research of this nature, especially in law, is often difficult to categorise under one subject heading as it involves a collaboration of works that may utilise a hybrid of methods.[155] The methods that will be employed in the research are desktop inquiry, semi-structured interviews, and a comparison of RE laws and policies of Australia and Cape Verde to those of Ghana.

It is particularly imperative as the research strategy of the study is doctrinal. As it sets to examine the challenges and opportunities in the deployment and development of RE and the role the law plays in Ghana.[156] The research is underpinned by a combination of reform-oriented and policy analysis approaches. This kind of research is to review, discover, examine, explain, and analyse facts, principles, provisions, concepts, or the functioning of specific laws

[153] Gul Nihal Gugul, Merih Aydinalp Koksal and V Ismet Ugursal, 'Techno-Economical Analysis of Building Envelope and Renewable Energy Technology Retrofits to Single Family Homes' (2018) 45 Energy for Sustainable Development 159 <https://doi.org/10.1016/j.esd.2018.06.006>.accessed 24 July 2020

[154] Lakshman Guruswamy, 'Energy Justice and Sustainable Development' (2010) 21 Colorado Journal of International Environmental Law and Policy 231 < https://heinonline.org/HOL/P?h=hein.journals/colenvlp21&i=235> accessed 29 August 2020

[155] Michael Salter and Julie Mason, *Writing Law Dissertation: An Introduction and Guide to the Conduct of Legal Research* (Pearson 2007) 31

[156] Terry Hutchinson and Nigel Duncan, 'Defining and Describing What We Do: Doctrinal Legal Research' (2012) 17 Deakin Law Review 83 < https://heinonline.org/HOL/P?h=hein.journals/deakin17&i=91> accessed 18 August 2019

systematically.[157] The purpose of the research methodology is to synthesise and disseminate new knowledge in the subject area.

The thesis adopts qualitative research as part of the strategy for the study. Qualitative research is defined as 'the interpretative study of a specified issue or problem in which the researcher is central to the sense that is made'.[158] This approach affords the researcher to critically analyse the legal frameworks and policies that underpin them to discover their strengths and weaknesses. The in-depth interviews carried out in the thesis are applied as supplementary to the existing scholarly works that have been discussed thus the shortcomings of the RE Act and policies as found in chapter three under section 3.11. The interviews particularly offer to shed more light on the challenges identified following the critical analysis of the RE Act and this further provides insights from the field and affirm what pertains in the existing literature. Furthermore, the thesis adopts some elements of a comparative method identifying any good practices that could be implemented in Ghana, most certainly adjusted to fit its legal, political, economic, and cultural environment. The comparison would be centred on RE laws and policies of Australia and Cape Verde to determine their success and to learn from their pitfalls. Finally, the thesis would apply the desktop approach in order to consult the necessary material for the study. It is important because research of this magnitude requires in-depth scrutiny of the literature for its valuable contents, which will be the building blocks of the study. It is going to be done by visiting the Brunel university library, British Library, University of Ghana Legon library, Ghana Parliament library, and online sources and websites.

Doctrinal research is defined as, "a detailed and highly technical commentary, and systematic exposition of, the context of legal doctrine''.[159] McConville and Chui explained that legal research is either doctrinal or non-doctrinal. They describe doctrinal legal research as the kind of legal research which takes the law as an internal self-sustaining set of principles which can be accessed through reading court judgements and statutes with little or no reference to the world outside the law.[160] Posner also says doctrinal legal research is the task that extracts doctrine from a line of cases or statutory text, re-states it, criticises it or extend it for sensible results in legal principles and common sense, using logic analogy judicial decisions and legal principles.[161]

The approach is acceptable as most legal studies are primarily based on black letter law, which deals with the interpretation of statutes and cases. It is worth noting that though the study of law is based on making logical conclusions, these conclusions are not treated as exact scientific conclusions. As such, they are based on the judgement that other factors can influence, for instance, politics and culture.[162] These overlapping factors have been described by Vicks as 'interdisciplinarity' a congregation of the various areas of study.[163] Nissani intimates that interdisciplinary study can be done with varying degrees of integration.[164] For

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[157] Md. Nuruddeen, The Legal Critical Literature Review (2015) 6(1) UUMJLS pp.23-24 <https://www.researchgate.net/publication/315735114> accessed 15 July 2019

[158] Ian Parker, 'Qualitative Research' in Peter Banister, Erica Burman, Ian Parker, Maye Taylor, Carol Tindall (eds), *Qualitative Methods in Psychology*: *A Research Guide* (Open University Press1994).

[159] Salter and Mason (n 155).

[160] M. McConville and W. Hong Chui, 'Introduction and Overview' in M. McConville and W. Hong Chui (eds), *Research Methods in Law* (Edinburg, Edinburg University Press 2007).

[161] Richard A Posner, 'Legal Scholarship Today', Harvard Law Review,115:5, 2002,1314-1326. <https://www.jstor.org/stable/1342547> accessed 20 July 2019

[162] Oliver Wendell Holmes Jr, "'The Path of the Law" (1897)'10:8 Harv L Rev 457, 465-6<http://moglen.law.columbia.edu/LCS/palaw.pdf> accessed 15 September 2019

[163] Douglas Vick, 'Interdisciplinarity and the Discipline of Law' (2004) 31 Journal of Law and Society 163, 193. <https://doi.org/10.1111/j.1467-6478.2004.00286.x> accessed 20 August 2019

[164]Moti Nissani, 'Fruits, Salads and Smoothies: A Working Definition of Interdisciplinarity' (1995) 29 Journal of Educational Thought 121, 124. <https://cdm.ucalgary.ca/index.php/jet/article/view/52385> accessed 12 July 2019

instance a researcher can demonstrate how two areas are closely related but do not go ahead to combine them. Vick states 'many `interdisciplinarians perceive doctrinalists to be intellectually rigid, inflexible, and inward-looking; many doctrinalists regard social-legal interdisciplinary research as amateurish dabbling with theories and methods the researchers do not fully understand'.[165]

This thesis is not seeking to be rigid or to lay claims to socio-legal research, but rather the remote objective is to make a critical in-depth evaluation of the RE Act and policies and their effectiveness in Ghana to address ES challenges. Once this thorough examination is done, the researcher will proceed to give recommendations from the findings. The thesis is doctrinal in its methodological approach as it attempts to critically analyse the legal material that would help answer the research questions.[166] There are some advantages to using the doctrinal approach; it lays the foundation on which the thesis can build to proceed. However, it is worth noting that doctrinal research has been criticised for being formalistic in approach.[167] In that sense, this, at times, can lead to the oversimplifying of the doctrine, which does not give reasonable grounds for the thesis and the questions it attempts to answer.[168] However, this thesis uses the doctrinal approach as a starting point, and the fears of the criticism will not manifest as it is the researcher who directs the approach to apply in the analysis of the material gathered. The sources of data for the thesis will be the RE legal instruments that are currently in operation in Ghana, eliciting knowledge through in-depth interviews from experts, policymakers, academics, non-governmental organisations, and a comparative analysis. These data will be subjected to scrutiny and analysis in order to answer the research questions.

1.11.1 Empirical Research

Brunel University London's regulations require that any research which involves human participants, the collection or study of their data, and the use of their organs or tissue require research ethics approval.[169] As such, in fulfilment of the requirement, the researcher made an application to the College of Business, Arts and Social Sciences Research Ethics Committee of Brunel University to undertake this project. The Ethics Committee granted the researcher approval for the research to be conducted between 01/05/2020 and 28/02/2022 before the researcher could embark on the trip to Ghana to collect data. However, the researcher could not go on the field trip in 2020 due to the outbreak of the Covid 19 pandemic until September 2021.

In the interview guide, questions are designed as open-ended, which gives the participants the opportunity to respond to the questions in their own words. The questions consisted of four main parts: The first part included questions on the socio-economic information of the participants, e.g., gender, age, and level of education. background information on the RE situation in Ghana, the RE law, policies, and incentives that the GoG has adopted to promote the development of RE in the country. The second part had questions focused on regulatory constraints and financial constraints. The third part contained questions that assessed the effectiveness of the RE Act and policies on RE development in Ghana, and the fourth part presented the closing questions. The interview questions were then piloted to ensure that the

[165]Vick (n 163).
[166] Hutchinson and Duncan (n 156).
[167] Salter and Mason (n 155).
[168] Michael Salter and Julie Mason, Writing Law Dissertation: An Introduction and Guide to the Conduct of Legal Research (Pearson 2007) 31
[169] Brunel University London, Code of Practice for Research Degrees, Applicable from September 2018 pg. 12.

proposed interview will investigate the research problem effectively, refine and shape the questions in readiness for the actual interviews to be undertaken.

On arrival in Ghana in September 2021, the researcher presented a letter of introduction from Brunel University London (College of Business, Arts and Social Sciences) to the chief directors of the various institutions to grant the researcher permission to recruit their staff for the research. The permission was granted through an official letter communicated to the researcher. The researcher found this process rather bureaucratic and complex which is frustrating to researchers. For the interviews, the researcher sampled experts from four key stakeholder groups applying the snowballing method.[170] In total, ten experts participated in the interviews, which took place between September to December 2021. The interviews were conducted via zoom due to Covid 19 Pandemic social distancing rules. The time duration ranged from 45 minutes to one hour and was mostly recorded with the consent of the participants, and this is deemed as an effective way of retrieving data.[171] The participants were asked questions from the interview guide.

The participants for the semi-structured interview came from the Ministry of Energy (MOEn), EC, academia, and Africa Centre for Energy Policy (ACEP). The selection of the participants who were referred mainly by their colleagues was guided by the specific area of specialisation in RE policy of the expert and their involvement in the RE subsector in Ghana. The researcher recruited three participants from the MOEn, three from EC, three from academia and one from ACEP. The selection of MOEn is because the ministry represents the GoG and has oversight responsibilities over the whole energy sector in Ghana. At the same time, the ministry initiates all energy policies through the EC, including RE. Furthermore, the EC was selected because it is the regulator of most of the policies evolved and advises GoG through the MOEn on energy matters, these are the key players the researcher wanted to interview to know the latest trend in the RE subsector in Ghana. These two institutions, MOEn and EC, are important in the development of RE as they play important roles in policy formulation, regulation, and implementation in Ghana.

The decision to interview these experts stems from the fact that they have accumulated both quantity and quality knowledge relevant to the topic over the decades. Expert knowledge and opinion are loaded with many years of study. Furthermore, experience in the field coupled with decision-making certainly is vital for the shaping of RE development in Ghana into the future. These data count as they throw more light on the understanding of RE development in Ghana. Collecting information from experts is proper as it affords the researcher the opportunity to collect vast volume of data within a relatively short period of time, which can be transcribed, analysed, and interpreted to answer the research questions.

There are three main types of interviews, namely: structured, semi-structured and unstructured.[172] Semi-structured which is the choice of this thesis lies in the middle of the other two, in this, the researcher has a set of predetermined questions to ask, which are primarily open-ended in the case of this thesis, and the participant is allowed flexibility to answer and provide more elaboration which elicits more in-depth knowledge.[173] The advantage of an in-

[170] Nissim Cohen and Tamar Arieli, 'Field Research in Conflict Environments: Methodological Challenges and Snowball Sampling' (2011) 48 Journal of Peace Research 423 < https://doi.org/10.1177/0022343311405698> accessed 10 December 2021

[171] Shazia Jamshed,' Qualitative research method-interviewing and observation' (2014) 5 (4) Journal of basic and clinical pharmacy <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4194943/pdf/JBCP-5-87.pdf> accessed 28 October 2021

[172] ibid

[173] Fiona Fylan, 'Semi-structured interviewing' In Jeremy Miles and Paul Gilbert (eds), *A handbook of research methods for clinical and health psychology* (Oxford University

depth interview is it allows the researcher to collect more detailed information about the research problem. However, the disadvantage is that participants may introduce their own biases in the answers they provide. As such, the questions are designed in a way to minimise this weakness, i.e., open-ended questions centred on the benefits of RE. To further minimise the occurrence of this, is to build rapport with the participants to win their trust to get the most relevant information from them.[174]

Finally, there may be some limitations in the robustness of the participants' answers because they come from their subjective views and experiences. Based on this, the researcher has complemented the findings with secondary sources thus (desktop analysis of the literature), which can be considered more objective to mitigate the weakness. Moreover, from the style of questioning, the researcher knows what he is seeking to achieve. therefore, these questions are designed into an interview guide.

The thesis has chosen semi-structured interview because it allows experts to be able to give more knowledge gained through several years of experience and practice, and they are now used more in contemporary times as a method for data collection in many disciplines, including energy hence the decision to use it.[175]

1.11.1.1 Semi-structured Interviews

The primary information for this thesis is derived from semi-structured interviews with experts from different areas of RE development and policy fraternity in Ghana. They provided invaluable knowledge and facts based on several years of experience and practice on RE in general and provided more insights on the implementation of the RE Act and policies specifically.

The method chosen to analyse and interpret the data collected from the semi-structured interviews was the qualitative content analysis using Microsoft word's qualitative content analysis. It is because the dataset is small and not complex; otherwise, if this had been a large dataset, the researcher would have used NVivo software to do the analysis. Qualitative content analysis is defined by Krippendorff as, ''a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use''.[176]'' The reason for using content analysis for the thesis is to organise and get meaning from the data that have been collected and to interpret them to draw realistic and trustworthy conclusions.[177] Data collected from the interviews were transcribed and analysed in a way that the differences and similarities were compared thus revealing the different patterns with regards to the data analysed. It led to the grouping of these data into categories and themes and finally the data was interpreted to make meaning out of them, which was then used to answer the research questions. Furthermore, this approach allows for an in-depth understanding of the data analysed which provides a deeper understanding of whether the RE Act and policies have been effective in addressing ES challenges in Ghana.

Press 2005) 65 <https://cpb-us-e1.wpmucdn.com/wp.wwu.edu/dist/8/2868/files/2018/04/Fylan-2005-Semi-structured-Interviews-1c47gyp.pdf> accessed 02 November 2021

[174] Lisa M. Given, *The SAGE Encyclopaedia of Qualitative Research Methods* (Vol. 2 SAGE Publication 2008) 432

[175] Timo von Wirth, Linda Gislason and Roman Seidl, 'Distributed Energy Systems on a Neighbourhood Scale: Reviewing Drivers of and Barriers to Social Acceptance' (2018) 82 Renewable and Sustainable Energy Reviews 2618 <https://doi.org/10.1016/j.rser.2017.09.086>. accessed 19 September 2021

[176] Klaus Krippendorff, *Content Analysis: An Introduction to Its Methodology* (2nd edn, SAGE 2004) 18

[177] Mariette Bengtsson, 'How to Plan and Perform a Qualitative Study Using Content Analysis' (2016) 2 Nursing Plus Open 8 <http://dx.doi.org/10.1016/j.npls.2016.01.001>. accessed 10 August 2021

1.11.1.2 Coding and Codes Categorisation

In qualitative data analysis, coding refers to labels used to organise ideas to interpret the data to enable the researcher to answer the research questions. The codes are assigned as texts of different sizes and are usually a word, or a short phrase that represents a broader idea or theme.[178] Coding is used to find patterns, similarities or differences between the different texts that have been analysed using the coding structure that was created, this procedure helps to bring together codes that have the same label and to find the most meaningful way of interpreting the data.[179] Which means the interpretation that has been made can be supported by the data which have been coded.

Coding is an integral part of the analysis but does not constitute analysis on its own. It helps in finding answers to the research problem being investigated systematically through the analysis process, which begins with raw information, evolving to abstract and to a more complex understanding of the concerns. It must be noted that coding is just one way of analysing qualitative data, not the way.[180] Coding is determined by two approaches, thus inductive and deductive. With the deductive, the researcher creates the coding list before the start of the analysis, whilst in the inductive approach, the codes are derived from the information generated from the interview transcripts, which correspond with the research questions and are used to do the analysis.[181] This thesis has adopted the inductive approach to allow the codes to be generated from the data collected from the interviews using the In Vivo coding which means using verbatim the words and phrases of the participants.[182]

On arrival in Ghana to collect data, the researcher encountered some challenges; thus, the bureaucracy request to submit a letter of introduction from the university before officials from the MOEn could speak to the researcher. After approval was granted, getting officials to participate in the research was not easy. Furthermore, due to the Covid 19 protocols in Ghana, a face-to-face interview could not be held and was changed to online. The field study results are discussed in chapter three- under section 3.11 of the thesis.

1.11.2 Desktop Inquiry

The Collection of data through interviews alone may not suffice the needs of the research. One flaw of this mode of data collection is the likelihood of participants introducing their biased judgement into the interview, so it will be prudent to consult and review the existing literature. These commentaries provide insights into the problem that has been investigated to cure biases. It is done to increase the robustness of the information. Consulting existing literature allows the researcher to identify the similarities and dissimilarities that exist in the works of other scholars. Furthermore, it gives the researcher the chance to understand the relevant issues pertaining to the field. So, in the end, the researcher will rely on these pieces of information to help make well-informed decisions and conclusions.

Because additional information would be needed to help the thesis deliver on its core objectives, the desktop approach is used to gather in-depth relevant information for the write-up. The desktop or library-based inquiry involves searching legal databases and other online relevant resources, press releases, and libraries, including the British Library, Brunel University Library, and Legon library (in Ghana). Also, relevant journal articles, textbooks, legislation, case law, NGO and industry reports, government reports, other relevant

[178] Johnny Saldana, *The Coding Manual for Qualitative Researchers* (2nd edn, SAGE 2013) 3
[179] Carl F. Auerbach and Louise B. Silverstein, Qualitative Data: *An Introduction to Coding and Analysis* (New York University Press 2003) 31
[180] Saldana (n 178).
[181] Bengtsson (n 177).
[182] Saldana (n 178).

documentation on Ghana's RE legal and policy frameworks will be consulted. All the different types of literature are being reviewed for the value of their contents. The relevant chapters of the thesis would make the analysis, synthesis, and assimilation on the material.

Adopting this method allows one to search all spheres of the laws relevant to the study and examine and analyse the topic in light of the prevailing legal landscape in the context of RE development in Ghana. The approach allows for critical evaluation in order to identify gaps, barriers, challenges, amendments, conflicts and lacunae in the law and the interactions between these laws and their implementation. The relevant policies are also discussed, and this enables the researcher to offer suggestions for reform.

In the desktop-based approach, information was gathered on the various RE policies and legal frameworks from some jurisdictions considered to be doing well in the RE sector for in-depth review. These countries include Cape Verde and Australia. Cape Verde is a state in West Africa just like Ghana but happens to be steadily and successfully harnessing its RES in a much better way than Ghana. Australia provides funding towards the harnessing of its RES, and it is among the world's leaders in solar rooftop adoption, a policy Ghana can adopt to improve its rooftop programme. All these countries have some success stories worth emulating by Ghana if it wants to overcome its energy generation deficit challenges and improve its ES. Therefore, a critical analysis of these legal and policy frameworks of these countries will be done to gather vital information which can be used to shape Ghana's RE policies and legal frameworks for better implementation.

1.11.3 Comparative Analysis

As mentioned earlier, the method to be used is the comparison of Australian and Cape Verdean RE laws and policies to those of Ghana. The comparison has become necessary due to the fact that RE has just begun to pick up the pace. As such, the researcher is looking across to other jurisdictions for policies that have been tested and yielded the desired results. It is a promising endeavour that can only be achieved when the researcher performs a comparison of the policies used in other countries.

Comparative analysis allows the study of the differences and similarities of the law or policies of different countries' legal systems to gain insight into the best policies used around the world for emulation. However, the thesis is not seeking to use comparative analysis to recommend the transplanting of any policy from another jurisdiction because Collins concluded that such an endeavour is not effective.[183] The reason is grounded and concurred with the arguments of Kahn-Freund, who says that legal rules have a historical setting and social development of a country, as a result, the direct transplant of a rule or law may not yield the same results as it did in its home jurisdiction.[184] Following these criticisms, Collins underscores that a comparative law study should be done to understand how one's legal system and a foreign jurisdiction have handled the same problem.[185] One central aim of the comparison in this thesis is to assess the RE policies of the two countries to learn lessons from the failed ones and to emulate the good ones and adapt them to suit Ghana's peculiar situation in its quest to overcome the barriers of RE development.

One disadvantage of using the comparative approach is that it is sometimes difficult to access information readily on some key issues that the thesis will be demanding in some jurisdictions. Another disadvantage of the comparative approach is that it could be used descriptively, thereby rendering the results of the comparison valueless, which does not fit into any relevant

[183] Hugh Collins, 'Methods and Aims of Comparative Law' (1991) 11:3 Oxford Journal of Legal Studies 396-406 <https://www.jstor.org/stable/764215> accessed 10 October 2019
[184] Kahn-Freund (n 21).
[185] Collins (n 183).

context of the research. The thesis seeks to avoid these disadvantages of the approach. Instead, it would focus on the results that could be used to understand the policies of other jurisdictions to enhance the quality of the thesis for the appropriate recommendations to be made. The complete comparative analysis of the RE laws and policies of Ghana, Cape Verde and Australia can be found in chapter four.

In conclusion, the thesis proceeds on the foundation of doctrinal research, which uses other essential research strategies and tools to derive the answers to the research questions. A combination of methods is employed to provide a robust research strategy; these include empirical research, the desktop inquiry and comparative analysis that are deemed fit to be added. Empirical research enables the researcher to gather the primary data necessary for the research. The desktop inquiry allows further searches of the relevant material from databases, books, newspapers, and journal articles to augment the empirical one. The comparative analysis affords the chance to check other jurisdictions for relevant material for the research. Finally, the comparative analysis allows the researcher to study the differences and similarities of the laws and policies of different countries to gain an insight into the best practice so that Ghana can emulate but not calling for a direct transplant of a policy from one jurisdiction to the other.

1.12 Layout of the Thesis

The thesis demonstrates the practical application of legal tools to establish the deployment and development of RETs to achieve sustainability in energy generation and consumption in Ghana. The thesis is arranged into eight chapters as follows:

Chapter One lays the foundation of the thesis and introduces the topic providing the background to the study, research aim and objectives, research questions, justification of the research, theoretical foundation, issues outside the scope of the study, literature review, the contribution of the research to knowledge, introduction to sustainable development as a conceptual framework and methodology.

Chapter Two follows the introduction and provides an overview of the energy sector in Ghana in general, which includes both conventional and RE sectors. The chapter probes further to see how the sector is coping with the current energy exploration, exploitation, and consumption trend. It has looked at how the sector has responded to global initiatives to stem the impact of climate change caused by fossil fuels and how to balance the ever-increasing demand for energy and, at the same time, cut carbon emissions.

Chapter Three examines the types of RETs, legal and policy frameworks deployed in Ghana. First, it explains the transition from conventional sources to RES. It reviews the existing legal frameworks and policies to ascertain their effectiveness in the development of RE, by providing a critical analysis of the RE Act and related policies. The main argument is that the existing legal frameworks and policies in their current state are grossly deficient and need review to cure the weaknesses in them in order to address ES challenges.

Chapter Four provides a comparative analysis of the RE laws and policies of Australia, Ghana, and Cape Verde. It has considered the institutional set-up of the countries including the strategies used to develop RE in their various countries. The results show that the solar rooftop initiative of Australia and RE development zones of Cape Verde are worthy of emulation by Ghana.

Chapter Five discusses the legal and policy frameworks that support RETs to make them environmentally friendly in Ghana so that humankind can gain from their environmental

benefits. The chapter also looks at the transition from fossil fuels to RETs and the impact on the environment. It further discusses the ability of legal tools to promote RETs in Ghana to make them competitive. Finally, it considers SD as a conceptual framework and assesses its potential as a legal tool to support the deployment of RETs.

Chapter Six discusses the challenges and opportunities in adopting RE and the effectiveness of the legal tools in addressing ES challenges in Ghana. It provides extensive discussion on ES. Finally, it discusses the mitigation actions required to eliminate the key barriers that impede RETs deployment. Nuclear has been considered to see whether it can provide the same benefits as RE; it came to light that it may possess similar benefits to RE, especially as it is emission-free, but concerns about its safety have been raised.

Chapter Seven considers the legal and policy frameworks on solar energy development and its adoption as a priority in Ghana. An overview of solar energy potential and solar photovoltaic (PV) deployment has been made. It has been confirmed that Ghana has a high potential for solar energy, and a case study has been conducted on the Pungu Solar Power Plant. Indeed, its exploitation is economically viable as well as environmentally beneficial. However, the supporting legal instruments establishing solar PV are inadequate. Therefore, a call is being made for the GoG to formulate legal and policy frameworks that would focus solely on solar PV, which will lead to its large-scale adoption and deployment. This is due to the economic and environmental benefits it can offer.

Chapter Eight draws the conclusion of this thesis and provides some recommendations for adoption in Ghana for sustainable energy generation and consumption. Applying the observation made by Solomon and Krishna, ‘while there is much ground for pessimism in accomplishing a rapid transition to sustainable energy, direct regulation and mandates appear to be the most effective’.[186] From the above statement, the thesis concludes that there is a need to develop a more effective legal and policy frameworks that would be dedicated to non-hydro RETs, especially solar PV, as Ghana is endowed with plenty of solar energy.

[186] Barry D Solomon and Karthik Krishna, 'The Coming Sustainable Energy Transition: History, Strategies, and Outlook' (2011) 39 Energy Policy 7422 <http://dx.doi.org/10.1016/j.enpol.2011.09.009>. accessed 31 July 2021

CHAPTER TWO

OVERVIEW OF THE ENERGY SECTOR IN GHANA

2.1 Introduction

This chapter aims to give an overview of Ghana's energy sector and see the transformation that has taken place over the years following the introduction of reforms in some subsectors. Ghana is a constitutional democracy whose legal system is founded on the English common law system.[187] The president serves dual roles; thus, he/she is the head of government and head of state at the same time. The Ghanaian system is hinged on the three arms of government, namely, the executive, the legislature, and the judiciary. The Parliament of Ghana operates the unicameral system with two hundred and seventy-five members of Parliament (MP), and the MPs are elected every four years. There is no term limit as to the number of times one can run for the office of MP. However, in the case of the president, there is a term limit, the winner of the election for the office of the president can rule for four years, and he/she can seek re-election for another four years making eight years in total, and that ends it. It means that the office of president is two terms, each term consisting of four years which cannot be exceeded as stipulated by the 1992 constitution of Ghana.[188]

Ghana's total landmass is estimated to be about 23,853,300 hectares, and approximately 14,850,000 hectares out of the total landmass is classified as agricultural for the purposes of farming, arable land constitutes about 28% and out of which16% represents permanent crops.[189] The current total population of the country stands at about 30.8 million people from the official provisional results of the 2021 Population and Housing Census.[190] Ghana is divided into sixteen administrative regions and Accra is the capital city.

Demand for energy to meet social and economic development and improve human livelihood and welfare is on the increase in order to meet the basic human needs and productivity.[191] The overall worldwide energy demand rose by 2.3% due to a robust global economy and strong demand to meet the heating and cooling needs of some regions.[192] Natural Gas (NG) emerged as the popular fuel of choice accounting for 45% rise in the energy consumed.[193] Demand for other fuels showed a significant increase, with fossil fuels leading by 70% and solar growing by 31% all in 2018.[194] Energy development has a close relationship with the

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[187] Michal Nachmany and others, 'Climate Change Legislation in Ghana the 2015 Global Climate Legislation Study A Review of Climate Change Legislation in 99 Countries Ghana Legislative Process Approach to Climate Change' <www.lse.ac.uk/GranthamInstitute/legislation/> accessed 8 June 2019

[188] The 1992 Constitution of the Republic of Ghana (Act 527) article 66 (2)

[189] Moses Hensley Duku, Sai Gu, and Essel Ben Hagan, 'A Comprehensive Review of Biomass Resources and Biofuels Potential in Ghana' (2011) 15 Renewable and Sustainable Energy Reviews 404 <ahttps://doi.org/10.1016/j.rser.2010.09.033> accessed 10 June 2019

[190] Ghana Statistical Service, 'Ghana 2021 Population and Housing Census' < https://census2021.statsghana.gov.gh/> accessed 25 November 2022

[191] Intergovernmental Panel on Climate Change, Special Report on Renewable Energy Sources and Climate Change Mitigation (Eds Core Writing Team, O. Edenhofer, R. Pichs-Madruga, Y. Sokona) (2011) <https://www.ipcc.ch/site/assets/uploads/2018/03/SRREN_FD-SPM_final-1.pdf> accessed 18 May 2019

[192] International Energy Agency, 'Global Energy Demand Rose by 2.3% in 2018, its Fastest Pace in the Last Decade' (IEA, 28 March 2019) <https://www.iea.org/newsroom/news/2019/march/global-energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-last-decade.html> accessed 11 August 2019

[193] ibid

[194] International Energy Agency, 'Global Energy Demand Rose by 2.3% in 2018, its Fastest Pace in the Last Decade' (IEA, 28 March 2019) <https://www.iea.org/newsroom/news/2019/march/global-

economic development of a country. Energy access by citizens of a country directly impacts the country's economic development and would ultimately lead to human development. However, it is reported that about 1.1 billion people worldwide have no access to this vital resource and therefore do not have access to electricity. According to Energy Access Outlook 2017, a good proportion of these people come from developing countries, about 95% of them are living in rural communities in Sub-Saharan Africa and developing Asia.[195]

Ghana is relatively endowed with different types of energy resources; these resources include hydro, biomass, wind, hydrocarbons, and solar. The primary energy consumed by most households in Ghana is from wood fuels in the forms of firewood and charcoal. However, the consumption of wood fuels, thus firewood and charcoal, is not sustainable. The unsustainable production and consumption of wood fuels have led to the depletion of the country's forests, even though that is not the only cause. According to the U.N Food and Agriculture Organisation (FAO), the rate of deforestation in Ghana is 3% per annum. Also, according to World Health Organisation (WHO), about 3.2 million people die prematurely in the world attributed to household indoor air pollution using firewood, charcoal, and dung.

According to Ghana's Strategic National Energy Plan document (2006 to 2020), the energy sector's vision is to develop an "Energy Economy" that would be able to deliver reliable, secure high-quality energy services, which is affordable to all sectors of the economy, in an environmentally friendly manner whilst making much contribution to the country's foreign export earnings. This vision has not been realised. In the first place, Ghana is not a major power and oil exporter; the oil produced from the country's oil fields is sold to the international market, and the country then imports oil to meet its domestic needs. The current energy generation is unreliable and erratic, leading to an energy crisis experienced from time to time.

Furthermore, Ghana built and relied on its hydropower dams. However, the over-reliance on these dams has plunged the country into an electricity crisis for about two decades due to erratic rainfall pattern attributed to climate change. This situation made the government to introduce other alternatives to augment the small power generated from the dams. The alternatives added into the electricity generation mix include thermal and non-hydro RE. This chapter is devoted to having an overview of the energy sector to see how the sector is coping with the current trend in energy exploration, exploitation, and consumption. Furthermore, it will look at how the sector has responded to global initiatives thus to balance the ever-increasing demand for energy and, at the same time, reduce carbon emissions caused by fossil fuels and stem its effects on the environment. Attention will be given to the various sub-sectors, including the electricity subsector, petroleum subsector and wood fuels subsector.

The chapter is divided into eight main sections with subsections, following the introduction is section 2.2 which gives a brief history of the different phases of electricity development in Ghana. Section 2.3 focuses on the institutional set-up of the electricity subsector. Section 2.4 discusses the electricity subsector. Section 2.5 examines the petroleum subsector. Section 2.6 discusses the wood fuels subsector. Section 2.7 looks at the legal regime governing the energy sector in Ghana and section 2.8 concludes the main issues discussed in the chapter.

energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-last-decade.html> accessed 11 August 2019

[195] Samuel Asumadu-Sarkodie and Phebe Asantewaa Owusu, 'A Review of Ghana's Energy Sector National Energy Statistics and Policy Framework' (2016) 3 Cogent Engineering <http://dx.doi.org/10.1080/23311916.2016.1155274> accessed 16 May 2019

2.2 History of the Different Phases of Electricity Development in Ghana

The energy sector is defined as comprising all energy extraction, conversion, storage, transmission, and distribution processes including companies that provide equipment and services.[196] A discussion was made on the history of the different phases of electricity development that Ghana has gone through in chapter one under section 1.2 and would be considered to be potentially part of this section.

2.3 Institutional Set-up of the Electricity Subsector

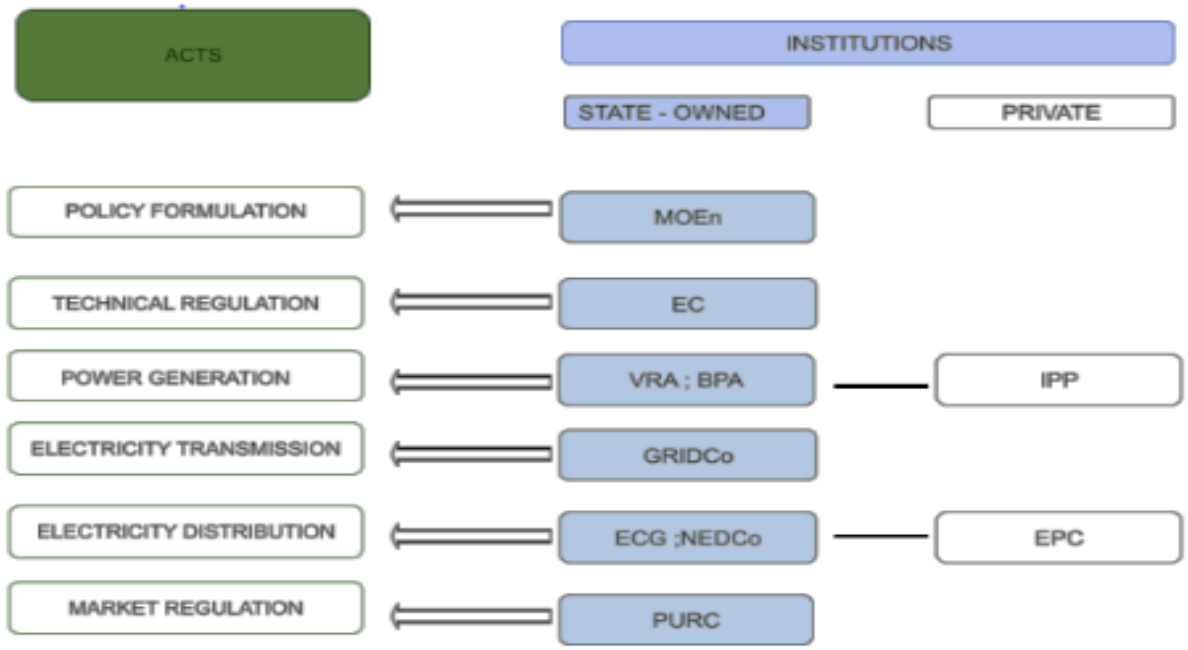
The Ghana electricity sector comprises three main bodies thus, the Ministry of Energy (MOEn), two regulatory bodies, namely the Energy Commission (EC) and Public Utilities Regulatory Commission (PURC) and an industry which is made of utility suppliers and consumers or buyers. The electricity sector is managed by three institutions whose work complements each other. The institutions are MOEn, EC and PURC, a government-funded independent regulator. The MOEn is a government institution whose sole responsibility is to formulate, monitor and evaluate policies, projects, and programmes and to oversee to the implementation of the National Electrification Scheme (NES) in the energy sector.[197] It also liaises with other agencies on matters concerning power and supervises state-owned utilities to ensure they render good services.

A synopsis of the functions of the institutions can be found in figure 1 below.

[196] James Chen, 'Energy Sector: Understanding What Types of Companies Comprise It' (Investopedia, 14 October 2022) <https://www.investopedia.com/terms/e/energy_sector.asp> accessed 27 December 2022

[197] Felix Amankwah Diawou and Jacek Kamiński, 'An Analysis of the Ghanaian Power Generation Sector Using an Optimization Model' (2017) 97 Journal of Power Technologies 15.2 <http://www.papers.itc.pw.edu.pl> accessed 12 July 2019

Figure: 1 Institutional Structure of the Electricity Sector in Ghana



Source: Adapted and Updated from Sakah and Others (2017)

The Energy Foundation of Ghana is a Public-Private Partnership, a non-profit making body. Its core functions include promoting energy efficiency and the promotion of RE. These functions would lead to the expansion of the country's energy mix to satisfy the ever-increasing demand for energy to improve Ghana's ES. The Private Enterprise Foundation entered into a partnership with the GoG to establish the Energy Foundation in 1997. It was done to approach energy consumption in all its forms in a sustainable manner.

2.4 Electricity Subsector

At this juncture, an in-depth look at the electricity subsector will be made to give an overview of how it has coped with the changes introduced and to understand the reforms that have taken place over the years to the present day. Electricity in Ghana plays a key role in economic growth and expansion. However, in recent times demand for electricity has continued to rise whilst the supply side is finding it challenging to keep up with this rise resulting in a major power crisis called 'dumsor' meaning off and on. The GoG, with the support of international donor agencies, has approached the challenge by outlining some measures to obliviate the crisis. These reforms include doubling installed generation capacity by 2015, attracting Independent Power Producers (IPPs) to the electricity generation market and the extension of

access to electricity to all communities nationwide in 2020.[198] Ghana has one of the highest electrification coverages in Sub-Saharan Africa, with 87% access to electricity as of 2021, according to EC.[199] The access rate by population was 28% in 1988.[200] However, there are some disparities in electricity access between the urban and rural areas with the urban areas having more access than their rural counterparts.

Ghana's main sources of electrical power include hydro, thermal and solar. The electricity subsector has undergone different transformation because state-owned companies previously dominated it. However, due to GoG's initiative in attracting private sector participation, IPPs have begun to penetrate the electricity generation market, which was hitherto the monopoly of state-owned companies. The distribution sector has two state-owned companies, ECG and NEDCo and a private company known as Enclave Power Company Ltd (EPC). However, in the generation sector, IPPs are actively involved spelling the end of the monopoly of VRA.

2.4.1 Power Producers and Reforms in the Electricity Subsector

Attention will be turned to the institutions that manage the electricity subsector. The VRA is a state-owned company responsible for the generation of electricity and supplying it in bulk to the transmitting company, Ghana Grid Company Ltd (GRIDCo).[201] VRA was established in 1961.[202] The GoG now turned its attention to thermal by bringing onboard thermal plants that use light crude oil and natural gas to generate electricity. As observed, the reforms in the energy sector were necessitated by two main factors thus the growing demand for power and difficulties in accessing finance to invest in the energy sector. The World Bank (WB), the traditional financier of the power sector, was unwilling to fund any power sector investments, especially in developing countries unless the countries involved committed to reforms of their energy sectors.[203]

Ghana eventually committed to reforms and got financial support from the WB. GoG accepted the bank's diagnosis of the problems facing the energy sector, but it, however, rejected the bank's prescription and designed its own programme.[204] These reforms were necessary as the transformation in the energy sector can be traced to the WB, especially the establishment of Ghana Grid Company and the two regulatory institutions: thus, EC and PURC. These institutions were created due to the reforms and are still vibrant and provide transmission, technical and regulatory services to the energy sector in Ghana. In addition, the reforms allowed the entry of IPPs into the energy sector, but prior to that, the sector was dominated by state-owned companies. Currently, there are many IPPs in the sector, with some having a

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[198] Ministry of Energy, 'National Energy Policy 2010' (MOEn, February 2010) <https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/GHANA%29%20National%20Energy%20Policy.pdf> accessed 28 July 2019

[199] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022

[200] George Yaw Obeng and Others, 'A Review of Trends, Policies and Plans for Increasing Energy Access in Ghana' <https://www.africancityenergy.org/uploads/resource_45.pdf> (The Energy Centre KNUST, May 2009) accessed 28 July 2019

[201] Michael A. Opam and John K. Turkson, 'Power Sector Restructuring in Ghana: Reforms to Promote Competition and Private Sector Participation' in John K. Turkson (eds), Power Sector Reform in Sub-Saharan Africa (Palgrave Macmillan, 2000)

[202] VRA operates the Akosombo and Kpong hydropower dams. It also operates the Tema TT1 IPP plant, the Aboadze T1 plant and the Takoradi Thermal Power Plant both located at Aboadze. VRA in partnership with TAQA runs the Takoradi International Power Company (TICo) a thermal plant located at Aboadze. Furthermore, VRA manages Tema TT2PP plant and Mines Reserves plant.

[203] Ishmael Edjekumhene, A. Bawa and Abeeku Brew-hammond, 'Power Sector Reform in Ghana: The Untold Story' [2001] Kumasi Institute of Technology (KITE) 1 <http://pdf.wri.org/power_politics/ghana.pdf> accessed 27 June 2019

[204] ibid

niche for RE. Furthermore, from the outset, the increase to access to electricity through the National Electrification Scheme was a priority to the GoG as part of the reforms. It set the target of extending electricity to every part of the country in 2020. However, the target was not achieved, albeit the national access rate increased to 87% according to the EC in 2021, which is still impressive compared to 28% in 1988, as seen above.

In recent times and years, VRA has undergone evolution which has brought about significant changes to its role and operations in the sector by ceding some of its functions (transmission, distribution) to other bodies to focus solely on generation, which is its core mandate. This restructuring process is done to bring about competition, and to encourage and attract private investment into electricity generation and supply in Ghana.[205] To this end, VRA transferred its transmission responsibilities to GRIDCo in 2005. In May 2012, the distribution sector was re-organised, and NED became a wholly owned subsidiary company of VRA, now called the Northern Electricity Distribution Company (NEDCo). VRA's responsibilities within the Volta Basin have been taken over by the Bui Power Authority (BHA), which is an IPP whose mandate is to develop hydro resources within that enclave; Bui lies within the Black Volta basin.[206]

Another important group in the generation sector who are active participants in the market is the IPPs. They have installed plants that use NG or light crude oil to fire thermal plants to generate electricity, and more of such producers are entering the market with some with the niche for the RE market e.g., Bui Power Authority. The introduction of thermal was to augment the shortfall in hydro generation. The installed plants used light crude oil and NG as the fuel to burn to generate electricity. The introduction has proven providential that more and more have been added until thermal has surpassed hydro in the electricity generation mix. The main challenge with the two fuels used is that they are derived from fossil fuels that produce carbon emissions which negatively impact the environment (climate change). Oil and gas reserves are dwindling whilst prices are high and very volatile; in the long-term energy planning, reliance on fossil fuel sources to feed the plants for electricity generation can be unreliable and unsustainable. Particularly as Ghana has signed up and committed to the global campaign to reduce GHG emissions to mitigate climate change. Embarking on more fossil fuel consumption means the country is reneging on its commitment.

Electricity generated from solar is small, as can be seen above, but following the enactment of the RE Act, it has started to pick up, and it is expected to grow steadily in the years to come as many IPPs have shown interest. The other RE consumed in Ghana apart from biomass is hydro derived from the three dams and solar. Ghana has the potential for mini hydro dams, and the sites have been identified which would be ideal for island communities not connected to the national grid to get electricity.[207] The feasibility studies have produced and raised one concern, and that is the rainfall pattern which has become unpredictable and irregular, this concern has made it difficult for the development of these sites as they are likely to face the same fate in rainfall variability like the three big dams.

When the electricity is generated, it is transmitted to the various outlets for distribution, through the system's network in the country. There are three state-owned companies involved in the business. GRIDCo is solely engaged in the transmission of power whilst the distribution is shared between ECG, NEDCo and now EPC. ECG distribution area covers the southern

[205] Opam and Turkson (n 201).
[206] Energising Economic Growth: "Making the Power and Petroleum Sectors Rise to the Challenge" World Bank June 2013 <http://documents.worldbank.org/curated/en/485911468029951116/Energizing-economic-growth-in-Ghana-making-the-power-and-petroleum-sectors-rise-to-the-challenge> accessed 20 April 2019
[207] Samuel Gyamfi, Mawufemo Modjinou and Sinisa Djordjevic, 'Improving Electricity Supply Security in Ghana - The Potential of Renewable Energy' (2015) 43 Renewable and Sustainable Energy Reviews 1035 <http://dx.doi.org/10.1016/j.rser.2014.11.102> accessed 15 August 2019

sector of Ghana, NEDCo covers the northern sector of Ghana, and EPC covers the Tema enclave free zone. A summary of the distribution companies and their area of operation can be found below in table 1.

Table: 1 Companies and their Distribution Areas in the Electricity Subsector in Ghana

Company	Area of Distribution
Electricity Company of Ghana	**Southern Part: Ashanti Region, Eastern Region, Central Region, Volta Region, Western Region, and Western North Region.**
Northern Electricity Distribution Company	**Northern Part: Northern Region, North-East Region, Savannah Region, Bono Region, Bono East Region, Ahafo Region, Upper East and West Regions, parts of Oti and Ashanti Regions and Western North Region.**
Enclave Power Company Ltd	**Tema Enclave Free Zone**

Source: Author's elaboration with ideas from the literature (2022)

It is important to discuss the main challenges the sector is experiencing. In the earlier discussion, GoG set a target of doubling installed capacity in 2015 from the 1990s figures. However, 2015 was instead a year that Ghana witnessed the worst energy crisis in the nation's history due to a shortfall in generation and an inability to meet demand. The MOEn resorted to a load shedding mechanism to manage the crisis. Another target of extending electricity to all communities in the country in 2020 became impossible.[208] This impossibility has been revealed in the EC of Ghana's energy statistics released in 2020 which showed that the national coverage stood at 85.33%, an indication that the target has been missed and a lot more needs to be done. Taking, for instance, 85% as the national coverage, it means 15% of the communities are still left uncovered, and it seems a herculean task for the government to accomplish this within the shortest possible time. However, according to the EC of Ghana, the national coverage stood at 87% in 2021. It is important to note that the NES has chalked a significant success, but a lot still needs to be done till the whole nation is covered.

Coming to the main challenge ECG is facing, the company's distribution network is aged, and the majority of the country's transmission and distribution systems were built several decades ago. They have since not undergone any upgrading, and as a consequence, most often, it is overloaded, leading to losses, and total system collapse. Another key challenge is poor investment in the transmission and distribution sectors. The two distribution companies, ECG and NEDCo, do not recover their cost of electricity distribution to their customers due to the low tariffs that have been set, and some customers, both private sector and individuals, do not pay their bills. The companies also record high losses due to old and overloaded networks in many areas. In addition, the GoG owes ECG huge debts in subsidies, and state institutions

[208] Ebenezer Nyarko Kumi, 'The Electricity Situation in Ghana: Challenges and Opportunities' [2017] University of Energy and Natural Resources, Sunyani, Ghana 30 <www.cgdev.org>. accessed 10 June 2019

such as departments, ministries, and agencies also do not pay their bills.[209] Furthermore, some of these distribution companies grapple with problems such as metering, billing, and theft. This ultimately leads to revenue losses, as such, the distributing companies are not able to meet their financial commitments to GRIDCo and other power generators.

2..4.2 The Role of Foreign Donors in the Electricity Subsector

In discussing the energy sector in Ghana, one cannot afford to overlook the role and activities of foreign donors. Foreign donors are actively involved in the oil and gas industry and the power sector in Ghana. This section is devoted to the activities of donors in the country's energy sector. The donor agencies mainly provide technical and financial support to the sector. The donor agencies include German GTZ, World Bank, U.K DFID, China Development Bank, U.S.A USAID, African Development Bank (AfDB), Japanese International Cooperation Agency (JICA), The Dutch Development Related Export Transaction Programme (ORET), the Swedish International development cooperation Agency (SIDA). In the electricity subsector, a good number of donors are involved in some key projects in the country. The NES got support from some donor agencies, for example, The Dutch Development Related Export Transaction Programme, the World Bank, JICA, and SIDA gave grants and soft loans.[210] The Self-Help Electrification Programme (SHEP) receives financial support from the Export-Import Bank of the U.S.A, SIDA, the Export-Import Bank of India, the Export-Import Bank of China, South African Government through soft loans. WB contributed significantly to the construction of the Akosombo Dam and the external loans that were provided.[211]

AfDB grants loans for the Ghana-Togo-Benin Power Interconnector, which is part of the West African Power Pool (WAPP).[212] The U.S.A Millennium Challenge Corporation (MCC) gives support that is meant for energy governance, policy improvements and reforms. GTZ of Germany provided the needed support for the successful enactment of the RE Act.[213] JICA provides support in the form of grants that help improve the electricity distribution system by providing new sub-transmission lines, solar PV systems and the training of electrical engineers.

2.5 Petroleum subsector

Ghana is a country in West Africa which produces relatively small quantities of oil and gas. Therefore, the GoG established the Ghana National Petroleum Corporation (GNPC) with the responsibility for exploring, developing, and distributing petroleum.[214] GNPC is the GoG's body representing the country in all oil and gas matters and is the institution in charge of licensing of oil and gas fields. The corporation is the national gas/energy aggregator and has the target to adequately supply fuel to meet the ever-increasing demand for energy in the country. Ghana

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[209] Ghana: 'Government to Engage IPPS Over U.S.$ 700 million Debt' (Ghanaian Times, 9 July 2019) <https://allafrica.com/stories/201907090526.html> accessed 14 August 2019

[210] Energypedia, 'Ghana Energy Situation''(Energypedia) < https://energypedia.info/wiki/Ghana_Energy_Situation#Electricity> accessed 21 June 2022

[211] Ishmael Edjekumhene, A. Bawa and Abeeku Brew-hammond, 'Power Sector Reform in Ghana: The Untold Story' [2001] Kumasi Institute of Technology (KITE) 1 <http://pdf.wri.org/power_politics/ghana.pdf>. accessed 10 November 2019

[212] Energypedia, 'Ghana Energy Situation''(Energypedia) < https://energypedia.info/wiki/Ghana_Energy_Situation#Electricity> accessed 21 June 2022

[213] ibid

[214] Richard Amponsah and Francis Kelvin Opei, 'Ghana ' s Downstream Petroleum Sector: An Assessment of Key Supply Chain Challenges and Prospects for Growth' (2014) 1 International Journal of Petroleum and Oil Exploration Research 1 <www.internationalscholarsjournals.org> accessed 28 June 2019

National Gas Company (Ghana Gas) is a subsidiary of GNPC. In addition, the GoG established another state-owned entity called the National Petroleum Authority (NPA), whose primary function is to set prices for petroleum products. Another body of importance in the petroleum sector is the only refinery known as the Tema Oil Refinery (TOR).

Through the activities of GNPC, Ghana finally discovered oil in commercial quantities offshore. It started to exploit it in the year 2010.[215] Tullow oil U.K is the operator of the offshore Jubilee field that was commissioned first, and which started production in 2010. Ghana exports its crude oil to the international market, and the country's natural gas production is used to fuel domestic power plants to generate electricity. The Ghana energy sector is expected to expand considerably in the next few years following more oil discoveries and the commencement of production from the Twenboa-Enyenra-Ntomme (TEN) and offshore Cape Three Points (OCTP) fields. The TEN and OCTP oil and natural gas fields came on stream in 2016 and 2017, respectively.

The Jubilee oil field came on stream in 2010 and produced light sweet crude oil.[216] The Jubilee field, since coming on stream, has had some technical challenges that have resulted in it not reaching its peak production of 126,000 barrels a day.[217] In 2017, the Jubilee field managed a production capacity of 89,600 barrels a day. In October 2017, the GoG approved the Greater Jubilee Full Field Development Plan. This multifield expansion project comprises, Teak, Mahogany East, and Akasa fields, all of which are in close proximity to the Jubilee field. The existing infrastructure will be used for the infill drilling.

Ghana imports crude oil for its domestic consumption. The country has only one refinery called TOR, which can refine 45,000 barrels a day. However, the refinery had technical problems due to a lack of maintenance and lack of efficient management, and this has left the refinery not to process crude even after the appointment of a new managing director and board.[218]

The NPA was established in 2005 by an Act of Parliament, Act 691.[219] Its functions include:[220]

(1) Regulation of the price of petroleum products,

(2) Monitoring and promotion of competition in the supply of petroleum products and

(3) Overseeing and establishing standards in the downstream petroleum sector.

The petroleum Commission and NPA regulate the upstream and downstream petroleum industries.[221] Bulk Oil Storage and Transportation Company Limited (BOST) is another state-owned company responsible for owning, managing, and developing a network of pipelines, storage depots and other transportation infrastructure throughout the country to ease distribution. As part of its mandate, it keeps strategic reserves stocks on behalf of the

[215] Petroleum Commission, 'Exploration History' <https://www.petrocom.gov.gh/exploration-history/ > accessed 7 January 2023
[216] Offshore Technology, 'Jubilee Field – Ghana' (Offshore Technology Focus,25 October 2009) <https://www.offshore-technology.com/projects/jubilee-field/ > accessed 30 July 2019
[217] Monica Skaten, 'Ghana's Oil Industry: Steady Growth in a Challenging Environment' [2018] Oxford Institute for Energy Studies <https://doi.org/10.26889/9781784671044> accessed 16 June 2019
[218] Thomas-Moore Adingo, 'TOR Yet to Process Crude; 8months After New MD, Board Appointment' (Business and Financial Times, 16 November 2022) < https://theftonline.com/2022/11/16/tor-yet-to-process-crude-8months-after-new-md-board-appointment/ > accessed 19 January 2023
[219] National Petroleum Authority Act, 2005 (Act 691).
[220] ibid
[221] Petroleum Commission Act, 2011 (821).

country.[222] As mentioned earlier, Ghana uses its NG to fuel thermal plants for domestic electricity generation. The country started full commercial natural gas production from the Jubilee field in 2014 and produced about 23 billion cubic feet (Bcf) in 2016. NG is delivered via pipelines from Kwame Nkrumah FPSO to the onshore Atuabo NG processing facility and then used to generate power for domestic use.

Before it started its NG production, Ghana relied on gas supply from Nigeria through the West African Gas Pipeline (WAGP). Unfortunately, the contract that was signed was not working for both countries, and the gas via WAGP very soon became unreliable due to feedstock constraints in Nigeria and Ghana's indebtedness to WAGP.[223] This situation affected Ghana's electricity generation capacity. The WAGP company in 2016 suspended the export of gas to Ghana due to the factors mentioned above. Ghana tried other ways to get around the unreliable gas from Nigeria, and one of such was the government turning to Liquefied natural gas (LNG) as an alternative fuel source. However, the country lacks the infrastructure to begin receiving LNG and attempts to develop the infrastructure have proven futile. In 2011 the Ghana National Gas Company Limited (Ghana Gas) was established by the GoG as a private limited liability company. Ghana Gas' mandate covers the building, owning, and operating of the infrastructure that is required for the collection, processing, transmission, and marketing of natural gas resources within the country.[224]

Oil Marketing Companies (OMCs) are licensed to procure petroleum products from TOR/BDCs to sell to the general public, and bulk consumers through all retail outlets and fuel stations throughout the country. Bulk Distribution Companies (BDCs), are companies that have been licensed to import crude oil and can store, sell, and distribute petroleum products as whole sellers to bulk customers and OMCs. These companies are able to provide monthly forecasts based on consumer demand data.[225] Nationwide Systems and Inspectorate/Bureau Veritas, Intertek, and Societe Generale de Surveillance (SGS) provide inspection services, testing, and calibration to the petroleum subsector to ensure compliance with standards.

2.6 Wood fuels Subsector

Biomass is a term that refers to all organic matter that is derived from plants and animals.[226] Ghana is relatively endowed with a variety of resources that include hydrocarbons, biomass, solar, wind, and hydro. All forms of energy can be classified broadly into either renewable or non-renewable. RE is a type of energy obtained from non-depleting sources such as biomass, solar, wind, hydro, and geothermal.[227] Non-RES are depleted at a rate faster than they are being replenished and are finite. They include oil, natural gas, coal, and nuclear energy. Biomass resources in Ghana include wood (firewood), charcoal, wood waste, agricultural crops and their waste by-products, animal waste, waste from food processing, and municipal

[222] Gideon Ofosu-Peasah and Ishmael Ackah, 'Strengthening Ghana's Downstream Petroleum Deregulation Regime: A Review of the 2016 CBOD Industry Report.' [2017] SSRN Electronic Journal <https://www.researchgate.net/publication/317065822_Strenghtening_Ghana's_Downstream_Petroleum_Deregulation_Regime_A_Review_of_the_2016_CBOD_Industry_Report> accessed 25 May 2019
[223] Energy Commission of Ghana, 'Energy (Supply and Demand) Outlook for Ghana' (2018) 5 Ghana Energy Commission 93. 65 <www.energy.com.gov.gh> accessed 12 June 2019
[224] Skaten (n 217)
[225] Ofosu-Peasah and Ackah (n 222)
[226] Moses Hensley Duku, Sai Gu and Essel Ben Hagan, 'A Comprehensive Review of Biomass Resources and Biofuels Potential in Ghana' (2011) 15 Renewable and Sustainable Energy Reviews 404 <https://doi.org/10.1016/j.ser.2010.09.033> accessed 10 June 2019
[227] Ghana's Renewable Energy Act, 2011 (Act 832)

solid waste. Biomass in the form of wood is the oldest form of energy used by humans.[228] The bulk of the energy supply in Ghana comes from wood fuels, thus firewood and charcoal. Wood fuels accounted for 34% of total energy consumed.[229]

The bulk of the wood fuel, about 90%, is derived from the natural forest. The remainder, 10% comes from wood waste, e.g., logging and sawmills residue and plants woodlots.[230] The savannah and transition zones of Ghana include areas like Wenchi, Kintampo, Afram Plains, Nkoranza, and Damongo produce the bulk of the dense wood fuel resources of the country. In recent times major charcoal producing towns such as Kintampo, Nkoranza, Donkorkrom, Damongo and Wenchi have witnessed the disappearance of most of their wood fuel resources and have to travel long distances to get wood for charcoal production. Private individuals ply the charcoal business with little government control or restriction, but EC has started to ban the export of charcoal produced from unapproved sources; approved sources are forests specifically grown for wood fuels purposes and sawmills residues.[231] Charcoal produced from wood sourced from the natural forest is prohibited.[232]

In July 2003, charcoal exporters are now required to obtain licenses or permits from EC before they could engage in the business. The charcoal is typically produced from rural areas and transported over long distances to the urban centres where wayside retailers sell it to final consumers.[233] A small fraction of the charcoal is exported to neighbouring West African countries and overseas markets. As a result, the urban dwellers turn to consume charcoal whilst the rural communities preferred choice is firewood.

Biomass can be used for many purposes due to its economic and environmental value. It can be used to generate heat, steam, and power for transportation fuels.[234] Typically, in Ghana, in the forms of wood and charcoal, it is used for cooking and heating water in most households in the rural and urban areas. Therefore, the primary energy mostly consumed. Biomass has a critical role to play in the mitigation of climate change as it can reduce GHG emissions compared to fossil fuels.[235] The usage of traditional fuels in Ghana is similar to other developing countries where biomass supplies the bulk of energy services for many indigenous rural populations, particularly firewood and charcoal are the most commonly used fuel for cooking and heating.[236] The biomass sector provides jobs for people engaged in the production and sale of charcoal for both the urban and rural dwellers alike. It can be used as a fuel for cooking, production of biogas, liquid fuels for transportation and for power

[228] Ayhan Demirbas, 'Biofuels Securing the Planet's Future Energy Needs' (2009) 50 Energy Conversion and Management 2239-2249 <http://dx.doi.org/10.1016/j.enconman.2009.05.010>.2240 accessed 5 July 2019
[229] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022
[230] Energy Commission, 'Sustainable Energy for All Action Plan' (EC, June 2012) <http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf> accessed 20 July 2019
[231] Michael Acheampong and others, 'Is Ghana Ready to Attain Sustainable Development Goal (SDG) Number 7? —A Comprehensive Assessment of Its Renewable Energy Potential and Pitfalls' (2019) 12(3) Energies 7 <https://doi.org/10.3390/en12030408> accessed 09 August 2019
[232] ibid
[233] Energy Commission Se4All-Ghana Action Plan (n 230).
[234] A Milbrandt,) 'Assessment of Biomass Resources in Liberia, Nrel, U.S. Agency for International Development (USAID) under the Liberia Energy Assistance Program, Technical Report NREL/TP6A244808' [April ,2009] Contract.1 <https://www.nrel.gov/docs/fy09osti/44808.pdf> accessed 07 July 2019
[235] International Energy Agency, 'World energy outlook 2012' (IEA, November 2012) < https://www.iea.org/reports/world-energy-outlook-2012 > accessed 14 April 2019
[236] Bernard Effah and Ernest Boampong, 'Asian Bulletin of Energy Economics and Technology Biomass Energy: A Sustainable Source of Energy for Development in Ghana' (2015) 2(1) <https://EconPapers.repec.org/RePEc:oaj:abeeat:2015:p:6-12> accessed 17 June 2019

generation.[237] Furthermore, it is essential in food processing as it is the fuel that can be used for baking, smoking of meat and fish, and brewing of pito.

Though the biomass (wood fuel) sector holds great prospects for ES. it is beset with some challenges worth mentioning. The resource presents both opportunities and risks for the energy sector development in the country. One of the major challenges is how to reduce the dependence on wood fuels in favour of modern energy. The fact is, over-relying on wood fuel; thus, firewood and charcoal has great consequences for the forest reserve of the country.[238] Indeed, its unsustainable production and consumption has led to the depletion of the country's forests. According to the U.N Food and Agriculture Organisation (FAO), the rate of deforestation in Ghana is 3% per annum.[239] It must be stated that wood fuels are not the leading cause of deforestation, but preferred wood fuels species are gradually disappearing due to over-exploitation. On the other hand, if wood fuel resources are managed well, they can provide a clean and sustainable energy source for use in an environmentally friendly way. Wood fuels are classified as RES, but in the case of Ghana, the resource is poorly managed, and as a result, it has instead become an exhaustible natural resource. Wood fuels use poses serious health challenges due to its inefficient use by exposing hundreds of women and children to indoor air pollution from cooking and heating.[240] According to the World Health Organisation (WHO) about 3.2 million people died prematurely in the world attributed to household indoor air pollution per year in 2020 using firewood, charcoal, and dung.[241]

Though biofuels have the potential to help in reducing the dependency on petroleum products and reducing GHG emissions, however, their cultivation poses some challenges to sustainable agriculture, thus bringing about food-fuel balance to the fore. For example, when certain crops like oil palm are used for biofuel production, they contribute to food shortages in the global market. This is because the land used to cultivate such crops competes for fertile arable land that could otherwise be used for food crop cultivation. Biofuel crops can potentially destroy the world's remaining tropical ecosystem that is home to a wide range of biodiversity whose survival is threatened by the clearing of their natural habitats to cultivate these biofuel crops. Following what has been discussed, the wood fuels subsector in the forms of firewood and charcoal is the primary energy source for most households in Ghana. It is used mainly for cooking and heating. The unsustainable consumption has brought in its wake the destruction of the forest. Moreover, biomass used for biofuel production competes with food crops for fertile arable land threatening world food security.

2.7 Legal and Policy Frameworks of the Energy Sector in Ghana

The Ghana power sector is governed by a well-established gamut of laws, policies, and regulations, which the government continues to develop till the present day. Most of the policies and regulations have been formulated by EC. In recent times it has played an instrumental role that led to the passage of the Renewable Energy Act. 2011 (Act 832). The

[237] Francis Kemausuor and others, 'Assessment of Biomass Residue Availability and Bioenergy Yields in Ghana' (2014) 86 Resources, Conservation and Recycling 28-37 <http://dx.doi.org/10.1016/j.resconrec.2014.01.007> accessed 14 May 2019

[238] Duku, Gu, and Hagan (n 226).

[239] Ishmael Ackah, 'Determinants of Natural Gas Demand in Ghana' (2014) 38 OPEC Energy Review 272 <https//doi.org/10.1111/opec.12026> accessed 16 August 2019

[240] Elizabeth M Remedio and Julije U Domac, 'Socio-Economic Analysis of Bioenergy Systems: A Focus on Employment' 53 <http://www.globalbioenergy.org/bioenergyinfo/sort-by-date/detail/en/c/10478/>.accessed 16 June 2019

[241] World Health Organisation, 'Household air pollution' (WHO, 28 November 2022) <https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health> accessed 9 January 2023

GoG also takes on board energy policies of the regional body, Economic Community of West African States (ECOWAS).

The first policy to consider is the National Energy Policy (2010) which spells out the government's policy direction. In the electricity sector, the policy performs the following:[242]

(1) Provides an overview of existing policy objectives, problems, and ways to solve the problems,

(2) Encourages the incorporation of RE into the energy mix,

(3) Suggests the use of waste to generate electricity and

(4) Encourages consumers to adopt energy efficiency practices.

In sum, the policy vision was to make Ghana a net exporter of power in 2015.[243] However, this vision was not realised in 2015; incidentally, in that year, electricity supply could not meet demand, and the power supply was erratic due to a shortfall in electricity generation. The country had to undergo a load shedding timetable to manage the crisis. Further discussion on National Energy Policy is going to be made in chapter three-under subsection 3.6.2

The next is, Energy Sector Strategy and Development Plan (2010)

This plan embodies the government's strategies, projects, and programmes as follows:[244]

(1) Energy Sector institutions,

(2) RE subsector,

(3) Waste-to-Energy,

(4) Energy and gender,

(5) Petroleum subsector and

(6) Power subsector.

One important objective of this plan was to incorporate a 10% share of RE into the national electricity generation mix in 2020. Unfortunately, this target was missed in 2020 and now extended to 2030, and only 0.3% was added.[245] Issues of concern raised on energy efficiency indicate that the electricity supplied to consumers is wasted through transmission and distribution losses; inefficient electrical equipment and poor attitudes toward energy conservation, and illegal connection, and which the GoG is determined to address.[246] The

[242] Ministry of Energy Ghana (n 198).
[243] Ministry of Energy, 'National Energy Policy 2010' (MOEn, February 2010) <https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/GHANA%29%20National%20Energy%20Policy.pdf> accessed 28 July 2019
[244] Ministry of Energy Ghana, 'Energy Sector Strategy and Development Plan' (MOEn, February 2010) < http://www.ecowrex.org/system/files/repository/2010_energy-sector-strategy-and-development-plan_ministry-of-energy.pdf> accessed 10 July 2019
[245] Energy Commission of Ghana, 'National Energy Statistics 2000 - 2019' (EC, April 2020) < http://www.energycom.gov.gh/files/2020%20ENERGY%20STATISTICS-revised.pdf > accessed 10 July 2021
[246] UNDP, 'Sustainable Energy for All (SE4ALL) Country Action Agenda December 2015-Ghana' <http://www.se4all.ecreee.org/sites/default/files/ll.ghana_se4all_vs_final.pdf> accessed 01 August 2019

Strategic National Energy Plan (2006 to 2020) another plan of importance will be discussed in detail in chapter three-under subsection 3.6.1

2.7.1 Economic Community of West African States (ECOWAS) Renewable Energy Policy

ECOWAS comprises fifteen member states, and all of them are located in the western sub-region of Africa with a population of over three hundred million people and a landmass of about 5.1 million square kilometers.[247] ECOWAS was formed following the emergence of the treaty of Lagos in 1975. The treaty was initially seen as an economic initiative, but emerging political events led to the treaty's revision to widen its scope and powers in 1993. It strives to foster interstate economic and political cooperation and regional integration. ECOWAS' vision is to create a borderless region where the citizens will have access to its abundant resources and be able to exploit same through the creation of opportunities under a sustainable environment.[248] This vision is yet to be achieved as free movement and doing business within the ECOWAS sub-region is still to a large extent restricted and citizens of Member States go through rigorous checks at the borders.

Ghana's economy, along with the rest of its regional neighbours' economies, is already and will be more affected by the effects of climate change in the coming decades; hence it is crucial to reduce GHG emissions and promote RETs to stem it. These objectives can only be realised by the adoption of RE policies proposed by ECOWAS for the Member States.[249] Whilst the transition to an RE powered economy offers the opportunity for innovation, the business sector will invest on account that governments provide the necessary regulatory frameworks that give certainty and incentives needed to attract the private sector.[250] ECREEE is providing the regulatory frameworks for the Member States to adopt. As Member States' financial Positions are weak, the attraction of private capital is crucial, and the sound policies contained in EREP would help in this direction.

Ghana is a member of ECOWAS, and as such, it is obliged to follow the regional body's RE policies in the quest to harness its RES. ECREEE RE policies such as EREP and EEEP have provided the legal and regulatory frameworks for Member States to adopt for their RE development. The energy sectors of ECOWAS countries are dominated by costly imported fossil fuels that are constantly facing price fluctuations, thus raising concerns about ES and GHG emissions.[251] In contrast, many of the countries in the sub-region are endowed with RES. However, the region relies on traditional biomass for cooking and heating, which has adverse health impact, particularly on women and children, due to its smoke when cooking in enclosed kitchens. The RE policy of ECOWAS is a regional policy that calls on Member States to achieve a target of increasing non-hydro RE (mini hydro, solar PV, wind, and biomass) in the

[247] ECOWAS CEDEAO, 'History' <https://www.ecowas.int/about-ecowas/history/> accessed 10 May 2021
[248] ECOWAS CEDEAO, 'Basic Information' <https://www.ecowas.int/about-ecowas/basic-information/> accessed 10 May 2021
[249] Karin Reiss, 'Developing Renewable Energy Sectors and Technologies in West Africa' < <https://www.un.org/en/chronicle/article/developing-renewable-energy-sectors-and-technologies-west africa#:~:text=In%202012%2C%20the%20ECOWAS%20member,48%20per%20cent%20by%202030 .> accessed 30 April 2021
[250] Celine Kauffmann and Cristina Tebar Less, 'Transition to a Low-Carbon Economy: Public Goals and Corporate Practices (2010) 10th OECD Roundtable on Corporate Responsibility 48 < https://www.oecd.org/corporate/mne/45513642.pdf> accessed 25 June 2021
[251] Presley K Wesseh and Boqiang Lin, 'Output and Substitution Elasticities of Energy and Implications for Renewable Energy Expansion in the ECOWAS Region' (2016) 89 Energy Policy 125 <http://dx.doi.org/10.1016/j.enpol.2015.11.007>. accessed 12 February 2021

region's electricity generation mix to 10% in 2020 and 19% by 2030 which does not include large hydro.[252]

Another target set by the regional policy is for Member States to increase the share of RE in the overall electricity generation mix, including medium and large hydro, to 35% in 2020 and 48% by 2030.[253] Furthermore, electricity access was set at 65% to be met in 2020. The policy has outlined an implementation plan to achieve the targets set. All Member States must enact a regional legal, institutional, and regulatory framework. Each Member State must have an RE policy, incentivise the private sector to participate in RE power generation and train local and national officials to design and operate RETs.[254] As such, between 2014 and 2015, following the adoption of regional policies, almost all the ECOWAS Member States had developed their National Renewable Energy Action Plans (NREAPs). The rationale of EREP is for Member States to harness their RES to reduce vulnerability and attain self-sufficiency and sustainable energy generation and consumption.[255] The vision of EREP is to increase the adoption of RES and to increase energy access to both rural and urban centres.[256] The vision has not been achieved following the release of the monitoring report in 2017. The overarching objective of EREP is to improve ES and energy sustainability in the region:[257] This objective has not been achieved as per the monitoring report of 2017.

In 2017 the current report on performance monitored by ECREEE showed that most of the targets set are likely to be missed in 2020, which may also apply to those set for 2030. The regional target set for electricity access in 2020 was pegged at 65% of the population. However, following the monitoring report, the region was able to manage only 52.3% in 2017.[258] Which by extension shows that when the 2020 monitoring report is released in six years, it is likely to confirm that the 65% target was missed. The region set 35% of RE installed capacity for medium and large hydro plants and 10% for non-hydro RE. The monitoring report in 2017 indicated that for medium and large hydro plants, the share was approximately 27.6% falling short of the 35% target and for grid-connected non-hydro RE, they contributed a share of 1.8% of installed capacity, also falling short of the target of 10%.[259] When the 2020 monitoring report is released in six years' time, it is likely to confirm that the targets have been missed for both large hydro and non-hydro RE plants. As a result, the vision of EREP which is to increase the adoption of RES and increase access has not been met, as seen in the performance report above and therefore the overarching objective of providing ES and energy sustainability has been derailed.

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[252] ECREEE, 'Sustainable Energy for All (SE4ALL), Framework and Status of Implementation' (ECREEE, September 2014) < http://www.ecreee.org/sites/default/files/documents/basic_page/ecowas_se4all_aa_and_re_ee_action_plans_status.pdf > accessed 7 February 2021

[253] ibid

[254] ECREEE, 'Sustainable Energy for All (SE4ALL), Framework and Status of Implementation' (ECREEE, September 2014) < http://www.ecreee.org/sites/default/files/documents/basic_page/ecowas_se4all_aa_and_re_ee_action_plans_status.pdf > accessed 7 February 2021

[255] ibid

[256] To secure an increasing and comprehensive share of the Member States' energy supplies and services from timely, reliable, sufficient, cost-effective uses of RE sources enabling: (1) Universal access to electricity by 2030 (2) A more sustainable and safe provision of domestic energy services for cooking thus achieving the objectives of the white paper for access to modern energy services by 2020.

[257] ECREEE (n 254).

[258] ECREEE, 'Regional Progress Report on Renewable Energy, Energy Efficiency and Energy Access in ECOWAS Region, Monitoring Year: 2017' (ECREEE, July 2019) <http://www.ecreee.org/sites/default/files/regional_progress_report_2017.pdf> accessed 12 January 2020

[259] ibid

2.7.2 Sustainable Energy for All Policy (SE4ALL)

SE4ALL is a U.N initiative that was launched in September 2011 by the U.N Secretary-General Mr. Ban Ki-moon to mobilise U.N Member States, civil society, and the private sector to take action to achieve three important objectives by 2030. These objectives include:[260]

(1) Ensure universal access to modern energy services,

(2) Double the global rate of improvement in energy efficiency and

(3) Doubling the share of RE in the global energy mix.

The GoG has recognised the potential of the SE4ALL initiative as a vehicle through which it can ride to implement its National Energy Policy (2010). The goals of the policy were to achieve universal access to electricity in 2020; to increase energy efficiency practices in residential, commercial, and industrial applications; and to integrate 10% share of non-hydro RE into the national electricity generation mix in 2020.[261]

All these targets have not been achieved, and therefore the addition of a 10% share of non-hydro RE in the electricity generation mix in 2020 has now been extended to 2030. The Ghana SE4ALL Action Plan was developed and launched in May 2013 with the support of UNDP Ghana. ECREEE, in December 2013, provided technical assistance to Ghana to reformulate its Action Plan to an Action Agenda.[262] This change came about when SE4ALL stakeholders in Africa decided to refocus their Action Plan documents into Action Agendas. Ghana's Action Agenda is hinged on three pillars of the SE4ALL initiative thus energy access, doubling the share of RE and energy efficiency in line with U.N SE4ALL objectives. With access, Ghana set a target of extending electricity to every part of the country in 2020. In light of this, the country has made significant strides toward increasing coverage to every part of the country from 1988 to 2020 through NES. The Self-Help Electrification Project is an initiative which encouraged communities to acquire their poles and ensure that 30% of the houses are wired, and the rest of the cost is borne by GoG for electricity extension.[263] However, in 2021, the national coverage was 87% falling short of the target but still impressive.[264]

With RE the GoG is actively exploring how to exploit its RES. Instruments like SNEP, NEP and the RE Act have been deployed toward achieving this aim. However, in 2020, the non-hydro RE target was missed, and only 0.3% from these sources was added due to many challenges, which will be discussed in chapter three.[265] In terms of Energy Efficiency (EE), GoG set many policy objectives to be achieved in 2020. Prominent amongst the objectives is to reduce transmission and distribution losses. It was projected that transmission losses would be decreased to 3.8% in 2020 whilst distribution losses would be decreased to 8.5% in 2020.[266] However, the electricity subsector has performed poorly in terms of the projections. Transmission and distribution losses are still very high at 5% and 29.7%, respectively at the end of 2021.[267] It is caused by many factors such as obsolete network which has not been upgraded, inefficient electrical gadgets, illegal power connection and lack of energy conservation by consumers. EE measures play significant contribution toward climate change

[260] Sustainable Energy for All, 'Sustainable Energy for All: An Overview' < https://www.un.org/millenniumgoals/pdf/SEFA.pdf> accessed 17 May 2022
[261] Angela Rhoda and Naa Ardua, 'Ghana's Energy Sector Policies Presentation' <https://eneken.ieej.or.jp/data/7462.pdf> accessed 14 June 2019
[262] UNDP Sustainable Energy for All (SE4ALL) Country Action Agenda (n 246).
[263] SE4ALL (n 260).
[264] Energy Commission of Ghana (n 199).
[265] Energy Commission of Ghana (n 198).
[266] SE4ALL (n 260).
[267] Energy Commission of Ghana (n 199).

mitigation; as such, the SE4ALL Energy Efficiency Accelerator Platform has been created to increase education on EE, policy action and investment.[268]

2.7.3 Legislation in the Energy Sector in Ghana

In Ghana, many laws and policies have been enacted to govern the energy sector. The GoG has used the law to oversee and manage the energy sector's operations. Law relating to energy has come from Parliament. Parliament has enacted many laws that apportion the role all the institutions involved in the energy sector are guided. Recently Parliament has added the Renewable Energy law into the legal frameworks to specifically deal with the development of RE in the country.

The Energy Commission Act, 1997 (Act 541) established EC as a body that would provide technical advice to the MOEn on regulatory matters, development, management, and the utilisation of energy resources in Ghana.[269] Furthermore; the EC Act created the legal framework that allowed IPPs to participate in the power sector. The Public Utilities Regulatory Commission Act,1997 (Act 538) established PURC which is tasked with the responsibilities of setting and regulating gas and electricity tariffs and ensuring that the utilities provide good customer service to their customers.[270] The Bui Power Authority Act, 2007 (Act 740) brought into being the Bui Power Authority (BHA) to superintend over the development of the hydro-electric project at Bui and to prospect for potential hydro-electric sites on the Black Volta River.[271] Regulation plays a very important role as it provides the specifics of implementing a law or a policy. The EC and PURC are the two institutions that develop regulations for implementation.

In discharging of their regulatory responsibilities EC and PURC developed two codes which are going to be discussed. The two codes are: National Electricity Grid Code and National Electricity Distribution Code. They play an important role by protecting the grid and distribution network against being overloaded as they are old and weak to reduce losses and provide fairness to all players. The National Electricity Grid Code is a system made of two or more individual electric systems that operate in synchronism that have connecting tie-lines. The code sets the procedures, requirements, practices, and standards for operating the National Interconnected Transmission System (NITS). The importance of the Grid Code is to afford NITS to provide a transparent, fair, safe, reliable, and cost-efficient delivery of electricity.[272] National Electricity Distribution Code is similar to the Grid Code. The Distribution Code sets the requirements and conditions that a distribution utility can engage in electricity distribution under its license. It covers safety standards, metering services, reliability and quality, and dispute resolution.[273]

The MOEn in 2010 outlined the government's policy direction for the energy sector by introducing The Energy Sector Strategy and Development plan. Its role included, among other things, government programmes, strategies, and projects for the development of the energy sector institutions, which covers the electricity subsector, the RE subsector and the Petroleum

[268] SE4ALL (n 260).
[269] Energy Commission Act, 1997 (Act 541).
[270] Public Utilities Regulatory Commission Act, 1997 (Act 538).
[271] Bui Power Authority Act, 2007 (Act 740).
[272] Energy Commission of Ghana, 'National Electricity Grid Code' (EC, October 2009) < http://energycom.gov.gh/files/National%20Electricity%20Grid%20Code.pdf> accessed 24 October 2020
[273] National Electricity Distribution Code, Energy Commission of Ghana < http://www.energycom.gov.gh/files/NATIONAL%20ELECTRICITY%20DISTRIBUTION%20CODE-FINAL%20(May%202012)%20.pdf> accessed 24 October 2020

subsector.[274] The RE Act was enacted to integrate RE into the electricity generation mix and to generate electricity in an environmentally and sustainable way. Also, to diversify and increase electricity supply with the use of RETs.[275] Furthermore, to attract private sector investment in the RE subsector.[276] To achieve these objectives, the MOEn, EC and PURC were tasked with the responsibility of delivering on these objectives. The duties include:

(1) Introduction of the feed-in tariff for RE (now repealed),

(2) Introduction of renewable energy purchase obligation,

(3) Licensing procedures to follow in the RE subsector and

(4) The establishment of a fund for the promotion of RE.

In the mid-1980s, the GoG introduced new legislative and regulatory reforms in the petroleum sector. The first was the enactment of the Ghana National Petroleum Corporation Act in 1983 (PNDCL 64), which established GNPC as the national company responsible for championing the government's activities in the oil and gas sector.[277] Its main task is to explore, develop, produce and disposal of hydrocarbons. The GNPC is also the government's advisor on oil and gas issues. GNPC, since its establishment, has played a dual role both as a regulator and an operator at the same time under the supervision of the MOEn. When the petroleum Act, 2011 (Act 821) was enacted, it ceded its regulatory functions to the Petroleum Commission, which assumed the regulator's role. The GoG introduced this new legislation to establish GNPC so that the company can focus on prospecting for hydrocarbons and liaise with other players in the oil and gas industry. Following the above action, the country discovered oil in commercial quantities in 2007.[278]

The Petroleum Commission Act, 2011 (Act 821) was promulgated to establish the Petroleum Commission as the regulator to manage the upstream petroleum industry operations in accordance with the law. This role hitherto was played by GNPC under PNDCL 84. It, therefore, depends on the commission to regulate and manage how to utilise petroleum resources the way the Act has stipulated. This action was taken by the GoG so that Ghana's oil could be managed well to avoid the oil curse as experienced by Nigeria.

In 2016, the Petroleum (Exploration and Production) Act, 2016 (Act 919) was passed to replace the earlier PNDCL 84 as the adjunct law to regulate the upstream petroleum activities.[279] The Act deals with the regulation in the granting of licences for upstream oil and gas operations. It, therefore, regulates the exploratory development and production of petroleum in the country in line with constitutional requirement, which has vested all-natural petroleum resources within the territorial borders of Ghana in the president to hold it in trust on behalf of the people of Ghana.[280] The Act gives permission to the MOEn to enter into

[274] Ministry of Energy Ghana, 'Energy Sector Strategy and Development Plan' (MOEn, February 2010) <https://ouroilmoney.s3.amazonaws.com/media/documents/2016/06/09/energy_strategy.pdf> accessed 19 August 2019
[275]Ghana's Renewable Energy Act, 2011 (Act 832).
[276] ibid
[277] Ferdinand Adadzi and Nana Serwah Godson-Amamoo, 'Ghana' in Christopher B Strong (eds), The Oil and Gas Law Review (6th edn, Encompass Print Solutions, Derbyshire 2018) <https://thelawreviews.co.uk> accessed 10 July 2019
[278] Vitol, 'Vitol Upstream (Ghana) Limited and GNPC's Sankofa -1A well discovers oil and gas offshore Republic of Ghana' (Vitol, 16 September 2009) <https://www.vitol.com/vitol-upstream-ghana-limited-and-gnpcs-sankofa-1a-well-discovers-oil-and-gas-offshore-republic-of-ghana/> accessed 10 August 2019
[279] Petroleum (Exploration and Production) Act, 2016 (Act 919).
[280] The 1992 Constitution of the Republic of Ghana.

agreements in relation to the exploration and production of gas subject to Parliamentary approval. Also, the Income Tax Act, 2015 (Act 896), as amended, provides the enabling environment and regime in order to tax the income of the contractors and subcontractors operating in the sector.[281]

2.8 Conclusion

The energy sector is crucial in developing any country and is a key player in Ghana's economic development and growth. Therefore, it behoves on the GoG to carefully plan the sector in an integrated manner in order to harness its energy resource potential to reduce the dependence on oil imports. In Ghana, in terms of legislation and regulatory frameworks, there are many laws and policies that have been enacted to govern the energy sector. The sector is therefore well regulated. The GoG has used the law to oversee and manage the energy sector's operations, laws relating to energy have come from Parliament. Parliament has enacted many laws that apportion the role all the institutions involved in the energy sector are guided. For example, recently, Parliament has added the RE Act into the legal frameworks to specifically deal with the development of non-hydro RE (mini hydro, solar, wind, and biomass) in the country.

Electricity subsector has gone through different phases to the present non-hydro RE phase. In the late 1960s, the country began to use hydroelectric power generated by the Akosombo and Kpong dams. The country relied on these dams until the mid-1980s, when erratic rainfall pattern brought about prolonged droughts that rendered the reservoirs dry and led to power rationing, severely affecting the economy. The GoG now turned its attention to thermal by bringing on stream thermal plants that use light crude oil and natural gas to run to generate electricity. As observed, the reforms in the energy sector were necessitated by two main factors, thus the growing demand for power and difficulties in accessing finance to invest in the energy sector. The WB, the traditional financier of the power sector, was unwilling to fund any power sector investments, especially in developing countries, unless the countries involved committed to reforms in the energy sector.

Ghana eventually committed to reforms and got financial support from the WB. GoG accepted the bank's diagnosis of the energy sector's problems, but it rejected its prescription and designed its own programme. These reforms were necessary; in assessment, the transformation in the energy sector can be traced to them (reforms), especially the establishment of Ghana Grid Company and the two regulatory institutions thus, EC and PURC. These institutions were created due to the reforms and are still vibrant and providing transmission, technical and regulatory services to the energy sector in Ghana. In addition, the reforms allowed the entry of IPPs into the energy sector, but prior to that, the sector was dominated by state-owned companies. Currently, there are many IPPs in the sector, with some having a niche for RE.

Furthermore, from the outset, the increase to access to electricity through the National Electrification Scheme was a priority to the GoG as part of the reforms. A target to extend electricity to every part of the country was set to be met in 2020. However, the target was not achieved, but the national access rate increased to 87% according to the EC in 2021. It is still impressive compared to 28% in 1988. Therefore, the reforms have played a significant role in the transformation of the energy sector in Ghana.

From the discussion, the GoG's reliance on thermal to power the economy and to meet the energy demands of every sector is not yielding the right results. The country is not getting its

[281] Income Tax (Amendment) Act, 2016 (Act 907).

energy policies right as more and more investment is made in fossil fuels like natural gas and light crude oil to fire the thermal plants. It is not working because these resources are expensive in the world market, demand is ever-increasing, and they are running out. Fossil fuels are also the source of GHG emissions, which have contributed to climate change. The government has now turned its attention to non-hydro RE, and in 2011 the RE Act was enacted to increase the share of non-hydro RE into the electricity generation mix by setting a 10% target to be met in 2020. However, in 2020 when the EC released its statistics, the share of non-hydro RE in the electricity generation mix was 0.3%, indicating the target had been missed. However, before 2020 the GoG had revised the date extending the target to 2030. Following the researcher's fieldwork in Ghana in 2021, an official of the MOEn indicated that more IPPs are into RE generation, and it is highly expected that the share of non-hydro RE will increase substantially in the coming years.

A well-coordinated plan requires an analysis of the various sectors of the economy and their potential energy requirement and how the energy sector can plan to accommodate the needs of all the sectors. First, it should be done to bring about an affordable and sustainable energy supply that can satisfy the needs of all sectors. Second, the sector's managers should adopt a proactive approach to energy generation than a reactive approach. Third, energy sector development needs to take on board research and development that will enquire into other alternative energy sources that will be added to the energy mix to expand the frontiers of energy generation and consumption. Fourth, it would gradually phase out conventional energy sources and usher in renewables. Finally, the energy sector needs huge investments to deal with the shortfall in generation to meet the demand and supply of all sectors of the economy.

The subsequent discussion is on chapter three, and it is going to examine the types of RETs and the legal and policy frameworks deployed in Ghana.

CHAPTER THREE

TYPES OF RENEWABLE ENERGY TECHNOLOGIES, LEGAL AND POLICY FRAMEWORKS DEPLOYED IN GHANA

3.1 Introduction

Renewable Energy Resources (RES) have played an important role in the history of humankind by meeting their energy needs since the beginning of civilisation. For many centuries, biomass has served as the oldest form of energy used by humans.[282] Biomass is an important energy source used for cooking, heating, and steam generation. Solar has been used both for drying and heating. Hydropower for movement and irrigation. Geothermal energy is energy extracted from heat available in the earth according to Ghana's RE Act. Geothermal can be used for heating and electricity generation. For many years, RES have also been used to generate electricity. This chapter aims to have an in-depth discussion on the various types of RETs deployed in Ghana. The legal framework and policies on RE would also be discussed to see how they facilitate the deployment and development of RETs in Ghana. Furthermore, the Renewable Energy Act, 2011 (Act 832) and policies will be analysed to ascertain their effectiveness both in addressing ES challenges and promotion of RE development in the country.

The increase in demand for energy and climate change mitigation have posed the most serious challenge for sustainable development (SD) globally.[283] How to meet the energy needs of the citizenry without compromising the economy and the environment remains a big challenge for every country.[284] Ghana in recent times has faced a myriad of electricity supply challenges. In the crisis, a supply deficit led to power rationing. Existing generation plants could not operate at full capacity due to fuel supply constraints, cum drought due to lack of sufficient rainfall. As a result, the government turned its attention to thermal power, which now dominates the country's electricity generation portfolio. The country's generation capacity is going to continue to face sustained demand due to economic growth, population growth, access, and urbanisation. Future supply is further going to face high demand due to the government's policy of 100% universal access to electricity in 2020.[285] This has been missed in the year 2020 as access stood at 85.33%.

There is a positive correlation between energy access and human development, so access to modern energy services for the country's socio-economic development is crucial. In light of this, Ghana has to integrate RETs into its generation mix to be in firm control to provide ES and insulate itself from shocks due to price hikes of fossil fuels and have reserve margins for emergencies. The transition from depending on fossil fuels to RE demands careful and prudent planning on the part of the government.[286] This careful planning requires the support of well-designed policies and instruments that are well adapted to overcome country-specific

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[282] Ayhan Demirbas, 'Biofuels Securing the Planet's Future Energy Needs' (2009) 50 Energy Conversion and Management 2239-2249 <http://dx.doi.org/10.1016/j.enconman.2009.05.010> accessed 5 July 2019

[283] A Zahedi, 'Australian Renewable Energy Progress' (2010) 14 Renewable and Sustainable Energy Reviews 2208 <http://dx.doi.org/10.1016/j.rser.2010.03.026>.accessed 10 September 2019

[284] Yaping Hua, Monica Oliphant and Eric Jing Hu, 'Development of Renewable Energy in Australia and China: A Comparison of Policies and Status' (2016) 85 Renewable Energy 1044 <http://dx.doi.org/10.1016/j.renene.2015.07.060>.accessed 20 January 2020

[285] Francis Kemausuor and others, 'A Review of Trends, Policies and Plans for Increasing Energy Access in Ghana' (2011) 15 Renewable and Sustainable Energy Reviews 5143 <http://dx.doi.org/10.1016/j.rser.2011.07.041>.accessed 10 October 2019

[286] Sarah Kelly-Richards and others, 'Governing the Transition to Renewable Energy: A Review of Impacts and Policy Issues in the Small Hydropower Boom' (2017) 101 Energy Policy 251 <http://dx.doi.org/10.1016/j.enpol.2016.11.035>. accessed 16 February 2020

barriers. In their quest to adopt RE, many countries have prioritised it by firmly enacting laws to establish it. Ghana has recognised the important role RE could play and has enacted the RE Act. The objective of the Act states "to provide for the development, management, and utilisation of RES for the production of heat and power in an efficient environmentally sustainable manner".[287] In the Act a target was set to add a10% share of non-hydro RE to the electricity generation mix in 2020. The Act has incorporated regulatory frameworks and policies to help achieve this target.

With these policies in place to support the development of RE in the RE subsector, they have not yielded the desired results. Non-hydro RE has seen only a paltry dependable generation of 94.65 MW, according to the EC of Ghana in its April 2022 update. This chapter explores why non-hydro RE has less penetration in the electricity generation mix eleven years after coming into force of the RE Act.

From the in-depth analysis, the RE Act, with its supporting policies, has been less effective and abysmal in promoting the development of RE.[288] Analysis of the various policies has revealed that the target of adding 10% share of non-hydro RE in the electricity generation mix was going to be missed and indeed it was missed in 2020. The share of non-hydro RE in the electricity generation mix was 0.3% in 2020. Government subsidies render many tariff regimes susceptible to unfair prices, and this sometimes compels IPPs to factor this into Power Purchasing Agreements (PPAs) negotiations with government representatives. The grid network is old and weak, and this causes a lot of transmission and distribution losses estimated to be over 34% in 2021 according to EC.

The Renewable Energy Fund, which is supposed to provide incentives for the development of RE which includes the payment of FIT, which has now been repealed in 2020, has not been established. The reason adduced for this is lack of funds. The Renewable Energy Authority has not been established as the RE Act requires. The Authority is clothed with the powers of an independent regulator. Regulatory complexities contained in the RE Act do not bode well for RE development, in this the minister of energy determines the terms and conditions of the licences but has no power to issue any licence. However, instead, the issuance of licences is done by the EC, this kind of arrangement consumes a lot of time in the acquisition of a licence to operate in the RE subsector in Ghana. The situation depicts a general poor implementation of the provisions of the RE Act and policies thereby making them less effective and not meeting the effectiveness criteria as discussed in section 3.12 and subsections 3.12.1 to 3.12.2 further below in the chapter.

The above fundamental challenges need to be addressed with an evaluation of the performance of the RE Act and policies so that Ghana can reap the full benefits of its RE law, regulatory frameworks, and policies. Nevertheless, with other supporting frameworks, the RE Act has sparked a renewed interest in RE investment among IPPs, which is positive. As there are attempts to implement many of the provisions of the RE Act, the gradual pace will accelerate at some stage leading to non-hydro RE deployment increasing substantially in the future. With a review and changes to some of the policies and regulatory frameworks that are in operation now, Ghana can still succeed in its RE agenda.

This chapter is divided into fifteen main sections with sub-sections. Following the introduction is section 3.2, which focuses on definitions. The historical development of RE in Ghana follows

[287] Ghana's Renewable Energy Act, 2011 (Act 832).
[288] Simon Bawakyillenuo, 'The Political Economy of Renewable Energy Investment in Ghana'. In Ana Pueyo and Simon Bawakyillenuo (eds), Green Power for Africa: Overcoming the Main Constraints (IDS Bulletin Brighton 2017) < https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/13387/IDSB48.5_6_10.190881968-2017.167.pdf?sequence=1> accessed 29 September 2019

it in section 3.3 Section 3.4 discusses the determinants of RE development and consumption. Section 3.5 discusses the types of RETs in Ghana. Section 3.6 provides a discussion on the existing RE legal frameworks. Section 3.7 gives an analysis of the RE Act. Section 3.8 discusses RE policy instruments. Section 3.9 discusses RE policies adopted in Ghana. Section 3.10 discusses the Renewable Energy Master Plan 2019. Section 3.11 discusses the results of the empirical research. Section 3.12 assesses the effectiveness of the RE Act and policies using the effectiveness criteria. Section 3.13 discusses the legal and regulatory barriers to renewable energy deployment in Ghana. Section 3.14 discusses the Economic Community of West African States RE policy. Finally, Section 3.15 concludes the chapter by summarising the salient points that have been discussed.

3.2 Definitions

3.2.1 Renewable Energy

RE is energy that is derived from non-depleting sources, which include hydro, solar, wind, biomass, ocean energy, geothermal and emits less or no GHG emissions.[289] RE can be defined as "energy obtained from natural and persistent flows of energy occurring in the immediate environment''.[290]

3.2.2 Non-renewable Energy

Non-renewable energy is "energy obtained from static stores of energy that remains underground unless released by human interaction".[291] It is a limited natural resource that cannot be replenished within a short time at a scale compared to its consumption—for example, fossil fuels (coal, oil, and natural gas).

3.2.3 Alternative Energy

The term alternative energy refers to energy sources that do not cause havoc to the environment and do not emit carbon emissions that cause climate change, like fossil fuels. They offer benefits that are different to fossil fuel sources, for example, ES and climate change mitigation.

3.3 Historical Development of Renewable Energy in Ghana

Ghana has built three hydro dams namely Akosombo, Kpong and Bui. The three dams constructed after independence have not been operating at full capacity due to poor rainfall pattern in recent years. As a result, the country moved to the thermal phase, which uses natural gas or light crude oil to fire thermal plants to generate electricity. It was followed by the addition of non-hydro RE into the energy mix.[292] Up until recently, Ghana enjoyed reliable, clean, cheap energy mainly generated from the hydro dams. Demand soon increased from

[289] Ghana's Renewable Energy Act, 2011 (Act 832).
[290] John Twidell and Tony Weir, *Renewable Energy Resources* (3rd edn, Routledge Taylor & Francis 2015) 4
[291] ibid
[292] William Gboney, 'Policy and Regulatory Framework for Renewable Energy and Energy Efficiency Development in Ghana' [2009] Climate Policy. <https://doi.org/10.3763/cpol.2009.0636> accessed 10 July 2019

540 GWh in 1968 to 3917 GWh by 1976.[293] However, it fell due to some economic shocks, which soon picked up again, leading to the construction of the Kpong Dam, which was commissioned in 1982 to augment the existing dam. The Bui dam came on stream in 2012 when the latest round of crisis began. In chapter one under section 1.2 a discussion on RE development in Ghana was made and is potentially considered to be part of this section.

3.4 Determinants of Renewable Energy Development and Consumption

Energy is the backbone and lifeblood of modern economies and one of the drivers of economic growth. A key player in producing goods and services alongside labour and capital.[294] Fossil fuels have provided the energy needed for our daily use, such as cooking, heating, cooling, lighting, and transport. It has improved our standard of living remarkably. However, on the other hand, the side effects of fossil energy consumption have brought about, GHG emissions leading to climate change which has impacted the environment. The challenge as to how to overcome the situation is daunting and demands solutions hence turning to RES.[295]

As discussed earlier in this chapter, Ghana is endowed with RES, and two main ones have been used over the years. These include biomass and hydropower. However, in recent times the country has incorporated more and begun to harness them, including solar and wind. The exploitation of these two has been given much attention by the GoG, culminating in the passage of the RE Act. So, what are the determinants of RE consumption in Ghana?

Before answering this question, it is important to highlight the general factors that determine the development of RE on the international stage and Sub-Saharan Africa (SSA). These are grouped into political, socio-economic, and country-specific factors, as shown by Marque, Fuinhas and Manso.[296] A brief discussion of these factors is crucial to the understanding of the motivation that drives countries to adopt RE.

3.4.1 Political Factors

Political factors such as ES, public policy and institutional variables are the influencers of the adoption of RE. These factors have been confirmed by the works of many scholars.[297] In addition, Stadelmann and Castro have investigated public policies and confirmed that they have indeed contributed to the growth of RE.[298] These policies include Feed-in tariff (FIT), quota, renewable portfolio standard (RPS), RE targets and green certificates. The researcher shall discuss ES only as it is the focus of the thesis. On ES, if domestic RES can be exploited

[293] Maame Esi Eshun and J. Amoako-Tuffour, 'A review of the trends in Ghana's Power Sector'. Energy, Sustainability and Society (2016) <doi:10.1186/s13705-016-0075-y> accessed 19 November 2019

[294] Raymond A Atuguba and Francis Xavier Dery Tuokuu, 'Ghana's Renewable Energy Agenda: Legislative Drafting in Search of Policy Paralysis' (2020) 64 Energy Research and Social Science 101453 <https://doi.org/10.1016/j.erss.2020.101453>.accessed 10 August 2020

[295] David Elliot, 'Sustainable Energy: Choices, Problems and Opportunities' in R.E Hester and R.M Harrison (eds), Sustainability and Environmental Impact of Renewable Energy Resources (Royal Society of Chemistry Cambridge 2003)

[296] António C Marques, José A Fuinhas and JR Pires Manso, 'Motivations Driving Renewable Energy in European Countries: A Panel Data Approach' (2010) 38 Energy Policy 6877< https://doi.org/10.1016/j.enpol.2010.07.003> accessed 12 October 2019

[297] Scholars such as Selim, Owusu and Rivas (2019), Kilinc-Ata (2016), Gyamfi, Modjinou and Djordjevic (2015), Ackah and Asomani (2015), Marques and Fuinhas (2012) and Carley (2009).:

[298] Martin Stadelmann and Paula Castro, 'Climate Policy Innovation in the South - Domestic and International Determinants of Renewable Energy Policies in Developing and Emerging Countries' (2014) 29 Global Environmental Change 413 <http://dx.doi.org/10.1016/j.gloenvcha.2014.04.011>. Accessed 20 September 2019

and deployed from the national level, they can reduce the dependence on foreign imports and make the country less vulnerable and improve its ES. This has been confirmed by the work of Gyamfi, Modjinou and Djordjevic which has intimated that RE has the potential to improve electricity supply security in Ghana.[299]

However, a study by Aguirre and Ibikunle suggests that, after all, ES is not a concern as widely publicised studies claim by many earlier researchers.[300] To buttress their findings, they have pointed out that many new technologies are emerging which have the potential to access fossil fuel deposits in areas that previously were thought to be inaccessible. The discovery of this new frontier has the potential to address the many concerns raised about conventional energy sources, therefore ES has become of less concern to policymakers and their citizens.[301] New technologies such as carbon capture, fracking, and offshore oil exploitation. have emerged. They contend that these technologies will make fossil fuels adapt to contemporary energy issues and continue to play a dominant role in energy consumption globally. In their conclusion, Popp and others share the same view, indicating that ES concerns are less important for countries adopting RE.[302] It is, however, important to draw attention that in the case of Ghana, ES and climate change challenges are the drivers for Ghana exploiting its non-hydro RES to address these challenges as stated in the RE Act.[303]

3.4.2 Country specific Factors

A country's specificities, such as its wealth, culture or production potential of renewables, can be the possible reasons for its RE adoption.[304] In relation to the geography of the country thus, the size or dimension (its geographical area), Menz and Vachon thus argue that when taken into account the physical characteristics of the available production technologies, it will confirm that greater geographic area is associated with a greater production potential of renewables.[305] Therefore, RE potentials of an individual country can become the motivation behind the adoption of RE. Menz and Vachon further contend that natural endowment only is not enough for a country to adopt RE, but in addition to it, the relevant policies adopted by the government to promote their deployment are crucial.[306]

However, a country's natural RES endowment, such as solar, wind, and hydropower, plays a major role in its RE deployment. These resources will have to be adequate in large quantities and quality so that investment in their exploitation will be competitive.[307] RE potential that a country has, has been discussed in the literature. Carley has intimated the fact that solar, wind and biomass endowment explains RE growth and asserts that countries endowed with these

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[299] Samuel Gyamfi, Mawufemo Modjinou and Sinisa Djordjevic, 'Improving Electricity Supply Security in Ghana - The Potential of Renewable Energy' (2015) 43 Renewable and Sustainable Energy Reviews 1035. <https://doi.org/10.1016/j.rser.2014.11.102> Accessed 16 July 2019

[300] Mariana Aguirre and Gbenga Ibikunle, 'Determinants of Renewable Energy Growth: A Global Sample Analysis' (2014) 69 Energy Policy 374 <http://dx.doi.org/10.1016/j.enpol.2014.02.036>.accessed 15 January 2020

[301] ibid

[302] David Popp, Ivan Hascic and Neelakshi Medhi, 'Technology and the Diffusion of Renewable Energy' (2011) 33 Energy Economics 648 <http://dx.doi.org/10.1016/j.eneco.2010.08.007>.accessed 14 September 2019

[303] Ghana's Renewable Energy Act, 2011 (Act 832).

[304] Marques, Fuinhas and Manso (n 296).

[305] Fredric C Menz and Stephan Vachon, 'The Effectiveness of Different Policy Regimes for Promoting Wind Power: Experiences from the States' (2006) 34 Energy Policy 1786 <https://www.sciencedirect.com/science/article/pii/S0301421505000091> accessed 21 June 2019

[306] ibid

[307] Lori Bird and others, 'Policies and Market Factors Driving Wind Power Development in the United States' (2005) 33 Energy Policy 1397 < https://doi.org/10.1016/j.enpol.2003.12.018> accessed 24 June 2019

resources will deploy these technologies to their benefit.[308] Stadelmann and Castro, in a similar vein, agree that governments are more inclined to support RE deployment if their countries have sufficient natural endowment of these resources.[309] Furthermore, in the Ghanaian context, RES endowment is a possible reason for the GoG turning to these resources. However, the problem is the legal and policy frameworks that have been deployed and how effective they have been in developing RE in the country.

3.4.3 Socio-economic factors

These factors include prices of conventional energy sources, carbon emissions, energy demand and gross domestic product. Among the factors, GHG emissions are going to be discussed, especially CO_2. Among GHG emissions, CO_2 has the largest share. For that matter, its reduction is top on the agenda to save the environment, which has been discussed in the study of scholars like Marques, Fuinhas and Manso.[310] The causes of climate change are related to the large quantities of GHG emissions accumulated in the atmosphere though optimum levels are essential for life on earth. However, what impacts the environment is the excess which, if not controlled, will continue to increase the average temperature of the planet beyond acceptable levels; these unacceptable levels can lead to rising sea levels, droughts, and excessive rains that cause floods. Of these GHG emissions, CO_2 plays a significant role in these adverse weather conditions.[311] As such GHG emissions reduction is an important determinant of RE adoption. The rest of the factors are also found in the Ghanaian context, which will be discussed in the subsection below.

3.4.4 Determinants of Renewable Energy Consumption in Ghana

As observed from the international determinants of RE consumption to SSA, some common variables which include climate change, prices of fossil fuels, CO_2, population, income, ES, and economic growth run through them. The same is expected for Ghana. There are variables that generally determine the development of RE, and the ones going to be discussed may fall under one of the groups mentioned above earlier. These variables include ES, climate change, GDP, population, income, CO_2, trade openness, foreign direct investment, and fossil fuel consumption. The discussion is going to focus on some of these variables to see among them those that influence RE consumption in Ghana. So, having known these drivers, how have they influenced RE consumption in Ghana?

According to a study by Ackah, population increase is a driver of energy consumption. More so, due to population growth and other demand sectors, demand for both hydropower RE and thermal consumption has increased considerably.[312] But the population has also had a negative correlation with the consumption of non-hydro renewables. Therefore, Ghana's use of renewables needs clarification. From the outset, Ghana relied on hydropower which comes from RES provided by three large hydropower dams. However, due to many factors, including population growth, poor rainfall pattern, increase in access, urbanisation and economic growth, the hydropower generation could not meet demand. As a result, it led to the most severe energy crisis from 2013 to 2017. Therefore, the government shifted attention to thermal

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[308] Sanya Carley, 'State Renewable Energy Electricity Policies: An Empirical Evaluation of Effectiveness' (2009) 37 Energy Policy 3071 <http://dx.doi.org/10.1016/j.enpol.2009.03.062> accessed 10 June 2019

[309] Martin Stadelmann and Paula Castro, 'Climate Policy Innovation in the South - Domestic and International Determinants of Renewable Energy Policies in Developing and Emerging Countries' (2014) 29 Global Environmental Change 413 <http://dx.doi.org/10.1016/j.gloenvcha.2014.04.011>.accessed 20 September 2019

[310] Marques, Fuinhas and Manso (n 296).

[311] Marques, Fuinhas and Manso (n 296).

[312] Ishmael Ackah, 'Modelling Renewable Energy Economy in Ghana with Autometrics' [2015] SSRN Electronic Journal <http://dx.doi.org/10.2139/ssrn.2597690> accessed 16 January 2020

and non-hydro RE to augment the shortfall in generation from hydropower. Grid installed capacity results are that thermal now leads in the electricity generation mix by 3,753 MW, followed by hydropower at 1,584 MW and non-hydro RE at 144.05 MW.[313] So, it is clear that non-hydro power is paltry with 144.05 MW compared to thermal 3,753 MW. Therefore, population growth leads to the consumption of more fossil fuels than non-hydro RE in Ghana.

According to the study, income has a positive relation to RE use. With this, it can be inferred that when people's income increases, it gives them the purchasing power to buy more electrical gadgets that use energy; as such, their RE consumption increases. This finding correlates with that of Lin, Omoju and Okonkwo, who opine that income increases will make the public inclined to adopt RE to reduce the air pollution caused by the combustion of fossil fuels to generate electricity.[314] However, this finding contradicts another study by Ackah, Appiah-Adu and Ahunu which posits that income is a driver of the consumption of more non-RE compared to RE, because an increase in income of people give them the purchasing power to buy automobiles, refrigerators, and gas cookers, and many more of these gadgets use fossil fuels.[315] Cars, for example, use oil to run, and refrigerators/fridges use electricity derived from fossil fuels such as gas, diesel, and light crude.

A study by Ankrah and Lin confirmed that the main determinants of RE are foreign direct investment and trade openness whilst GDP per capita was inconsequential.[316] The study also showed that the continuous consumption of fossil fuels is inimical to the development of RE. On the other hand, foreign direct Investment and trade openness positively correlate with RE use. An increase in both variables leads to an increase in RE electricity generation, an indication that Ghana's economy supports technology transfer. Furthermore, as the country opens its doors, it allows the flow-in of knowledge, special skills and technology on RE which invariably leads to its development. The trade openness finding is consistent with the study of Omri and Nguyen, who concluded that trade openness is a major driver of RE consumption in a sample of sixty-four countries comprising low, middle-income, and high-income subpanels.[317]

The study by Ankrah and Lin further reveals that fossil fuels have a negative relation to RE because an increase in fossil fuel use leads to a decrease in RE development. This finding is in tandem with the lobby effect theory ''power of the lobby of conventional energy undermining renewable energy'' which Sovacool postulates that it has a negative influence on RE development.[318] The meaning of this is that the increase in the supply of fossil fuels like natural gas, and light crude oil to fire thermal plants to generate electricity has reduced the development of RE in Ghana and instead led to the expansion of thermal in recent years.. The increase in fossil fuel supply, which delays RE's development, explains the power of the lobbyist to impede RE integration. Ghana has enacted the RE Act, but the government's recent

[313] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022
[314] Boqiang Lin, Oluwasola E Omoju and Jennifer U Okonkwo, 'Factors Influencing Renewable Electricity Consumption in China' (2016) 55 Renewable and Sustainable Energy Reviews 687 <http://dx.doi.org/10.1016/j.rser.2015.11.003>. accessed 14 March 2020
[315] Ishmael Ackah, Kwaku Appiah-Adu and Linda Ahunu, 'What Factors Drive Energy Consumption in Ghana?' <https://mpra.ub.uni-muenchen.de/66095/> accessed 20 February 2020
[316] Isaac Ankrah and Boqiang Lin, 'Renewable Energy Development in Ghana: Beyond Potentials and Commitment.' [2020] Energy <https://doi.org/10.1016/j.energy.2020.117356> accessed 20 March 2020
[317] Anis Omri and Duc Khuong Nguyen, 'On the Determinants of Renewable Energy Consumption: International Evidence' (2014) 72 Energy 554 <http://dx.doi.org/10.1016/j.energy.2014.05.081>.accessed 12 September 2019
[318] Benjamin K Sovacool, 'Rejecting Renewables: The Socio-Technical Impediments to Renewable Electricity in the United States' (2009) 37 Energy Policy 4500 <http://dx.doi.org/10.1016/j.enpol.2009.05.073>.accessed 12 November 2019

activities in the energy sector after the passage of the Act confirm that the power of the lobbyist is at work. It is because more thermal plants have been built that use fossil fuels to the neglect of RE, and this consumption trend is set to continue to increase into the foreseeable future. Financial development is considered most often a positive contributor to RE development, as concluded by Brunnschweiler.[319] However, It intimated that RE is most often considered capital intensive and financial institutions will always see RE projects as risky, which attract higher rates on any borrowed money. It, therefore, makes it difficult for investors to raise the needed capital to finance RE projects in Ghana.

GDP per capita has shown an insignificant relationship with RE which indicates that Ghana's economic growth over the years has not had any significant positive correlation with non-hydro RE development. This conclusion confirms the work of Manegaki, who came to a similar conclusion for the EU.[320] In the Ghanaian context, past economic policies were focused on other demand sectors with non-hydro RE barely featuring and still today, it is not a priority in the economy compared to education, job creation, and exchange rate. However, this is not the same in other countries like China, where RE is given priority in its economic affairs.

One important determinant of RE consumption is endowment; thus, the potential of having these resources in sufficient quantities and in good quality influences governments to exploit them. Ghana is sufficiently endowed with many of these RES, but the most readily available and exploitable ones include solar, wind, biomass, and mini hydropower.[321] In Ghana, the average daily solar irradiation levels range between 4.0 to 6.5 kWh/m²/day.[322] Wind energy resources fall into wind classification of 3 and 6 which are good for power generation. Solar irradiation potential is very high in the northern parts of the country, whilst wind energy speed is high along the country's coastal regions, with few sites identified in the interior regions. Due to the availability of solar and wind, the government, with the support of some players in the energy sector, enacted the RE Act to harness these resources for the generation of electricity and heat. A target was set which was missed and now extended to 2030.

The literature had already indicated that the target is likely to be missed due to many factors. Some of such factors are the poor implementation of the RE Act and policies, and the lack of funding for the RE subsector. Furthermore, the variability of solar and wind resources makes it difficult and expensive to exploit them. Solar, for instance, is readily available during the day but not at night as such investment needs to be made in storage systems to store the harvested solar energy to be used later in the night. Wind too shows some weakness in terms of speed which sometimes falls below average speed in some areas making it difficult for its exploitation. These challenges have impacted these sources from achieving any significant penetration since the enactment of the RE Act. Nevertheless, a study by Rio and Unruh confirms that resource endowment is a driver of RE adoption, this follows the observation that

[319] Christa N Brunnschweiler, 'Finance for Renewable Energy: An Empirical Analysis of Developing and Transition Economies' (2010) 15 Environment and Development Economics 241. <https://doi.org/10.1017/S1355770X1000001X> accessed 15 March 2020

[320] Angeliki N Menegaki, 'Growth and Renewable Energy in Europe: A Random Effect Model with Evidence for Neutrality Hypothesis' (2011) 33 Energy Economics 257 <http://dx.doi.org/10.1016/j.eneco.2010.10.004>.accessed 10 November 2019

[321] Marilyn Winifred Asmah, Johanna Myrzik and Benjamin Kwame Ahunu, 'Challenges in the Ghanaian Power System: The Prospects of Renewable Energy Sources' (2015) 2015-Novem IEEE AFRICON Conference 1 < https://ieeexplore.ieee.org/document/7331945> accessed 10 January 2020

[322] Marriette Sakah and others, 'Towards a Sustainable Electrification in Ghana: A Review of Renewable Energy Deployment Policies' (2017) 79 Renewable and Sustainable Energy Reviews 544. < http://dx.doi.org/10.1016/j.rser.2017.05.090> accessed 10 November 2019

Spain is one of the countries in Europe that has good solar irradiation, particularly in the east and south regions, and this is enough motivation for the country to adopt PV installations.[323]

The above conclusion has been contradicted by Gosens, who intimated that, natural resources endowment is a small part of a larger set of drivers of RE adoption.[324] Gosens posits that instead, the quality of natural resources drives the development of solar photovoltaic (PV) and wind.[325] This result is not as strong as would have been expected. It explains that measures of the quality of natural resources have significant power over measures of abundance. The results indicate that countries with high-quality resources are more likely to deploy them, e.g., wind turbines and solar panels, because of these technologies' profitability. However, it must be noted that resource quality is not a sufficient condition for developing a strong market for these natural resources. Furthermore, some countries are endowed with RES but are unmoved to harness them. Nigeria, for example, is endowed with RES such as solar, mini hydro, and wind, however, these resources have been left untapped.[326] This buttresses the point that resource endowment is not the only factor in the adoption of RE. However, this notwithstanding, countries with poor quality resources have managed to develop them, thus wind and solar PV. The study points to other drivers that play a crucial role in RE adoption and not just resource endowments. Other drivers of significance for RE integration are good RE policies and regulatory frameworks.

3.5 Types of Renewable Energy Technologies (RETs) in Ghana

From the empirical research, the participants mentioned the various RES Ghana was harnessing as follows**; of *the ten (10) participants, who were asked the question, on which RES were currently being harnessed in Ghana, all named the RES as hydro (mini and large), solar, wind and biomass. This affirmation is captured in the literature that Ghana is endowed with plenty of RES.[327] Although Ghana has wind energy potential, the participants were not convinced that the potential could be harnessed soon to make an impact. However, one official was confident that wind exploration was viable but accepted that more feasibility studies were ongoing, which will eventually lead to a large-scale deployment of the resource (wind).***

3.5.1. Solar Energy

Solar energy is sunlight converted into different forms of usable energy. The following are the established solar technologies in use, solar photovoltaic (PV), high-temperature solar thermal electricity and solar heating and cooling:[328]

[323] Pablo del Río and Gregory Unruh, 'Overcoming the Lock-out of Renewable Energy Technologies in Spain: The Cases of Wind and Solar Electricity' (2007) 11 Renewable and Sustainable Energy Reviews 1498 < https://doi.org/10.1016/j.rser.2005.12.003> accessed 12 December 2019
[324]Jorrit Gosens, 'Natural Resource Endowment Is Not a Strong Driver of Wind or PV Development' (2017) 113 Renewable Energy 1007 <http://dx.doi.org/10.1016/j.renene.2017.06.062>. accessed 20 February 2020
[325] ibid
[326] Oluwaseun Viyon Ojo 'An Overview of the Legal and Regulatory Framework for Renewable Energy Projects in Nigeria: Challenges and Prospects' (2017) 1 (1). Unilag Law Review 22 <https://ssrn.com/abstract=2997075> accessed 10 June 2019
[327] Sakah and others (n 322).
[328] International Energy Agency, 'Solar' (IEA, 15 December 2022) <https://www.iea.org/fuels-and-technologies/solar> accessed 14 January 2023.

3.5.1.1 Solar PV

Photovoltaic solar energy involves the direct conversion of solar radiation to electricity. A PV system comprises several solar cells that can focus sunlight and convert it into electricity. In Ghana, PV is popularly called solar panel. The design is suited for installation on rooftops and positioned in a way that the cells can maximise sunlight to generate solar power. The total global solar PV installed capacity reached 825 GW at the end of 2021, according to the International Renewable Energy Agency (IRENA).[329] Grid-connected solar PV total installed capacity in Ghana reached 143.9 MW, and this is coming from VRA, Meinergy, Beijing Xiaocheng Company (BXC), Bui, and Distributed solar PV solar plants.[330] These solar plants occupy large portions of arable land, e.g., BXC is situated on a hundred-acre parcel of land and costs about US$30m. The cost of building the Punga solar park amounted to US$8.08m as seen in chapter seven-under subsection 7.9.1

Ghana's solar irradiation levels range between 4.0 to 6.5 kWh/m²/day, and annual sunshine duration ranges between 1800 to 3000 hours per annum.[331] Ghana is endowed with solar energy; solar radiation is abundant in any part of the country. However, the two pioneer solar power plants in the country have been sited at the outskirt of the main load centres. Due consideration is given to issues such as land affordability; in remote areas like Navrongo, the land is cheap compared to Accra or Tamale. Solar radiation is very high in the northern parts of Ghana. Accessibility to the distribution network is close and NEDCo is the off-taker of the electricity generated from Pungu in Navrongo.

3.5.1.2 Advantages of Solar Energy

Solar energy is a vital resource that can contribute to the country's ES and, at the same time, mitigate climate change. Some of the advantages of using solar energy technology include solar power does not release any GHG emissions and therefore does not pollute the environment after installing the panels. Investment can be recouped as there are no utility bills to pay. It is a source of clean power that is available throughout the year. It reduces the dependence on imported oil and natural gas and therefore, no price volatility compared to fossil fuels. It can create jobs for manufacturers of solar panels and technicians who install the panels.

3.5.1.3 Disadvantages of Solar Energy

However, the downside to solar power are as follows: capital intensive for initial cost for the solar panels and installation. Buttressing this point, generation of solar energy is relatively expensive when compared to thermal. Take for instance the Solar Power Plant at Navrongo in the Upper East region of Ghana which generates 2.5 MW of electricity, it occupies about 3.4 hectares of land and cost almost US$9m.[332] Nevertheless, when a life cycle analysis is conducted between a solar energy system and a thermal plant, the former is environmentally

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[329] International Renewable Energy Agency, 'Renewable Capacity Highlights' (IRENA, 12 April 2022) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Apr/IRENA_-RE_Capacity_Highlights_2022.pdf?la=en&hash=6122BF5666A36BECD5AAA2050B011ECE255B3BC7#:~:text=11%20April%202022&text=Renewable%20generation%20capacity%20increased%20by,10%20G> accessed 14 June 2022

[330] Energy Commission of Ghana (n 313).

[331] Sakah and others (n 322).

[332] ECREEE, 'Case Study Navrongo Solar PV Project Ghana' (ECREEE, December 2017) <http://www.ecreee.org/sites/default/files/ecreee_case_study_navrongo_solar_pv_project_ghana.pdf > accessed 10 January 2022

friendly compared to the latter.[333] Also, solar power is only available in the daytime, and therefore to be able to use it at night, an additional cost is incurred to procure large battery banks. In Ghana, the peak of energy consumption is between 6.00 p.m. to 11.00 p.m. at this time, solar is not available, which invariably leads to the increase in the cost of investing in storage technology which is likely to increase the cost further for consumers. Furthermore, it needs a large expanse of land and space as efficiency is not yet maximised. Ghana is grappling with a housing deficit of about two million housing units.[334] So, large tracts of land to be earmarked for solar PV projects will worsen the housing situation the country is already experiencing.

The agricultural sector will be hit with solar PV projects as large hectares of land could be reserved for these projects, which could threaten the country's food security. Further discussion on solar PV and food security can be found in chapter seven-under section 7.6 of the thesis. Highly toxic materials are used in the manufacture of solar PV panels with little knowledge of their health and environmental consequences; this is the case, especially when they have reached the end of their life span.[335] Less energy is generated on cloudy days even though technology has improved to derive energy from daylight and not the intensity of sunlight. It is not entirely carbon-free; in the manufacture of solar panels, the energy used comes from conventional sources that emit GHG emissions. Table 2 below displays a summary of the advantages and disadvantages of solar energy.

Table: 2 Summary of the Advantages and Disadvantages of Solar Energy

Advantages of solar energy	**Disadvantages of solar energy**
Solar power does not release any GHG emissions and therefore does not pollute the environment after the installation of the panels.	**Solar is capital intensive for the initial cost for the solar panels and installation.**
Investment can be recouped as there are no utility bills to pay.	**Solar energy is only available in the daytime and therefore to be able to use it in the night, additional cost is incurred to procure large battery banks.**
It is a source of clean power that is available through-out the year.	**Solar technology needs large hectares of land and space as efficiency is not yet maximised.**
It reduces the dependence on imported oil and natural gas and therefore no price volatility as compared to fossil fuels.	**Extremely toxic materials are used in the manufacture of solar panels with little knowledge on their health and environmental consequences, this is the case especially when they have reached the end of their life span.**

[333] E.A. Alsema, M.J. de Wild-Scholten and V.M. Fthenakis, 'Environmental Impacts of PV Electricity Generation - A Critical Comparison of Energy Supply Options' <http://lumma.org/energy/papers/Alsema2006.pdf> accessed 20 June 2022

[334] Ayesha Algade Amadu, 'Lessons from Covid-19' (GH Headlines, 2 May 2020) < https://ghheadlines.com/agency/citifm/20200502/135395262/ayesha-algade-amadu-writies-lessons-from-covid-19// > accessed 10 March 2020

[335] Stephanie Weckend, Andreas Wade and Garvin Heath, 'End of Life Management: Solar Photovoltaic Panels' (IRENA, June 2016) < https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEAPVPS_End-of-Life_Solar_PV_Panels_2016.pdf>. accessed 12 May 2020

It can create jobs for manufacturers of solar panels and technicians who install the panels.	**Less energy is generated on cloudy days even though technology has improved to derive energy from day light and not the intensity of sunlight.**
	It is not completely carbon-free, in the manufacture of the solar panels, the energy used is coming from conventional sources that emit GHG emissions.

Source: Author's elaboration with ideas from the literature (2022)

3.5.2 Wind Energy

Wind technology harnesses the wind to provide mechanical power with windmills or turbines to generate electricity. The turbines allow the harnessing of the power of wind in order to convert it to energy (electricity). When the wind blows, the turbine turns in a clockwise direction which enables the blades to spin and, in the process, capture the energy. The energy captured is then transmitted through the shaft to an embedded generator that converts the energy to electricity. The electricity generated is then transferred to a transformer which finally transmits it to the grid. Wind energy has been used for centuries until the advent of the fossil trio, which relegated it to the background. However, following the world's renewed interest in renewables, to combat fossil fuels externalities, wind energy is back to provide negligible zero-emissions clean energy for electricity generation which can be supplied to remote areas.[336] The technology can be deployed either onshore or offshore with the onshore wind as the current most economical renewable energy technology used in energy generation. Offshore wind projects are capital intensive compared to land-based ones. One advantage of offshore wind projects is that, given their position in the sea, they benefit from high wind speed and are able to harness wind energy better than their land-based counterparts.[337] Generation of electricity through wind turbines is now competitive. Global wind power capacity reached 849 GW at the end of 2021.[338]

Ghana is endowed with sufficient RES, which includes wind energy. Wind energy speed ranges between 8.4 to 9.9 m/s.[339] At this juncture, it is worth stating that wind power does not feature in the energy mix of Ghana because initially, poor feasibility studies gave wind speed to be low, thereby minimising the chances of exploring and exploiting it.[340] But due to improvement in technology in measuring wind speed, it has been discovered that there is much prospect relating to harnessing it, especially along the coastlines of Winneba, Takoradi

[336] Manwell J.F, McGowan J.G and Rogers A.L, *Wind Energy Explained: Theory, Design and Application (*2nd edn John Wiley & Sons Ltd 2009) 521

[337] International Energy Agency, 'Wind' (IEA, 12 December 2022) <https://www.iea.org/fuels-and-technologies/wind> accessed 17 January 2023.

[338] International Renewable Energy Agency, 'Renewable Capacity Highlights' (IRENA, 12 April 2022) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Apr/IRENA_-RE_Capacity_Highlights_2022.pdf?la=en&hash=6122BF5666A36BECD5AAA2050B011ECE255B3BC7#:~:text=11%20April%202022&text=Renewable%20generation%20capacity%20increased%20by,10%20G> accessed 14 June 2022

[339] Ghana, 'Sustainable Energy for All Action Plan' (EC, June 2012) <http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf> accessed 20 January 2020

[340] Energy Commission of Ghana, Energy Statistics Handbook 2018 (EC of Ghana 2018) < http://www.energycom.gov.gh/files/2018%20Key%20Energy%20Statistics.pdf> accessed 19 July 2020

and Ada. In addition, wind power is a cost-effective energy source in many parts of the world, though it has to compete with other sources in some regions. However, research is effectively levelling the cost for both onshore and offshore. Another advantage is that it is a domestic energy source providing unlimited opportunity to harness it locally.

Wind power is a sustainable source due to its availability. When wind turbines are operating, they do not emit any GHG emissions directly, thereby aiding countries in reducing emissions and combating climate change. IRENA has forecast that by 2050, wind energy will offset nearly 6.3 gigatonnes of carbon dioxide annually.[341] Capturing wind power does not lead to the depletion of our natural resources and wind as a resource is readily available and plentiful. Wind energy reduces the dependence on fossil fuels, thereby bringing about ES. Wind energy is a renewable source, so there is no fuel price volatility which is generally associated with fossil fuels.[342] Wind energy exploitation creates many jobs for people involved in the wind industry.

Though wind energy provides clean energy and has the potential to shore up the ES of the country, there are some problems associated with its generation and consumption. The challenges with wind power are, for instance, some viable locations for wind farms are situated in challenging remote areas, which makes harnessing it difficult and expensive. In addition, a wind energy developer would have to spend a lot of funds on wind power projects; such projects are capital intensive and expensive.[343] Wind energy generation cannot be said to be zero carbon emission-free. Wind turbine is manufactured from different material and the processes leading to its construction involve the use of energy which does not come from renewable sources, and therefore technically it cannot be said to be emission-free. The offshore turbines have also caused some obstructions to aquatic life and disturbed their natural habitat.

One major environmental concern related to wind farms is the noise pollution that comes from wind turbines. Pilot studies conducted by physicians in some countries, including the UK, have concluded that some families are suffering from health and sleep-related ailments which are linked to noise emanating from wind turbines.[344] Further, Carley and Konisky writing on energy justice, also confirm that low-carbon technologies produce negative externalities that will be borne disproportionately by people who live close to these facilities. e.g., noise disruption by turbines.[345] The pilot studies above put forward the suggestion that a wind turbine with a generation capacity of 2MW should be sited about a distance of 2KM away from noise-sensitive residential properties to keep the noise at acceptable levels.[346] To further ascertain the veracity of the noise pollution of wind turbines, the university of Salford conducted a

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[341] International Renewable Energy Agency, 'Future of Wind Deployment, investment, technology, grid integration and socio-economic aspects' (IRENA, October 2019) < https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Oct/IRENA_Future_of_wind_2019.pdf > accessed 15 August 2020

[342] Shiva Gorjian, 'An Introduction to Renewable Energy Resources' (2017) <https//doi:10.13140/RG.2.2.27055.53928> accessed 21 January 2020

[343] Tarang Agarwal, Shivank Verma and Ashutosh Gaurh, 'Issues and Challenges of Wind Energy' [2016] International Conference on Electrical, Electronics, and Optimisation Techniques, ICEEOT 2016 67. <https://doi.org/10.1109/ICEEOT.2016.7754761> accessed 11 November 2019

[344] Barbara J. Frey and Peter J. Hadden, 'Noise Radiation from Wind Turbines Installed Near Homes: Effects on Health' (2012) <http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=AEE2BDAF9F2BAC9BF3836AE024917B40?doi=10.1.1.172.354&rep=rep1&type=pdf> accessed 14 December 2019

[345] Sanya Carley and David M Konisky, 'The Justice and Equity Implications of the Clean Energy Transition' (2020) 5 Nature Energy 569 <http://dx.doi.org/10.1038/s41560-020-0641-6>. accessed 20 December 2021

[346] ibid

research on wind farms and the available data did not confirm the farms cause a statutory nuisance as stipulated under the Environmental Protection Act 1990, suggesting that after all the situation is not bad as previously thought.[347] Furthermore, many of the complaints died down following improvement of the designs and the introduction of a turbine control system.[348]

Wind farms have also been criticised for their negative effect on birds through the loss of nesting, feeding grounds, roosting, displacement through disturbance and even survival as the blades kill many especially migrating birds.[349] However, the impact of wind turbines is minor if compared to other energy sources; Sovacool estimated that conventional power stations (fossil fuels) kill twenty times more birds than wind turbines per GWh.[350] Onshore wind farms occupy vast hectares of arable land which could otherwise be used for agricultural purposes thus posing food security concerns.

Offshore wind farms can reduce the landscaping impact related to onshore wind farms; so far, there have not been severe environmental issues raised about offshore wind farms, though more research is needed now and in the foreseeable future.[351] Musial and others have argued that some of the public concerns of the negative environmental impact of wind turbines on marine life have been exacerbated, by poor media research misinformation reportage instead of proper documented research-based facts and information.[352] The summary of the advantages and disadvantages of wind energy is found in table 3 below as follows:

Table: 3 Summary of Advantages and Disadvantages of Wind Energy

Advantages of wind energy	**Disadvantages of wind energy**
Wind energy is a clean and environmentally friendly source of energy e.g., no GHG emissions.	**Wind speed is variable and sometimes the wind is just not blowing enough for the energy to be harnessed.**
Wind energy is cost effective because it is completely free.	**Sometimes it poses a threat to wildlife thus killing birds that fly into the spinning blades.**
Wind energy is renewable and a sustainable source of energy, the wind blows, and the energy is harnessed and does not run out like fossil fuels.	**Noise pollution is sometimes associated with the turbines. As some brands make a lot of noise. But technological development in the manufacture of the turbines is improving and the noise concerns are being addressed.**

[347] Department for Business Enterprise and Regulatory Reform, 'Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report' (2007). Report by the University of Salford. < http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk//files/file40570.pdf> accessed 10 January 2020

[348] ibid

[349] Catherine Bowyer and others, 'Positive Planning for Onshore Wind – Expanding Onshore Wind Energy Capacity while Conserving Nature' (2009). A Report by the Institute for European Environmental Policy <http://www.rspb.org.uk/Images/Positive%20Planning%20for%20Onshore%20Wind_tcm9-213280.pdf> accessed 12 November 2019

[350] Benjamin K Sovacool, 'Contextualising Avian Mortality: A Preliminary Appraisal of Bird and Bat Fatalities from Wind, Fossil-Fuel, and Nuclear Electricity' (2009) 37 Energy Policy 2241 < https://doi.org/10.1016/j.enpol.2009.02.011> accessed 20 September 2019

[351] Robin Pelc and Rod M Fujita, 'Renewable Energy from the Ocean' (2002) 26 Marine Policy 471 <https://doi.org/10.1016/S0308-597X(02)00045-3 > accessed 10 February 2020

[352] Walt Musial, Sandy Butterfield and Bonnie Ram, 'Energy from Offshore Wind' (2006) Offshore Technology Conference <https://doi.org/10.4043/18355-MS> Conference Paper NREL/CP-500-39450 accessed 14 November 2019

Job creation for the manufacture of wind turbines, installation, and maintenance.	**The siting of wind turbines onshore can interfere and limit the use of the land for other purposes such as crop production. Offshore turbines can also interfere with marine life.**
Wind farms sites can co-exist with other land users especially for crop production.	**After the turbines run their full lifespan, the decommissioning and disposal sometimes become problematic.**

Source: Author's elaboration with ideas from the literature (2022)

3.5.3 Biomass

Through photosynthesis, energy is stored in biomass, an energy source for human consumption. Biomass resources are diverse, and there is a high volume of consumption of one of the categories, fuelwood, in developing countries, especially in Asia and SSA. This category is consumed in the forms of firewood and charcoal. Other forms include forestry and crop residues, agro-industrial and municipal wastes. Biomass can also produce liquid fuels, for example, ethanol, methanol, vegetable oils, including biogas produced by anaerobic respiration, which is common in India and China.[353] Over 34% of Ghana's energy use comes from biomass which is the primary energy consumed in most households in the country in the forms of firewood and charcoal.[354] These forms are used for cooking and heating. Many small and medium-sized enterprises use biomass for bakery, fish smoking, brewing of alcoholic drinks, coffee and tea drying, and tobacco curing.[355] If biomass is exploited sustainably, it can be converted into modern energy carriers that can be described as clean with fewer carbon emissions. When biomass is harvested near where it is consumed, its economic benefits can be maximised, and this is why it is popular among rural users. Bioenergy has the potential to mitigate GHG emissions if the resources are exploited in a sustainable way using efficient bioenergy systems. The sustainable use of bioenergy can make a significant improvement to rural economic development, thereby enhancing ES and helping to reduce environmental impact.[356]

Biomass accounted for about 56.9 EJ of global domestic energy supply in 2019.[357] It is relatively inefficient in generating energy compared to other forms of RES such as solar and wind. Some researchers have found it challenging to comprehend how biomass has come to be classified as a renewable fuel because it is seen to have features similar to fossil fuels, such as odours and GHG emissions.[358] Carneiro and Ferreira have identified some

[353] Richard L. Ottinger and Fred Zalcman, Legal measures to promote renewable and energy efficiency resources in Adrian J. Bradbrook and Richard L. Ottinger (eds), *Energy Law and Sustainable Development* (IUCN, Gland, Switzerland and Cambridge, UK 2003).
[354] Energy Commission of Ghana (n 310).
[355] Stephen Karekezi and Timothy Ranja, *Renewable Energy Technologies in Africa* (Zed Books Ltd, London, UK 1997) 2
[356] Helena Chum and others, 'Bioenergy' in Ottomar Edenhofer, Ramon Pichs Madruga, and Youba Sokona (eds.), *Renewable Energy Sources and Climate Change Mitigation (Special Report of the Intergovernmental Panel on Climate Change* (Cambridge University and New York 2011).
[357] World Bioenergy Association, 'Global Bioenergy Statistics 2021' (WBA, 2021) <https://www.worldbioenergy.org/uploads/211214%20WBA%20GBS%202021.pdf > accessed 25 June 2022
[358] Lorraine Whitmarsh and Paul Upham, 'Public Responses to Climate Change and Low Carbon Energy' Appearing in Thomas Roberts and others (eds), *'Low Carbon Energy Controversies'* (Routledge 2003).

environmental impact of biomass which include emissions from the movements of vehicles used in the process of production, changes in soil fertility, and the use of pesticides and fertilisers during crop production.[359] However, some writers are of the view that good land and forest management techniques can mitigate the environmental side effects.[360] The resource is exploited in a way in Ghana that can be described as unsustainable for the following reasons: Forest cover of the country is depleted to levels that are considered unsustainable, and because of that more biodiversity has been affected. Natural habitats of some wildlife have been destroyed and lost. Some wood species have been exploited to levels beyond their replenishable capacity and are gone extinct.

Trees in the forest, through the carbon cycle, use carbon to grow and help capture carbon for very long periods of time. However, biomass consumption undermines this process as there are only fewer trees left to capture the carbon. The use of biomass affects tree stocks, and in some cases, woodlots are cultivated for traditional biomass purposes. These woodlots are grown for traditional biomass consumption and take up fertile lands that would otherwise be used to cultivate food crops. It can further be observed that biomass does nothing to tackle the central issue of carbon dioxide accumulation in the atmosphere, which may have some dire consequences for biodiversity. The burning of biomass leads to the release of a lot of chemical pollutants into the atmosphere causing immense pollution.[361] The combustion of biomass also causes indoor pollution, which is a health risk to many consuming it, leading to the deaths of millions of people.[362]

The burning of crop residues as a fuel brings negative consequences on biodiversity by removing vital nutrients from the soil, thereby reducing the organic matter composition, which makes the soil lose its water-holding capacity and fertility. On the other hand, bioenergy, which excludes traditional biomass though good and serves as a renewable source, competes for fertile lands. As a result, fertile lands that could otherwise be used to cultivate food crops are instead used for the cultivation of biofuel crops, which poses a threat to world food security.[363] Biomass has many positives as a renewable source which does not impact the environment. However, the unsustainable consumption of the resource, both traditional biomass and biofuel, invariably lead to the erosion of the net positive GHG emission mitigating impact it makes. Given this, a balance needs to be struck between its sustainable use. Thus, a combination of adaptation measures with biomass exploitation and use can bring about sustainable opportunities for forests, crops, and bioenergy.

Biomass plays a beneficial environmental function in that it ensures the effective disposal through the utilisation of both plant and animal wastes which would otherwise have constituted environmental hazards. Sims, Rogner, and Gregory observed that agricultural and forest residues such as rice husks, bagasse, bark, and sawdust could be used in waste-to-energy conversion, this is to generate heat and power for rural industries and communities where their

[359] Patricia Carneiro and Paula Ferreira, 'The Economic, Environmental and Strategic Value of Biomass' (2012) 44 Renewable Energy 17-22< https://doi.org/10.1016/j.renene.2011.12.020> accessed 12 February 2020

[360] Rosa M. Saez, Pedro Linares and J. Leal, 'Assessment of the Externalities of Biomass Energy, and a Comparison of its full Costs with Coal' (1998) 14 Biomass and Bioenergy 469-478 < https://doi.org/10.1016/S0961-9534(98)00016-6> accessed 20 January 2020

[361] David Pimentel and others, 'Renewable Energy: Economics and Environment Issues' (1994) 44 (8) Bioscience 536-547<https://www.jstor.org/stable/1312281> accessed 27 January 2020

[362] World Health Organisation, 'Household air pollution' (WHO, 28 November 2022) <https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health> accessed 16 May 2020

[363] Green Facts, 'Liquid Biofuels for Transport Prospects, risks and opportunities' <https://www.greenfacts.org/en/biofuels/l-3/4-environmental-impacts.htm> accessed 10 May 2020.

usage is common.[364] They cited Denmark, where 40% of electricity is generated from biomass cogeneration plants which use straw, wood waste and animal waste for biogas, also, in Finland, 10% of electricity is generated from forest residues, pulp liquors and sawdust.[365] However, the two countries have, since the publication by Sims, Rogner, and Gregory, increased their biomass consumption. It is, however, not clear whether plant and animal waste are classified as ''biomass'' under the RE Act of Ghana. It would be helpful if this determination is made. Even though animal and plant waste are still considered waste, the issue is that the carbon emissions that come with them are relevant when the waste is used for energy generation. Unfortunately, the RE Act is silent on it.

Panwar, Kaushik and Kothari have observed that large quantities of animal manure and slurries generated today by the animal breeding industry and wet organic streams constitute a constant pollution risk; as such, they pose potential negative consequences on the environment if not managed in an optimal manner.[366] The use of biomass technologies would help in such optimal management. Furthermore, municipal solid waste, waste from food processing and waste products from the pulp and paper industry can all be converted into biomass energy.[367] Knopf and others have observed that large scale energy crop production will increase competition for land, agricultural inputs and water, and this may lead to challenges and put pressure on other aspects of sustainability such as food security, water use and land use.[368] Indeed Flavin and Dunn intimate that in the future biomass use will be faced with challenges such as land limitation and water among many other factors.[369] However, the land issue associated with biomass can be avoided by the use of non-food lands for the production of raw materials through the introduction and promulgation of legislation. In many parts of Ghana, large swathes of land are lying idle and can be used to cultivate energy crops.

Whitmarsh and Upham have raised the issue of carbon emissions during the process of production.[370] However, the researcher holds the view that when the raw material is converted to energy, trees can be planted to replace those harvested for energy and through the carbon cycle process, the new trees will re-absorb the carbon dioxide released during combustion as most trees can grow rapidly to tall heights within a year. On the whole, through good laws, the use of biomass technologies has some benefits for the environment, including the mitigation of soil erosion, reduction of pressure on landfills, water pollution and forest cover for wildlife habitats.[371] Energy crops do offer many benefits to humankind when they are used for

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[364] Ralph E.H. Sims, Hans-Holger Rogner and Ken Gregory, 'Carbon Emission and Mitigating Cost Comparisons between Fossil Fuel, Nuclear and Renewable Energy Sources for Electricity Generation' (2003) 31 Energy Policy 1315-1326 < https://doi.org/10.1016/S0301-4215(02)00192-1> accessed 15 February 2020

[365] ibid

[366] N.L. Panwar, S.C. Kaushik and Surendra Kothari, 'Role of Renewable Energy Sources in Environmental Protection: A Review' (2011) 15 Renewable and Sustainable Energy Reviews 1513-1524 at 1517< https://doi.org/10.1016/j.rser.2010.11.037> accessed 15 February 2020

[367] Athanasios Angelis-Dimakis and others, 'Methods and Tools to Evaluate the Availability of Renewable Energy Sources' (2011) 15 Renewable and Sustainable Energy Reviews 1182-1200 at 1192. <https://doi.org/10.1016/j.rser.2010.09.049> accessed 10 January 2020

[368] Brigitte Knopf and others, 'Managing the Low-Carbon Transition – From Model Results to Policies' (2010) Vol. 31 The Energy Journal (Special Issue 1) 223 at 238. < https://doi.org/10.5547/ISSN 0195-6574-EJ-Vol 31-No-9> accessed 12 December 2019

[369] Christopher Flavin and Seth Dunn, 'Renewable Energy Technologies and Policies: Status and Prospects' (1997) 5 Buffalo Environmental Law Journal 1 <https://digitalcommons.law.buffalo.edu/belj/vol5/iss1/1> accessed 5 February 2020

[370] Whitmarsh and Upham (n 354).

[371] Ayhan Demirbas, 'Potential Applications of Renewable Energy Sources, Biomass Combustion Problems in Boiler Power Systems and Combustion Related Environmental Issues' (2005) 31 Progress in Energy and Combustion Science 171-192. <https://doi.org/10.1016/j.pecs.2005.02.002> accessed 23 January 2020

biomass. Rowe, Street and Taylor observed some of these benefits, including increases in the soil organic matter, for instance, the cultivation of some energy crops like coppice and miscanthus for short rotation is linked to the improvement of soil conditions that include water retention, fertility, and soil texture because of reduced tillage.[372] In Ghana, people engaged in biomass production business derive their sustenance from it which provides jobs for them.

The main challenge in biomass energy use and supply in Ghana has to do with how to reverse the decline in the availability of wood fuel resources in the country. Furthermore, how to adopt new sustainable approaches in its production and use by bringing about improvement in the efficiency of generation and consumption. Whilst policy is focused on improving the production of biomass and uses in the short-term, the increase in the regeneration and substituting fuel in the medium to long term and eventually shifting from biomass to other sustainable alternative energy sources should be the main goal.

Bassam noted the environmental benefits of biofuels using energy crops as substitutes for monoculture food crops. Bassam's observation is as follows:

> Wide utilisation of plant raw materials for energy offers the chance to re-organise agriculture production towards an environmentally consistent system through increasing the number of plant species, re-introducing traditional crops, and introducing new alternative crops. It will lead to the production of different energy feedstocks with more significant outputs and lower environmental inputs. It will also lead to diversification, improving the landscape's appearance, reducing input such as fertilisers, herbicides, fungicides, and fuels, in crop management, and improving the microclimate through water use and recycling mechanisms. Crops can absorb CO_2 released from the combustion of biofuels and produce oxygen from water during photosynthesis, thus reducing the depletion of oxygen in the atmosphere.[373]

If agriculture can be re-organised or re-arranged according to the above observation, it would go a long way to address the challenges posed by biofuels. A summary of the advantages and disadvantages of biomass can be seen in table 4 below.

Table: 4 Summary of Advantages and Disadvantages of Biomass

Advantages of Biomass	**Disadvantages of Biomass**
Biomass is readily and widely distributed and available locally as a renewable source of energy.	**Biomass energy is less efficient when compared to fossil fuels e.g., ethanol when compared to gasoline.**
It is cost effective because energy derived from it, is inexpensive when compared to oil and coal.	**It can lead to deforestation and biodiversity loss.**
It is less expensive when compared to fossil fuels.	**It can be expensive when extracting, harvesting, and storing of the different types of biomasses.**
It is less polluting and can be described as carbon neutral- it is part of the carbon cycle.	**It is not completely emission-free, its consumption brings about**

[372] Rebecca L. Rowe, Nathaniel R. Street and Gail Taylor, 'Identifying Potential Environmental Impacts of Large-Scale Deployment of Dedicated Bioenergy Crops in the UK' (2009) 13 Renewable and Sustainable Energy Reviews 271-290 at 277 < https://doi.org/10.1016/j.rser.2007.07.008> accessed 30 January 2020

[373] Nasir EL. Bassam, Energy Plant Species: Their Use and Impact on Environment and Development (James & James Science Publishers Ltd., 1998) 43

	indoor pollution which kills millions of people annually.
It reduces the dependence on fossil fuels, and it provides jobs for people engaged in its production and distribution.	**Biomass plants compete with food crops for arable land and thereby posing a threat to food security.**

Source: Author's elaboration with ideas from the literature (2022)

.3.5.4 Hydroelectric Power

Hydropower or waterpower is the power derived from falling water or fast current water that produces energy that can be harnessed for electricity. The flowing water produces energy that is captured to generate electricity, known as hydroelectric power or hydropower. Hydropower is a form of RE that is obtained from running water and is able to convert it into electrical power. This technology has been around for centuries, and the global annual hydropower generation capacity was 4418 TWH in 2020.[374] Hydropower is the world's largest RE source that is used for electricity generation, and it plays a vital role in GHG emissions reduction. Hydropower is a mature technology that is still evolving; hydropower projects can be classified according to the way they harness water to generate power as follows:[375]

Reservoir, in this the project collects water for storage which is released through a power plant for the generation of electricity; it provides for flexibility of electricity generation according to the dictates of demand and reduces the dependence on the variability inflows.

Pumped storage, in this the project pumps water from a lower-level reservoir to a higher-level reservoir for release via a power plant during peak demand and

Run-of-river is a project that harnesses energy for electricity generation from a flowing river, with limited storage capacity.

After independence in 1957 from British colonial rule, Ghana built two hydroelectric dams, namely Akosombo and Kpong. In addition, the Bui hydroelectric dam has recently been added to the existing two. Since the construction of these dams, the country relied on them for decades for power until the early 1990s, when the rainfall pattern changed, and this affected power generation and consumption. After that, however, these dams still supply the country's electricity needs and are still part of the generation mix.

The benefits of hydropower cannot be over-emphasised as humans have harnessed the energy from running rivers for over centuries to cater for their energy needs. Hydropower supplies about 16% of the world's electricity requirements.[376] Hydro has a 5.6% share in the energy mix, and the grid electricity generation mix has a 34.1% share, according to the EC of Ghana's 2021 energy statistics. What are the advantages and disadvantages of hydropower? Once the dam has been built, the flowing water, which is unrestricted, converts the current to energy. This source is renewed by rainfall and sometimes snow in some regions, and the energy generated is described as clean and carbon-free. The plants can generate and supply

[374] International Energy Agency, 'Hydropower' (IEA, 12 December 2022) <https://www.iea.org/fuels-and-technologies/hydropower> accessed 21 January 2023
[375] ibid
[376] Madhumitha Jaganmohan, 'Global hydropower industry- statistics & facts' (Statista, 28 October 2022) <https://www.statista.com/topics/2577/hydropower/#dossierSummary__chapter1> accessed 9 January 2023

large quantities of cheap electricity, and the plants can be adjusted relatively easily according to demand by controlling how water flows through the turbines. Hydropower dams can also be used for irrigation to cultivate crops all year round without depending on the rainfall pattern of the locality, e.g., Kpong hydropower in Ghana. Furthermore, dams can be used to store water during the rainy season and during floods for use during the dry season and in times of scarcity.

However, the large hydropower dams have wreaked havoc and disrupted the rivers' ecosystems and the riparian communities, and thereby harming wildlife and displacing the residents and causing an ecological disaster that has completely changed the area.[377] The Akosombo dam, for example, flooded large swathes of land around the Volta River basin and displaced about 80,000 residents and created the largest man-made lake in the world by surface area.[378]

As discussed in chapter one, the theoretical-conceptual framework under subsection 1.6.2.4 on energy justice, this dam caused one of the injustices under the distribution and recognition dimensions. The poor settler farmers and uneducated people bore the worst brunt of the flood contrary to energy justice standards. When the dam was commissioned, the power was not even extended to the displaced communities like Gulbi and Bajameso. This injustice occurred because during the planning and implementation stages; they failed to take into consideration the recognitional, distributive, and participatory needs of the communities.[379] Hydropower projects hinder salmons from swimming upstream to spawn even though, in some cases, ladders are provided, this kind of equipment has not worked successfully. The dams cause the different stock of fish to lose their natural habitats. The building of dams has led to the loss of forests, loss of some species populations, wildlife habitats and the degradation of the ecological areas because of the impact of the reservoir.[380] Hydropower plants can also bring about low dissolved oxygen levels in the water. This situation is harmful to aquatic life in the river. For these reasons, the Ghanaian government is trying to beef up its ES and has encouraged mini hydropower dams and has legislated in favour of these dams to the neglect of large hydropower dams, as seen in the RE Act. As noted above, the devastation dams have caused saddled governments with huge debts in terms of repairs and re-settling of displaced people.

It is envisaged that the hydropower dams would generate carbon-free electricity. However, the recent discovery that decaying organic material found in the reservoirs emits methane which is one of the greenhouse gases that contributes to global warming, undermines the benefits of hydropower dams.[381] However, this notwithstanding, it can be argued that the environmental impact of hydroelectric dams can be attenuated. This impact would still be very minimal compared to the burning of fossil fuels. Therefore, the mitigation of the impact of dams on biodiversity cannot be wholly ameliorated. However, when there is an understanding

[377] Richard L. Ottinger and Rebecca Williams, 'Renewable Energy Sources for Development' (2002) 32 (2) Environmental Law <https://www.jstor.org/stable/43267559> accessed 24 November 2019
[378] Ghana: 'A Dam at the Cost of Forests' (WRM Bulletin 102, 8 January 2006) <https://www.wrm.org.uy/bulletin-articles/ghana-a-dam-at-the-cost-of-forests#:~:text=In%201965%2C%2080%2C000%20farmers%20were,and%20other%20water%2Dborne%20diseases> accessed 14 April 2022
[379] Franziska Müller and others, 'Assessing African Energy Transitions: Renewable Energy Policies, Energy Justice, and SDG 7' (2021) 9 Politics and Governance 119 <https://doi.org/ DOI: 10.17645/pag.v9i1.3615> accessed 10 April 2022
[380] World Commission on Dams, 'Dams and Development: A New Framework for Decision - Making' (WCD, 2000) < https://www.internationalrivers.org/sites/default/files/attached-files/world_commission_on_dams_final_report.pdf> accessed 10 December 2019
[381] Ottinger and Williams (n 377).

between the stakeholders, it can lead to an effective way of managing and reducing the impact.

Dams can be designed and planned strategically to allow fish to pass to spawn. Thus, water flowing at existing dams can be calibrated to give ecosystems more recovery period and breeding time during floods and spillage. Decommissioned dams can undergo reclamation to restore them to their natural status for biodiversity to thrive again. Legislation alongside policy can be promulgated to protect some rivers or water bodies from being dammed, and this can preserve the biodiversity and ecosystem, leaving them intact. Furthermore, Ottinger and Williams have observed that small or mini dams can reduce the perceived environmental harm associated with large dams in the generation of hydroelectric power.[382] These measures cannot holistically address the havoc and impact dams have caused but are just mitigating measures intended to lessen the devasting impact that come along with them.

Due to stringent environmental impact assessment requirements, the construction of large dams is no more attractive as before. The RE Act defines hydropower as any water-based energy system that generates electricity whose generation capacity does not exceed 100 MW, so if a project exceeds that, it means it has gone beyond the Act's classification. This narrow definition is borne out of the concern of the hazards that come along with large dams, which Ghana has suffered from in the construction of the early big dams such as the Akosombo dam. Large dams are said to have a bio-physical impact on the environment, such as floods, loss of land and habitat, changes in the hydrological system and aquatic ecology, disruption in fish habitat and the sedimentation of the reservoir, which creates backwater effects; all these factors make the construction of large new dams less attractive.[383]

However, it is important to argue that hydroelectric projects that have been refused to go ahead due to environmental concerns, as seen in the Shieldaig and Stattadale case in Scotland, is at variance with the very reasons why RE is encouraged for sustainable energy consumption. If such projects are not allowed, fossil fuels will continue to be used, leading to the destruction of the environment that the rejection was seeking to protect. In view of this, Pillai, Reid and Black have observed that if climate change targets are not achieved because hydroelectric projects are not granted approval due to environmental concerns, then the very habitat that is being protected would soon be destroyed by climate change as a result of the effects of the consumption of fossil fuels.[384] They are however, of the opinion that environmental impact assessment (EIA) rules must be respected, RE targets are general and in situations where environmental concerns are raised suitable alternative hydroelectric sites should be located elsewhere. Pillai and others observed that concerns raised about fish and other aquatic species' movement being hampered by the physical construction of the dam had been assuaged; many hydro dams now have fish ladders that aid the free movement of fish in them.[385]

Nevertheless, contrary to the much-highlighted negative effects on fish life, Clemons has intimated that the flooding that follows the spillage of the dam indeed aids the fish to move into the flood plains to feed and breed, which has instead led to the boosting of fish

[382] Richard L. Ottinger and Rebecca Williams, 'Renewable Energy Sources for Development' (2002) 32 (2) Environmental Law <https://www.jstor.org/stable/43267559> accessed 24 November 2019
[383] World Commission on Dams, 'Dams and Development: A New Framework for Decision-making' (WCD, 2000) < https://archive.internationalrivers.org/sites/default/files/attached-files/world_commission_on_dams_final_report.pdf> accessed 21 October 2019
[384] Aylwin Pillai, Collin T. Reid and Andrew R. Black, 'Reconciling Renewable Energy and the Local Impacts of Hydro-Electric Development' (2005) 7(2) Environmental Law Review 110-123. <https://doi.org/10.1177/14614529050070020 3> accessed 12 November 2019
[385] ibid

populations.[386] Furthermore, floods replenish groundwater stocks and wetlands and naturally fertilises farmland and increase the fertility of the soil, which benefits nearby farmers.[387] According to EIA requirement, any project such as a hydro dam needs to undergo an environmental impact assessment to identify any issue of concern from the very beginning of the project. If any issues are identified, steps can be taken to mitigate them before the project is executed. Table 5 below presents a summary of the advantages and disadvantages of hydropower.

Table: 5 Summary of the Advantages and Disadvantages of Hydropower

Advantages of hydropower	Disadvantages of hydropower
Hydropower is an RE source; it does not run out unless the water stops flowing.	**The building of hydropower dams is capital intensive.**
Hydropower is a reliable RE source; it is not variable like solar and wind.	**Hydropower dams can interfere with the natural habitats of some species e.g., fish.**
It is emission-free, it does not pollute the environment, pollution only occurs during the construction of the plants.	**Produces carbon and methane emissions when the plants in the reservoirs die.**
Maintenance costs are usually low and do not require many workers to attend to the plants.	**Susceptible to droughts, when the rainfall pattern is bad for a particular season, there will be no water in the reservoirs.**
It is relatively very safe compared to fossil fuels and nuclear energy. No fuel is involved.	**Flooding risk, poses risk of flooding to nearby towns that are below it.**

Source: Author's elaboration with ideas from the literature (2022)

3.6 Review of Existing Renewable Energy Legal Frameworks

Ghana could improve its electricity supply by exploring and exploiting its RES potential. The country is endowed with sufficient RES. However, these resources have not been harnessed to augment the existing energy mix to meet demand for economic growth.[388] As such, the country has been experiencing power outages in the last decades due to a shortfall in generation to meet demand.[389] The situation seems to be easing following government's action of investing in more thermal at the peak of the crisis between 2013 to 2016 which has resulted in thermal dominating in the electricity generation mix now. As a result, Ghana's

[386] Karlie Shea Clemons, 'Hydroelectric Dams: Transboundary Environmental Effects and International Law' (2009) 36 Florida State University Law Review 487. <http://ir.law.fsu.edu/lr/vol36/iss3/5> accessed 10 November 2019

[387] Karlie Shea Clemons, 'Hydroelectric Dams: Transboundary Environmental Effects and International Law' (2009) 36 Florida State University Law Review 487. <http://ir.law.fsu.edu/lr/vol36/iss3/5> accessed 10 November 2019

[388] Nana Asare Obeng-Darko, 'Renewable Energy and Power: A Review of the Power Sector Reform and Renewable Energy Law and Policy Nexus in Ghana' (2019) 11 Africa Review 17 < https://doi.org/10.1080/09744053.2018.1538677> accessed 10 March 2020

[389] Samuel Gyamfi and others, 'The Energy Efficiency Situation in Ghana' (2018) 82 Renewable and Sustainable Energy Reviews 1415 <https://doi.org/10.1016/j.rser.2017.05.007> accessed 05 June 2019

installed electricity generation capacity now stands at 5,481 MW at the end of 2021.[390] The government's efforts to develop its RES for the generation of electricity endorsed two key policy documents that contain the aims and vision of the government on how to develop RE in Ghana. The two policy documents are Strategic National Energy Plan (SNEP) 2006 to 2020 and the National Energy Policy (NEP) 2010. Following the adoption of these documents, the GoG went a step further to enact the RE Act.

3.6.1 Strategic National Energy Plan (SNEP) Document from 2006 to 2020

SNEP (2006 to 2020) is the first policy document that contains in detail the government's plans on how to explore and harness the RES of the country for the generation of electricity. The document shows the government's determination to develop an efficient energy market, that is capable of providing efficient energy services for economic growth, through a well-planned and clear path that would lead to the utilisation and efficient management of energy resources in the country.[391] The GoG realised the urgency in diversifying its energy portfolio to include non-hydro RE after the hydro dams were generating below capacity and could not meet demand. Other concerns that prompted the GoG to shift attention to non-hydro RE include population, climate change, and ES. Nevertheless, certain factors buoyed the government to make the shift; these factors included resource endowment such as the abundant solar energy, which is barely exploited and the fast-growing demand for energy by the various sectors of the economy.[392]

In SNEP, the GoG, through the EC, for the first time, set a target it wanted to achieve when it started to exploit its RES. The target that was set was to incorporate a 10% share of non-hydro RE into the electricity generation mix in 2020.[393] The RE integration plan was to start at 0.05% in 2007 and gradually increase to 10% in 2020, and the generation capacities were to come from mini hydro plants, biomass, wind, and solar.[394] Aside the 10% RE target, the government set another goal which was, to extend electricity by 30% to all rural parts of the country in 2020 using RETs through a programme known as rural electrification.[395]

In achieving the aims of SNEP, several recommendations were made in the plan, which included the establishment of a feed-in tariff scheme to promote RE development. It was backed by a regulatory framework that supported existing large RE generating plants to be able to connect to the national grid by acquiring licences that granted them access. District assemblies were encouraged to champion the provision of electricity services to off-grid communities in their respective areas using mini-grids that derived their energy from RES.[396]

It is worth noting that several sections of SNEP have not been implemented, which has impeded the successful implementation of the plan's provisions. The provisions of SNEP are not binding and rather voluntary and were not officially adopted by the government; hence it

[390] Energy Commission of Ghana (313).
[391] Energy Commission of Ghana (313).
[392] Energy Commission of Ghana, 'Strategic National Energy Plan 2006-2020: Main Report' (EC, July 2006) <http://www.energycom.gov.gh/files/snep/MAIN REPORT final PD.pdf>.accessed 10 June 2019
[393] ibid
[394] Energy Commission of Ghana, 'Strategic National Energy Plan 2006-2020: Main Report' (EC, July 2006) <http://www.energycom.gov.gh/files/snep/MAIN REPORT final PD.pdf>.accessed 10 June 2019
[395] International Energy Agency, 'Strategic National Energy Plan (SNEP) 2006-2020' (IEA, 29 August 2016) <https://www.iea.org/policies/4771-strategic-national-energy-plan-snep-2006-2020> accessed 19 June 2020
[396] ibid

did not find itself obliged to implement the contents of the plan.[397] Furthermore, the EC under SNEP is seen as weak and unable to perform some of its core functions like monitoring.

3.6.2 National Energy Policy (NEP) 2010

In 2010, the energy Sector Strategy and Development Plan was launched as NEP by the MOEn following a change in government after the general election in Ghana. The NEP policy instrument is understood to be an update of SNEP, which reiterated the GoG's determination to develop RE to achieve the targets set in SNEP. The NEP instrument gave the government's policy direction and enumerated the challenges that the energy sector was facing. In NEP, RE integration was part of the government's aim to develop and increase the share of solar, wind, waste-to-energy, and mini hydro in the national energy mix and to ensure their efficient generation and use. In NEP, a critical look revealed that the new strategy now shifted focus to two RETs, thus wind power and mini hydro.[398] A rather too ambitious target of adding 500 MW in the generation mix in 2020 was set.[399]

The document captured climate change as one of the aims behind the government adopting non-hydro RE. In the document, the challenges identified were the sustainable exploitation of biomass in the forms of firewood and charcoal through efficient means and the reduction of the cost of wind, solar and waste-to-energy technologies. These challenges have contributed to the non-achievement of RE policies that were deployed. Following this, proposals were made to surmount these challenges. Some of the measures that were put forward are as follows: to have improved and sustainable use of biomass; shifting from relying on biomass and going for other alternative sources like solar and wind; collaboration between local scientists and engineers and their international counterparts to use research to cut down the cost of solar and wind technologies to make them competitive.[400]

In the SNEP document, the RE target was spelt out; the review of SNEP changed the target to a goal. The 10% target in SNEP was conspicuously missing. It was deliberately expunged and not reflected in the new document. The target is replaced with a goal, something that baffled many people in the industry. The possible reason could be that the authorities realised that the 10% target was not achievable within the stipulated time frame earlier given. The authorities' failure to include the target in NEP could dampen the spirit of investors and send wrong signals that the GoG might have changed its approach towards the RE subsector and is not keen on increasing the development of RE.

NEP policy document lacks clarity on how some targets contained in it will be achieved. For instance, the NEP power subsector policy framework targets the increase of electricity access from 66% in 2010 to universal access in 2020. There are no details to show how this will happen within a period of ten years. It also aims to improve production, promote the efficient use of biomass in the short term and finally switch from biomass to alternative energy sources. It is not clear how the proposed switch is going to take place within ten years (2010 to 2020). In a country where biomass is a primary energy source and accounts for about 34% of total energy consumed in households across the country, the switch will be seen as rather over-ambitious and unrealistic due to its widespread use for cooking and heating both in the rural

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[397] Joseph Nii Tettey Ashong, 'How Effectively Has Ghana Implemented Its Policy for Large-Scale Renewable Electricity Deployment: A Qualitative Assessment' (2016) 7 Renewable Energy Law and Policy Review 133 <https://www.jstor.org/stable/26256493>.accessed 10 June 2019

[398] Marriette Sakah and others, 'Towards a Sustainable Electrification in Ghana: A Review of Renewable Energy Deployment Policies' (2017) 79 Renewable and Sustainable Energy Reviews 544. < http://dx.doi.org/10.1016/j.rser.2017.05.090> accessed 10 November 2019

[399] ibid

[400] Ministry of Energy, 'National Energy Policy 2010' (MOEn, February 2010) <https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/GHANA%29%20National%20Energy%20Policy.pdf> accessed 28 July 2019

and urban areas.[401] It would not be easy to eliminate it in the primary energy supply mix given that it is mostly used among rural dwellers and after all, it is classified as an RE resource.

In the mix of all these, the government's RE policy on biomass is nebulous in that, in one breath, the government wants to reduce the dependence on firewood and charcoal because of deforestation concerns and indoor air pollution associated with it. In another breadth, the government intends to encourage the growth of woodlots for biomass production.[402] These two approaches, thus switching from biomass use to alternative energy sources and growing woodlots for biomass production by the government, sends mixed signals as to what the actual RE policy is. The aim of switching from biomass to alternative energy sources creates the impression that biomass is not regarded as an RE resource and that the authorities do not recognise it as such. However, biomass is indeed considered an RE resource globally.[403] Both SNEP (2006 to 2020) and NEP (2010) have recognised biomass to be an RE resource. In addition, Ghana's RE Act has included biomass in the list of natural resources that are considered renewables.[404] As seen earlier, the shift to two RETs that is wind power and mini hydro, could signal a lack of coordination between EC and other government institutions which could be a source of impediment to its implementation.

3.6.3 The Renewable Energy Act, 2011 (Act 832)

RES provides electricity in an environmentally friendly way to run the economy. These resources have not been exploited for a long time due to the government not incorporating them in its decision-making processes. Developed and developing countries are now introducing policies and instruments that would promote the development of RE.[405] The parliament of Ghana in 2011 passed the Renewable Energy Act, 2011 (Act 832) to provide for the development, management, utilisation, and adequate supply of RE for the generation of heat and power and related matters.[406]

The government of late president H.E John Evans Atta Mills passed the RE Act and set a target of adding a 10% share of non-hydro RE to the electricity generation mix which was to be met in the year 2020 however, the target was missed and now extended to the year 2030. In 2013 a new government (NDC party) was formed after the general election that was held in 2012. Upon assumption of office the new government was confronted with severe power outages known in the local parlance as ‘dumsor’ meaning off and on.[407] The new government turned its attention to fossil fuels (thermal) instead of RE to overcome the crisis hence the addition of more and more thermal until it surpassed hydro in 2016.[408] This approach has been identified by Kilinc-Ata as the traditional way of addressing energy crisis by governments to

[401] Energy Commission of Ghana (n 313).
[402] Ministry of Energy Ghana (n 400).
[403] International Renewable Energy Agency, ‘Bioenergy & biofuels’ (IRENA) <https://www.irena.org/bioenergy> accessed 16 April 2020
[404] Ghana's Renewable Energy Act 2011 (Act 832).
[405] Cassendra Phun Chien Bong and others, 'Review on the Renewable Energy and Solid Waste Management Policies towards Biogas Development in Malaysia' (2017) 70 Renewable and Sustainable Energy Reviews 988 <http://dx.doi.org/10.1016/j.rser.2016.12.004>.accessed 12 January 2020
[406] Ghana's Renewable Energy Act, 2011 (Act 382).
[407] Samuel Gyamfi and others, ‘The Energy Efficiency Situation in Ghana’ (2018) 82 Renewable and Sustainable Energy Reviews 1415.<https://doi.org/10.1016/j.rser.2017.05.007> accessed 06 January 2023
[408] Energy Commission of Ghana (n 313).

provide a quick fix to the problem.[409] The reason stated above is why the GoG diverted attention from RE to thermal and the poor implementation of the provisions of the RE Act.

Therefore, it is not that the GoG is incompetent, or having vested interests. In terms of political will, it cannot be concluded that it was lacking because the new government that was formed came from the same political party as the previous one and in Ghana governments that come from the same political party tend to continue with the policies of their predecessor. In 2017 a new government (NPP party) was formed from a different political party and in 2020 it repealed the FIT policy through the RE amendment Act, 2020 (Act 1045). The Akuffo Addo government has continued with the addition of more thermal like its predecessor and not much attention is given to the RE agenda as envisaged in the RE Act. The two succeeding governments have not made any significant changes to the RE Act apart from the repeal mentioned above.

In order to provide the legal and regulatory frameworks through which RE policy goals can be delivered, the rules for the regulation of the RE subsector are set out in the RE Act. Aside from these rules in the law, institutions are mandated to issue legislative instruments to help regulate the RE subsector and effectuate regulatory rules as stipulated in the RE Act. The overarching objective of the Ghanaian RE Act is "to provide for the development, management and utilisation of RES for the production of heat and power in an efficient and environmentally sustainable manner".[410]

Apart from the significant objective stated above, many aims have been drawn to fulfil the Act's objectives. These include:[411]

(1) the provision of:

(a) a framework to support the development and utilisation of RES and

(b) an enabling environment to attract investment in RES,

(2) the promotion of the use of RE,

(3) the diversification of supplies to safeguard ES,

(4) improve access to electricity through the use of RES,

(5) the building of indigenous capacity in technology for RES,

(6) public education on RE production and utilisation and

(7) the regulation of the production and supply of wood-fuel and biofuel.

The RE Act has set rules to regulate the RE subsector; some of the rules are going to be discussed. The RE Act stipulates that a licence is needed for anyone to undertake any commercial activity in the RE market in Ghana. The EC is mandated to grant licences to utilities. However, the drawing of the conditions of a licence is done by the Minister of Energy and not the EC (Renewable Energy Act, 2011 (Act 832) sec. 50(b)). The Act also sets some criteria to be met before a licence can be granted, and one of such conditions is that if an

[409] Nurcan Kilinc-Ata, 'The Evaluation of Renewable Energy Policies across E.U. Countries and U.S. States: An Econometric Approach' (2016) 31 Energy for Sustainable Development 83 <http://dx.doi.org/10.1016/j.esd.2015.12.006>.accessed 10 May 2019

[410] Nurcan Kilinc-Ata, 'The Evaluation of Renewable Energy Policies across E.U. Countries and U.S. States: An Econometric Approach' (2016) 31 Energy for Sustainable Development 83 <http://dx.doi.org/10.1016/j.esd.2015.12.006>.accessed 10 May 2019

[411] Ghana's Renewable Energy Act ,2011 (Act 832) section 2.

entity is granted a licence, it is not transferable. However, it becomes transferable under certain situations where prior approval is allowed by the EC Board. Furthermore, the Act requires that before a licence is granted, the person or entity is a citizen, a corporate body registered under the Companies Act of 1963 (Act 179) or under any other law of Ghana or a partnership registered under the Incorporated Private Partnerships Act of 1962 (Act 152) (Renewable Energy Act, 2011 (Act 832) sec. 9 (a-c)

Coming to regulation under the RE Act, the Act gives power to three key institutions to regulate the RE industry. These include the Minister of Energy, the EC, and the PURC. Under the institutional arrangement, the Minister of Energy is responsible for providing policy direction that will lead to the achievement of the objectives of the Renewable Energy Act, 2011 (Act 832) sec.3. The EC's responsibility is to provide technical regulation on the utilisation and development of RES. In order to discharge its duties, the EC provides technical advice to the minister on matters relating to RE and, in the process, creates a platform between government, civil society, and the private sector for the promotion of RE. Finally, the PURC is tasked with the responsibility to approve rates for the purchase of electricity from RES by public utilities and, at the same time, approve the fees for grid connection.

Support instruments for the development of RE can be classified into fiscal incentives and regulatory or financial frameworks. Technically speaking, none of these support mechanisms can single-handedly integrate RE on its own. Many countries employ a combination of these incentives and promotional tools to provide a supportive environment for the development of RE. FIT, grid access, RPS, and net metering are going to be briefly discussed as there is a detailed section later in the chapter for FIT and RPS as they are the policies Ghana has adopted for the development of RE.

3.6.4 Regulatory Framework**s**

Feed-in tariff (FIT) is a widely used RE policy which was included in the RE Act, which has now been repealed by the Renewable Energy (Amendment) Act, 2020 (Act 1045). The reasons for its repeal have been given under subsection 3.11.1 The FIT was intended to guarantee the price of the sale of electricity generated from RES (Renewable Energy Act, 2011 (Act 832), sec. 25 (1)). The former FIT of Ghana had three essential components. They include renewable energy purchase obligation (REPO), FIT rate (repealed) and a connection to transmission and distribution systems (Renewable Energy Act, 2011 (Act 832) sec. 25 (2)) (a-c)). REPO calls on a utility or a bulk customer to purchase a percentage of its electricity from RES or pay a premium to EC, which also determines how much should be paid. (Renewable Energy Act, 2011 (Act 832) sec. 26 (4) (a and b)). The RE Act obliges a utility company to purchase electricity from a generator of RES at FIT rates which PURC approves (Renewable Energy Act, 2011 (Act 832) sec.27 (4), 28 (1) and 29), now repealed by RE (Amendment) Act, 2020 (Act 1045). The RE Act stipulates that an RE generator be allowed to connect to any transmission or distribution system within its local area. The operators of these systems are obliged to enter into an agreement with the RE generator, and the RE generator is liable to pay for the connecting installation to the metering point of the grid (Renewable Energy Act, 2011 (Act 832) sec.30 (3)). This section can be problematic as some RE generators may not be in an excellent financial position to pay the connecting and installation fees. Instead, it could be a barrier for them to connect to the grid, and an operator could put many impediments in the connection process to frustrate RE generators. Furthermore, as pointed out by Sakah and others, the situation is that the RE power generator bears the cost of grid connection and enhancement.[412] The actual amount of RE power fed into the grid has to conform to the dictates of the grid company. This development is inimical to the

[412] Sakah and others (n 322).

development of RE.[413] It must be stated that after the repeal of FIT in 2020, REPO and connecting to the transmitting and distributing networks have remained.

3.6.5 Grid Access

One of the biggest challenges in the RE subsector in the generation of RE electricity is the poor grid network infrastructure. The cost of upgrading it, is huge, and this dire state of the grid makes it difficult to transmit large quantum of RE electricity.[414] To increase the share of RE in the electricity market, grid companies should be obliged to give priority access to RE that is both the transmitters and distributors.[415] However, in Ghana, RE access to the grid is not a priority, and this has adversely affected the FIT scheme to operate effectively as envisaged, which has now been repealed. The cumbersome bureaucratic PPA contracts between RE generators and utilities would have been eliminated if grid access had been a priority. Nevertheless, a good PPA can foster long term contracts that can reduce financial risks, which eventually leads to a reduction in costs for RE developers.[416] In Ghana, transmission losses from GRIDCo are 5% and distribution losses are 29.7% for the three distribution companies namely ECG, NEDCo and EPC.[417]

Because of these losses, the country has grid access policies that limit RE integration's impact on the weak grid infrastructure. As such, generated energy must comply with subcodes performance requirements to connect variable RE electricity to the transmission and distribution networks. This grid access requirement is somewhat baffling when compared to countries that are equally using FIT as a policy, these countries, Germany, Spain, and Kenya, have made RE access to their grids a priority. The RE generator bears the connection and enhancement costs to the metering pointy of the grid in the case of Ghana. These subcodes policies certainly would impact RE developers/generators who may not have much financial clout. This arrangement imposes extra financial expenditure on RE developers, and this cost could increase the overall generation cost, which does not auger well for RE development in Ghana. These subcodes policies that determine the actual power that is fed into the grid are somewhat skewed to the advantage of the grid companies.

It would have widespread implications for RE development even with good FIT schemes. The fact is that the grid company is vertically integrated and has distribution subsidiaries like ECG. NEDCo. These subsidiaries, for example, get their supply from GRIDCo, and GRIDCo would like to defend its profit and will not want to incur "standby costs" as a result of unused power fed to the grid. This protection from risks does not auger well for RE development.

3.6.6 Net Metering

It is a mechanism whereby an electric meter measures both the generation and consumption of electricity. Here the client is referred to as a prosumer. The prosumer can offset their electricity consumption with generated electricity which ends with a balanced account or a

[413] Sakah and others (n 322).
[414] Luka Punda and others, 'Integration of Renewable Energy Sources in Southeast Europe: A Review of Incentive Mechanisms and Feasibility of Investments' (2017) 71 Renewable and Sustainable Energy Reviews 77 < https://doi.org/10.1016/j.rser.2017.01.008> accessed 20 March 2020
[415] Angel A Bayod-Rújula, 'Future Development of the Electricity Systems with Distributed Generation' (2009) 34 Energy 377 < https://doi.org/10.1016/j.energy.2008.12.008> accessed 10 February 2020
[416] Govinda R Timilsina and Kalim U Shah, 'Filling the Gaps: Policy Supports and Interventions for Scaling up Renewable Energy Development in Small Island Developing States' [2016] Energy Policy < https://doi.org/10.1016/j.enpol.2016.02.028> accessed 10 December 2019
[417] Energy Commission of Ghana (n 313).

retail credit in kWh, which is billed monthly or rolled over to the next month.[418] Net metering is popularly used in the U.S.A with buyback, rolling credit or both. The net metering policy for Ghana is designed to provide credits for prosumers who supply electricity to the grid. Sometimes this credit can be used to offset the electricity that the generator has consumed. There is no clarity as to whether the generator must pay an access charge or not for the credit usage. This technology is good, but it is not workable in off-grid and island communities where energy generation cost is high compared to the grid where it is relatively low. It can bring about a disparity in prices, which makes it difficult for these communities to enjoy the same treatment under the net metering policy.

3.6.7 Financial Framework

RE deployment is much dependent on its attractiveness to private sector investors, who in turn derive funding from financial institutions and are more efficient than public investors when they face the forces of the market, which determine things in favour of competition. However, in Ghana, the energy market is not fully liberalised. It is still susceptible to the government's influence in which fuel prices are heavily subsidised.[419] In developing countries, public funding and fiscal incentives are most often effective in promoting RE generation than other policies.[420] This is so as many RE projects in the rural areas in Ghana are publicly financed via state institutions, for example, off-grid systems, community solar PV lighting and solar home systems. The RE Act provided for the establishment of the Renewable Energy Fund through the support of the EU. It was envisaged to provide long term financial support for the development of RE.[421] It is regrettable that the implementation of the Fund has been stalled due to lack of funding. This laudable vision has been left unattended to, to the detriment of the development of RE in the country.[422] However, the government has increased the petroleum product levy, and the amount accrued from the increase is going to be committed to the establishment of the Renewable Energy Fund.[423] The MOEn has established the RE Business Fund as required by the Renewable Energy Act which aims to provide incentives to the private sector to invest in RE projects based on Build, Own, Operate and Transfer.[424] It must be pointed out that even though the Fund has been established, it has not been funded to enable it to carry out its functions as stipulated in the RE Act.

3.6.8. Fiscal Incentives

RE generation does not compete well with conventional energy sources due to the latter enjoying heavy subsidies, and this has made them cheap compared to RE. In order to increase RE competitiveness, governments have started to provide incentives like tax exemptions and

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[418] Rodolfo Dufo-López and José L Bernal-Agustín, 'A Comparative Assessment of Net Metering and Net Billing Policies. Study Cases for Spain' (2015) 84 Energy 684 < https://doi.org/10.1016/j.energy.2015.03.031> accessed 17 December 2019

[419] Norton Rose Fulbright, 'Investing in the African electricity sector Ghana Ten things to know' <https://nanopdf.com/download/investing-in-the-african-electricity-sector-ghana_pdf> accessed 10 October 2020

[420] Antonio A Romano and others, 'Renewable Investments: The Impact of Green Policies in Developing and Developed Countries' (2017) 68 Renewable and Sustainable Energy Reviews 738 <http://dx.doi.org/10.1016/j.rser.2016.10.024>.accessed 20 January 2020

[421] Ghana's Renewable Energy Act ,2011 (Act 832).

[422] Government of Ghana, 'The Budget Statement and Economic Policy for the 2014 Financial Year' (MoF, 19 November 2013) <https://www.mofep.gov.gh/sites/default/files/budget-statements/2014_Budget_Statement.pdf> accessed 18 March 2020

[423] Mridul Chadha, 'Ghana Increases Levy on Petroleum Products To Fund Solar Power Projects' (CleanTechnica, 5 March 2015) <https://cleantechnica.com/2015/03/05/ghana-increases-levy-petroleum-products-fund-solar-power-projects/> accessed 20 February 2020

[424] UNDP, 'China-Ghana South-South Cooperation on Renewable Energy Technology Transfer' (UNDP, May 2014) 1 < https://info.undp.org/docs/pdc/Documents/CHN/ProDoc%20-%2091276.pdf> accessed 18 December 2019

others have imposed carbon or energy taxes on conventional energy sources as part of the initiative to protect the environment from the damage caused by fossil fuels. It is an attempt to increase RE investment. In Ghana, investors are offered generous packages when they register to invest in the RE subsector. Some of these include exemptions from the payment of import duties and levies on all plant machinery and equipment meant for RE generation. "Tax holidays" are applied, thus exemption from payment of income tax on profits for ten years. Temporary subsidies and tax exemptions effectively bring new RETs into the marketplace, and they are essential in accelerating the market acceptability of the new technologies, these support mechanisms are justifiable as far as subsidies for fossil fuels continue to persist so that the field can be levelled for RE.[425] So far, the financial support given for the development of RE is tax-based incentives. These are meant to boost the development of RE in the short-to-medium term to reduce financial risks most often related to investing in the RE subsector.

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3.7 Analysis of the Renewable Energy Act, 2011 (Act 832)

The enactment of the RE Act, coupled with some support frameworks thus grid access codes, RE Fund, REPO, RE Authority, Research and Development (R&D) has chalked some success in the development of the RE subsector. These include the development of the framework for the RE Fund, the development of the net metering code and RE subcodes for transmission and distribution systems. Furthermore, the development of licensing manual for RE service providers and the completion of draft guidelines for Renewable Energy Purchase Obligation.[426] The RE Act has also rekindled interest in RE and raised awareness of its benefits especially for ES and climate change mitigation.

At this stage, it is prudent to review how far the Act has fared in achieving its objectives since coming into force in 2011. One outstanding policy that the Act sought to achieve is its 10% target that was set to be achieved in 2020. However, as the year 2020 was fast approaching, a study by Obeng-Darko revealed that the target was not going to be achieved as planned, thereby spelling little penetration for non-hydro RE in the electricity generation mix.[427] Indeed in 2020 the target was not achieved. This failure can be attributed to many factors which are going to be discussed.

3.7.1 Karl Mallon's Ten Features of Successful Renewable Markets

The non-achievement of policy targets is not only limited to Ghana, but it has also been a global challenge. The inability to deploy large scale RE prompted Mallon to investigate policy errors worldwide. Mallon identified ten factors which are categorised into drivers, contexts, and society. These factors need to be integrated into a policy framework that will promote RE's successful deployment and development. They include transparency, well-defined objectives, well-defined resources and technologies, appropriately applied incentives, adequacy, stability, contextual frameworks, energy market reform, land use planning reform, and equalising the community risk and cost-benefit distribution.[428] Mallon further argues that these factors need

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[425] Richard L. Ottinger and Fred Zalcman, Legal measures to promote renewable and energy efficiency resources in Adrian J. Bradbrook and Richard L. Ottinger (eds), *Energy Law and Sustainable Development* (IUCN, Gland, Switzerland and Cambridge, UK 2003).

[426] Bernard Aboagye and others, 'Status of Renewable Energy Resources for Electricity Supply in Ghana' (2021) 11 Scientific African e00660 <https://doi.org/10.1016/j.sciaf.2020.e00660>.accessed 10 May 2021

[427] Nana Asare Obeng-Darko, 'Why Ghana Will Not Achieve Its Renewable Energy Target for Electricity. Policy, Legal and Regulatory Implications' (2019) 128 Energy Policy 75 <https://doi.org/10.1016/j.enpol.2018.12.050> accessed 10 November 2020

[428] Karl Mallon,' Ten Features of Successful Renewable Markets' in Karl Mallon (ed*), Renewable Energy Policy and Politics: A Handbook for Decision-Making (*Earthscan UK,2006) 35

to be sufficiently incorporated into the legal frameworks of a country; otherwise, the country risk failing in its RE development. In this regard, Ghana cannot afford to fail in its RE Act regime, given the energy crisis, the country has gone through in recent years. The question now is, do the contents of the RE Act meet the factors mentioned above?

An in-depth examination of the RE Act leads to the conclusion that the framers of the Act did a thorough work because, arguably, the factors enumerated by Mallon have been met. Starting from the objective of the Act in section 1 through to tariff regimes in sections 26-29, then allowing access to transmission and distribution systems in section 30, the creation of Renewable Energy Fund in section 31, and then amendments in section 52, all of these sections have met Mallon's criteria.

Take Mallon's factor 'well-defined objective' and juxtapose it with the Act's objective captured in section 1, and it fits the requirement. The section states the objective as: the provision and utilisation of RES for the generation of heat and power in an efficient and environmentally sustainable manner. The RE Act defines RE as, energy obtained from non-depleting sources including wind, solar, hydro, biomass, biofuels, geothermal energy, and ocean energy.[429] The Act, among other things, has urged the diversification of energy generation to include non-hydro RE in the electricity generation mix to ensure ES. It has also sought to create an enabling environment to attract investors for the development of RES. Section 1 has aptly satisfied Mallon's criteria by stating what it wants to achieve, how to achieve it and why it wants to achieve it and therefore has passed the Mallon criteria test.

The Act might have performed satisfactorily with regards to Mallon's criteria. However, there are some issues that need to be brought to light that highlight the challenges the RE subsector is facing in practical terms. These issues have been responsible for the slow integration of RE into the electricity generation mix. They have impeded the achievement of the target that was set to be attained in 2020 and now extended to 2030. The broad spectrum of these issues border on policy, regulatory and legal. All these issues emanating from the RE Act need to be addressed; if not, they may impede the RE subsector's proper regulation to achieve the Act's objectives.

3.7.2 Discussion on the Sections of the Renewable Energy Act, 2011 (Act 832)

Sections 8 through to 24 prescribe the processes and procedures to follow to acquire a licence to operate in the RE industry. However, these processes seem rather cumbersome and bureaucratic. For instance, if an application for a licence is made, the EC will take sixty-five days to communicate its decision to the prospective investor, which is time-consuming and at times frustrating.[430] A prospective RE developer needs a Wholesale Electricity Supply Licence authorising him/her to generate electricity from RES to supply to distribution utilities and bulk customers. The process involves many stages to accomplish, and the required submissions include Exhibit WS 1-36 as captured on page 18 of the licence manual.[431] To spend sixty-five days (five working days for the EC's board to acknowledge receipt of an application and within sixty days to communicate its decision to the potential investor) for the acquisition of a licence to operate may be seen as justifiable theoretically but in practical terms it may discourage many RE investors as the required submissions are many and demanding to fulfill. Furthermore, due to red tape in the regulatory process, an RE investor will have to also visit other state agencies, like the Registrar General's Department (to provide evidence that the applicant has a Certificate of Registration and Certificate to Commence Business),

[429] Ghana's Renewable Energy Act, 2011 (Act 832).
[430] Ghana's Renewable Energy Act, 2011 (Act 832) section 10 (2)
[431] Energy Commission of Ghana, 'Licence Manual for Service Providers In The Renewable Energy Industry' (EC, September 2012)
<http://www.energycom.gov.gh/files/RE%20LICENCE%20MANUAL.pdf> accessed 04 January 2023

Environmental Protection Agency (to show an environmental assessment permit), Town & Country Planning (proof of title to land , planning and construction permit and site plan), Geological Survey Department of Ghana (provide a report attesting to either the absence of or acceptable levels of seismic activity on and around the proposed site), District Assembly (proof of the relevant permits for construction) and Water Resources Commission (proof of water use permit for hydro power generation) to acquire the necessary licences, approvals, certificates and permits as part of the process before the commencement of an RE project.[432] It does not augur well for a country that is seeking to attract investors to the RE subsector, and this could possibly discourage potential investors due to the daunting nature of the processes involved.

From the empirical research conducted, this issue came up, and the following was what the participants said regarding the licence acquisition process: **Most of the participants bemoan this long time to acquire permits, certificates, and licences, which is totally unnecessary and has become a clog in the wheels of RE development in the country. Though due process is necessary, but the length of time and the required submissions involved is the source of concern. These permits, licences and certificates are not issued by the same institution, and these institutions and bodies all have their own requirements, which have become frustrating and a challenge for RE developers. This is a response from a senior ACEP official, the official had not compared the sixty-five days coupled with the required submissions with other jurisdictions but said, If it takes such a daunting process for a licence to be granted, then it does not speak well of Ghana, it comes back to the business environment; due diligence has nothing to do with bureaucracy and red tape. It can be short whilst the standards are still maintained. Ghana can check to see what other countries are doing in terms of licence/permit acquisition and have a comparative analysis of other jurisdictions, to see the best practice.[433]**

Ghana's electricity sector is monopolised by the state and can be described as less investor-friendly, and as such, the situation can prevent the Act from achieving its objectives. Though sections 25 to 29 of the Act incorporate a FIT regime then in operation, which secured a market share for renewables, this may not play out successfully. As some market distortions like subsidies undermine this share of the market allocated to RE. Subsidies distort the arrangement envisaged by the Act, as such, this will have negative repercussions on renewables. This situation does not provide a level playing field for RE. It is particularly so when the cost of RE is considered because the initial cost of RE is capital intensive compared to conventional energy, which enjoys subsidies. Subsidies favour conventional energy and act against RE. It will become a stumbling block for deploying and developing RE in Ghana unless renewables also receive the same subsidies as conventional energy sources.

According to section 5 of the RE Act, the setting of RE tariffs is the prerogative of PURC; the primary legislation has not prescribed any methodology to be used or what level of tariffs should be introduced and has not fixed a deadline for the approval of the tariffs to take place. The two regulatory bodies thus, PURC and EC, have developed a FIT scheme for the various RES, and a consultation process has taken place to implement the proposed RE tariffs. In July 2013, PURC published tariff levels for the various RETs. A grid code was approved in 2009 by PURC, but this avoided the inclusion of specific provisions for RE plants. FIT has now been repealed in 2020.

The RE Act serves as the legal base for regulating the RE subsector; as such, the Act requires that the different regulatory bodies formulate legislative instruments to regulate the subsector. However, this requirement has not been met as none of the regulators has initiated any such

[432] ibid
[433] Participant 8 interview held via zoom on 21 November 2021

regulatory instruments as mandated by the RE Act. The instruments are supposed to address issues such as conditions of licences to be granted, fees, the setting of technical standards for the integration of RE into the grid, and instruments that regulate financial incentives that support the generation, development, and utilisation of RES in the country. Unfortunately, all these instruments are non-existent. In addition, the RE Fund and Authority, are yet to be established, all these create the impression that there is no regulation in the RE subsector of Ghana.

3.7.3 Regulatory Issues and Complexities

Another issue relating to regulation in the RE subsector is the problem of 'percentage'. As required by REPO, a distribution system operator (DSO) or a bulk customer is enjoined to purchase a percentage of its total electricity from RES or else pay a premium to the EC as may be determined by it. (Renewable Energy Act, 2011 (Act 832) sec.26 (4) (a and b)). Both the EC and PURC are mandated by the RE Act to set this percentage for DSO or bulk customers to buy electricity from RE generators, but this determination is yet to be made.[434]

Given this, the question to ask is whether the regulatory bodies have failed to set the 'percentage' or what? Or do they prefer DSOs to pay the premium to the neglect of the purchase obligation? Without the “percentage” set for the purchase of electricity from RES, a requirement in REPO would be overlooked by bulk customers and DSOs, and they will not be penalised for non-compliance. For DSOs and bulk customers, this requirement will incur additional operational expenditure compared to the payment of a premium which may be cheaper. It must be pointed out that this generous requirement gives room for DSOs and bulk customers to opt for the payment of a premium that may be cheaper and more convenient instead of the purchase obligation. It is likely to leave RE generators to have a diminished market for their power and will likely impact the penetration of RE in the electricity generation mix.

There is another regulatory issue emanating from the RE Act; this has to do with the responsibilities of the EC and the MOEn. Under the granting of licences to investors, the Minister of Energy is responsible for drawing the conditions of the licences but has no power to issue any licence. The issuance of licences rests with the EC. This arrangement under the Act introduces bureaucracy into the acquisition of a licence. Both roles, thus determination of the conditions of a licence and issuance, could be vested in the EC as already the EC is responsible for seeing to it that the conditions set out in the licences for operations are met. As a reminder, under the EC Act 1997, the EC is mandated to determine the conditions of licences for any commercial undertaking in the energy industry. In light of this, one will assume that such functions could have been harmonised and vested in the EC as both the EC Act and RE Act are dealing with and using the same agency to deliver the objectives set in both Acts. Given this, the separation of functions between the EC and the Minister of Energy under the RE Act does not auger well for a smooth acquisition of a licence to operate in the RE subsector and could be one way of slowing down the development of RE in Ghana. All these add up to make the licence acquisition process long, cumbersome, and frustrating, which could make investment in the RE subsector unattractive to prospective RE investors.

As noted earlier, the RE Act lays the foundation for the legal and regulatory frameworks through which RE policy targets can be achieved. However, since the RE Act came into force in 2011, there has not been any auditing of the various policies that have been put in place to regulate the RE subsector to ascertain their effectiveness. If such appraisals are conducted, they will provide the government with vital information needed to monitor the RE subsector to

[434] Nana Asare Obeng-Darko,' Regulatory Rationale and Theoretical Approaches: Ghana's Renewable Energy Law and Policy Perspective' (2018) Oil Gas. Energy Law J. Ogel.16. < https://www.ogel.org/article.asp?key=3725> accessed 14 April 2020

see the progress that has been made in terms of the targets and goals that have been set, albeit to see whether they are achievable within the time frames that have been set. This kind of assessment is important as it would afford the GoG the opportunity to adjust the targets or goals accordingly if need be. For instance, SNEP 2006 to 2020 and NEP 2010, which was an update of SNEP, have not been assessed to know whether they need updating due to the rapid changes that have taken place over the last decade with regards to RE development. A further review of both documents' policy aims on RE could further refocus them for a thorough and robust achievement of the laudable objectives of incorporating non-hydro RE into the electricity generation mix.

The RE Act stipulates that an independent regulator should be established for the RE subsector to function well., An independent regulator is needed to see to the implementation of RE policies and measures in the sector, but here is the case, there is no one such Authority like that established. It is important to note that regulatory agencies under the current situation lack autonomy and are constantly under the influence of the political power of the day.[435] It is for this kind of interference that the office of an independent regulator becomes more imperative who would be able to carry out its functions mentioned in section 53 of the RE Act devoid of interference. If the agency is established, it will be known as the Renewable Energy Authority. It is envisaged that when the authority comes into being it will perform the following functions: oversee to the implementation of RE activities in the country, execute RE projects initiated by the state or in which the state has an interest and manage the assets in the RE subsector on behalf of the state. (Renewable Energy Act 2011 (Act 832), sec. 53)

However, in the interim, in the absence of the Authority, the RE directorate is performing the functions mentioned above until the RE Authority is established. This interim directorate is a sub-division under the MOEn. The workers of the directorate are under the control of the minister of energy, a situation which does not guarantee independence from politicians. As such, there is no consistency as to what is done; for instance, in Ghana, when there is a change of government and a new minister takes office, especially in the case of a different party winning the election, which is different from the previous one, the likelihood of most of the workers being replaced with new ones is very high simply put it, their tenure of office is tied to the political power that appointed them.[436] These changes in staffing of the RE directorate following a change of government is responsible for changes in government policy on RE for the RE subsector. So experienced workers who served under the previous administration would be made redundant and are not able to commit to continuity, thus ensuring that regulatory goals are met as required by the RE Act. These changes in staffing, whenever there is a change of government, send the wrong signals to investors, which may be interpreted as not guaranteeing their investments in RE.[437] One wonders how the directorate can perform its delegated functions effectively as required by the RE Act under this kind of circumstances. This kind of arrangement does not meet the standard requirement for an independent regulatory agency which does not also meet international good practice, as such the agency should be free from political influence and only work on its core mandate, which is to deliver the objectives of the RE Act for the development of RE in Ghana.

Despite these difficulties the directorate faces, there are some benefits to be derived from being under the MOEn. Funding allocation for the RE directorate’s operations would be budgeted for in the MOEn's annual budget. This would limit the financial constraints the

[435] Dayann Obeng-Darko, 'Renewable Energy in Ghana and the Lessons from the EU: An Examination of the Regulatory Support Schemes' (2016) 7 Renewable Energy Law & Policy Review 46 <https://www.jstor.org/stable/10.2307/26256506> accessed 08 April 2020
[436] Dayann Obeng-Darko, 'Regulation of the Renewable Energy Sector and the Proposed Renewable Energy Authority in Ghana: An Examination' (2017) 8 Renewable Energy Law & Policy Review 7 < https://www.jstor.org/stable/10.2307/26377524> accessed 14 April 2020
[437] ibid

directorate would otherwise have faced. Another advantage is that all the different directorates under the ministry will have the opportunity to cooperate with each and share experiences to achieve the country's energy policy goals.

3.8 Discussion on the Renewable Energy Policy Instruments

There are many RE policies that have been deployed worldwide to enable governments to address energy challenges such as ES, climate change, competitiveness, and pollution.[438] The most used RE policies include FIT, quotas, and tender. However, for the Ghanaian context FIT has now been repealed in 2020.

3.8.1 Quotas (Renewable Portfolio Standard)

Quotas are described as quantity-based policy instruments in which the government requires electricity retailers or utilities to supply or generate a minimum percentage of electricity demand from RES.[439] This policy is also known by several other common names such as Renewable Portfolio Standard (RPS), Renewables Obligation Certificates (RO/ROC) and Renewable Electricity Standard (RES).[440] This policy is popularly used in the U.S.A, RPS policies are popular state instruments because they are feasible. Their adoption helps promote new RETs to become cost-competitive with conventional energy sources.[441] RPS relies on private investment and, most at times, gets support in promoting RE growth. RPS is good at regulating the amount of RE electricity that is generated. It is most at times implemented alongside tradable green/renewable energy certificates (REC) to track and verify compliance.[442] RPS can eliminate barriers facing deployment that relate to infrastructure, technology availability and funding, which ensures RE targets are met at least cost with minimum government involvement.[443] The UK version of RPS used for the development of RE has stalled in spite of strong commitment towards the lowering of carbon emissions. The causes are attributed to both internal and external failures in the policy design.[444] The Chinese experience points to the fact that RPS would be ineffective without the legal obligation for utilities to purchase RE electricity from RE Independent Power Producers. The observation

[438] David Jacobs and others, 'Analysis of Renewable Energy Incentives in the Latin America and Caribbean Region: The Feed-in Tariff Case' (2013) 60 Energy Policy 601 <http://dx.doi.org/10.1016/j.enpol.2012.09.024>.accessed 17 April 2020

[439] Greg Buckman, 'The Effectiveness of Renewable Portfolio Standard Banding and Carve-Outs in Supporting High-Cost Types of Renewable Electricity' (2011) 39 Energy Policy 4105 <http://dx.doi.org/10.1016/j.enpol.2011.03.075>.accessed 05 January 2020

[440] Richard Schmalensee, 'Evaluating Policies to Increase Electricity Generation from Renewable Energy' (2012) 6 (1) Review of Environmental Economics and Policy < https://doi.org/10.1093/reep/rer020> 45 accessed 14 January 2020

[441] Barry G Rabe, 'States on Steroids: The Intergovernmental Odyssey of American Climate Policy' (2008) 25 Review of Policy Research 105 < https://doi.org/10.1111/j.1541-1338.2007.00314.x> accessed 17 April 2020

[442] Andrew Ford, Klaus Vogstad and Hilary Flynn, 'Simulating Price Patterns for Tradable Green Certificates to Promote Electricity Generation from Wind' (2007) 35 Energy Policy 91 < https://doi.org/10.1016/j.enpol.2005.10.014> accessed 12 February 2020

[443] Christoph Heinzel and Thomas Winkler, 'Economic Functioning and Politically Pragmatic Justification of Tradable Green Certificates in Poland' (2011) 13 Environmental Economics and Policy Studies 157 < https://doi.org/10.1007/s10018-011-0010-6> accessed 12 December 2019

[444] Geoffrey Wood and Stephen Dow, 'What Lessons Have Been Learned in Reforming the Renewables Obligation? An Analysis of Internal and External Failures in UK Renewable Energy Policy' (2011) 39 Energy Policy 2228 <http://dx.doi.org/10.1016/j.enpol.2010.11.012>.accesses 10 January 2020

has been that even though the obligation exists, six of the major utilities have not met it, thereby raising enforcement issues.

It is important to highlight the strengths and weaknesses of quota or RPS—the strengths of RPS lie, especially when compared to FIT. One merit of RPS is its theoretical power to accommodate RES-E subsidy costs. It can be achieved through the obligation to purchase a certain quantity of electricity from RES in combination with its incentivising mechanism of sourcing electricity at the least-cost.RES types.[445] Menanteau and others argue that RPS gives government the opportunity to have direct control as to the quantity of installed RES-E capacity and vicariously over the marginal cost of RES-E generated.[446] Finon also argues that one important strength of RPS is the likelihood it gives control over collective subsidy costs, and this ability to contain subsidy cost makes RPS to have a high static efficiency thus the ability to contain short-term costs and disregarding longer-term costs consequences.[447] Finon further intimates that the application of non-compliance penalties fees imposed when retailers fail to buy the required amount of RES-E further buttresses the static efficiency advantage.[448] Another theoretical advantage of RPS is that its mechanism recognises a separation between RES-E generation and consumption, as such it is better suited than FIT to the unbundling of liberalised electricity markets where both generators and distributors are not vertically integrated.[449]

The strengths of RPS help to understand why it is a popular instrument in RE development, but despite these strengths, the instrument is challenged by some constraints that are as follows. RPS subsidies are undifferentiated, meaning payment of the same amount is made regardless of RES-E type, and because of this, they support low-cost types of RES-E to the neglect or do not offer any incentive to high-cost types of RES-E. Another disadvantage of RPS is that it only gives incentives to the least-cost RES-E and therefore lacks dynamic efficiency: the reduction of long-run marginal costs through the development of RES-E types which are less mature.[450] Also, climate change awareness is now widely known, and RPS does not support a variety of RES-E types exposing its weakness as a mechanism. Another criticism of RPS is that it provides a homogeneous subsidy to all RES-E types and, in doing so, over-subsidise mature, least-cost RES-E types whilst it under-subsidises less mature, high-cost types of RES-E.[451]

Sweden is an example of how low-cost generators have been overcompensated under the RPS system. RPS, as seen above, does not encourage less mature technologies, so in Texas some time ago, there was a considerable increase in wind capacity, but solar generation remained quite expensive to compete favourably with conventional generation.[452] UK uses RPS called renewable obligation (RO) which is focused on onshore wind and landfill gas and

[445] Buckman (n 439).
[446] Philippe Menanteau, Dominique Finon and Marie Laure Lamy, 'Prices versus Quantities: Choosing Policies for Promoting the Development of Renewable Energy' (2003) 31 Energy Policy 799 < https://doi.org/10.1016/S0301-4215(02)00133-7> accessed 4 December 2019
[447] Dominique Finon, 'The Social Efficiency of Instruments for The Promotion of Renewable Energies in the Liberalised Power Industry' (2006) 77 Annals of Public and Cooperative Economics 309 < https://doi.org/10.1111/j.1467-8292.2006.00308.x> accessed 14 February 2020
[448] ibid
[449] Menanteau, Finon and Lamy (n 446).
[450] Adam B Jaffe, Richard G Newell and Robert N Stavins, 'A Tale of Two Market Failures: Technology and Environmental Policy' (2005) 54 Ecological Economics 164 < https://doi.org/10.1016/j.ecolecon.2004.12.027> accessed 12 January 2020
[451] Buckman (n 439).
[452] Ole Langniss and Ryan Wiser, 'The Renewables Portfolio Standard in Texas: An Early Assessment' (2003) 31 Energy Policy 527 <https://doi.org/10.1016/S0301-4215(02)00095-2> accessed 10 August 2019

this means market development and the learning of other technologies would be limited.[453] Furthermore, because the quota is a non-tradable strategy, it leads to market distortions among the utility companies depending on their geographical conditions.[454] RPS schemes are designed to increase the diffusion of RES-E at the same time minimise costs, in view of this they tend to limit the different types of technology deployed.[455] The pressure put on the reduction of costs does not encourage investment in R&D on the part of manufacturers of equipment, and this can slow down the development of the equipment industry.[456]

3.9 Renewable Energy Policies in Ghana

Attention is now going to be focused on RE policies deployed in Ghana. In Ghana's Renewable Energy Act, 2011 (Act 832) the most important RE policies to aid the development of RE are Renewable Energy Purchase Obligation (REPO) and net metering. FIT was one of the policies that was implemented under the RE Act but was repealed in 2020 as such it has not been included in this section.

When it is finally implemented, the proposed REPO of Ghana will require distribution utilities and bulk consumers to procure a percentage of their electricity from RES. Apart from the penalty spelt out for non-compliance, there is no indication of how the obligation will be met. There is no clarity on whether utilities can trade-off RECs, or they are expected to generate their quotas. Ghana's RPS policy is seen as too ambitious to enforce. Due to political uncertainties in developing countries, it is needless to pile more uncertainties in policy designs; policy designs should seek to limit these to the barest minimum; this is good, especially for new developers in the sector.[457] It is against this background that RPS is generally not recommended for developing countries if it does not contain a standardised contract or guaranteed market.[458] Looking at the power distribution market in Ghana, it is evident that it is dominated and monopolised by state-owned institutions like VRA, ECG and GRIDCo as such one can guess that they may want to initiate new RE projects themselves or their subsidiaries rather than new entrants like RE IPPs. The argument is that until policy reforms in the energy sector eliminate this monopoly, the current arrangement in the RE Act is not going to make any significant impact in relation to grid connection regarding RE electricity in Ghana.

In comparison between FIT and RPS, most studies affirmed that FIT policy increased RE deployment more than RPS. However, an important point needs to be made; the literature has revealed that FIT is most widely used in the European Union whilst RPS is popular in the

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[453] Catherine Mitchell, D Bauknecht, and PM Connor, 'Effectiveness through Risk Reduction: A Comparison of the Renewable Obligation in England and Wales and the Feed-in System in Germany' (2006) 34 Energy Policy 297 < https://doi.org/10.1016/j.enpol.2004.08.004> accessed 4 January 2020

[454] Thomas Faber and others, 'Promotion Strategies for Electricity from Renewable Energy Sources in EU Countries' [2000] … : Institute of Energy … 1 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.198.2947&rep=rep1&type=pdf> accessed 10 February 2020

[455] Lene Nielsen and Tim Jeppesen, 'Tradable Green Certificates in Selected European Countries - Overview and Assessment' (2003) 31 Energy Policy 3 < https://doi.org/10.1016/S0301-4215(02)00112-X> accessed 27 March 2020

[456] Volkmar Lauber, 'REFIT and RPS: Options for a Harmonised Community Framework' (2004) 32 Energy Policy 1405 < https://doi.org/10.1016/S0301-4215(03)00108-3> accessed 28 December 2019

[457] Giancarlo Aquila and others, 'An Overview of Incentive Policies for the Expansion of Renewable Energy Generation in Electricity Power Systems and the Brazilian Experience' (2017) 70 Renewable and Sustainable Energy Reviews 1090 <http://dx.doi.org/10.1016/j.rser.2016.12.013>.accessed 11 April 2020

[458] Dieter Holm, 'Renewable Energy Future for the Developing World' in Detlef Stolten and Viktor Scherer (eds), *Transition to Renewable Energy System* (Wiley-VCH Verlag GmbH & Co. KGaA 2013) < https://doi.org/10.1002/9783527673872.ch9> accessed 10 January 2020

United States of America. Following this revelation, it is understandable not to credit any one of the two to be more advantageous than the other; it all depends on the government's objectives that determine which of the instruments to go in for. It does not look surprising that the framers of the RE Act chose the two policies for which FIT has now been repealed.

The Renewable Energy Act, 2011 (Act 832) sections 25 and 26 address electricity generation issues and have specifically adopted FIT (repealed) and RPS policies to cater for that requirement. The RE Act mandates the EC and PURC to be the regulatory institutions for the RE subsector. The EC deals with technical issues, whilst PURC deals with the setting of tariffs as stipulated by section 5 of the RE Act. The policies to be used to deliver the objectives of the RE Act include REPO (RPS), net metering and a provision that caters for connection to the transmission and distribution grid. As seen in the theoretical discussion earlier, each of the instruments has its strengths and weaknesses depending on the country's energy targets. However, FIT is the most appropriate policy instrument to adopt, commonly used worldwide to promote technological development, On the other hand, if the policy aims and objectives are to increase the share of RE in the generation mix significantly and cost reduction, then REPO (RPS) or tender have an edge and maybe the suitable instruments to deploy to achieve such objectives.[459] Ghana intends to add a 10% share of non-hydro RE to the electricity generation mix by 2030 hence it is adopting REPO. However, in practical terms or in the real world, policies have different objectives set to achieve, and this may require a combination of the different instruments to be deployed simultaneously. Alternatively, in some cases, a particular instrument might be modified to suit or become compatible with other policies in order to achieve some desired objectives.

However, the obstacle that hinders the development of RE in Ghana is the implementation and enforcement constraints of RE law, policies, and regulations. The regulatory frameworks and policies included in the RE Act are RE Fund, net metering, REPO, and RE Authority. These instruments are critical to the development of RE, but the implementation and enforcement have been poorly executed, which has posed a severe challenge to the RE subsector.[460] Some of them are yet to be implemented, e.g., RE Fund, RE Authority, net metering, and REPO. The net metering policy of Ghana has been discussed already under subsection 3.6.6 above and would therefore not be discussed further.

3.10 Renewable Energy Master Plan (REMP) 2019

The REMP was developed in 2019 by EC and it is an investment-oriented framework for the development and promotion of Ghana's rich renewable resources to enhance economic growth, improve social life and aid the implementation of the RE Act to mitigate climate change and provide energy security.[461] The Plan will be implemented over a twelve-year period, starting from 2019 to 2030. The targets of the various RE sources are presented in table E1 of the plan's document.[462]

One of the most important objectives of REMP is to increase the share of non-hydro RE (solar, wind, biomass and mini hydro) in the electricity generation mix from 42.5 MW in 2015 to

[459] M. Meyer-Renschhausen, 'Evaluation of Feed-in Tariff-Schemes in African Countries' (2017) 24 Journal of Energy in Southern Africa 56 <http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-447X2013000100008&lng=en&nrm=iso> accessed 15 May 2020
[460] ibid
[461] Energy Commission of Ghana , 'Ghana Renewable Energy Master Plan' [EC, Feruuary 2019] <.https://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf> accessed 10 May 2022
[462] ibid

1363.63 MW (with grid-connected systems totalling 1094.63) by 2030.[463] REMP targets to add 741.3 Mega Watt-peak (MWp) from solar, 327.0 MWp from wind, 122.1 MWp from biomass and 200 MWp from mini hydro and wave by 2030.[464] It will be implemented in three cycles with the first cycle starting from 2019 to 2020, the second cycle will run from 2021 to 2025 and the third cycle from 2026 to 2030.[465] The projected generation capacity in 2020 was going to be 198.3 MWp, 2025 is going to be 965.44 MWp and for 2030 it is going to be 1390.44 MWp.[466] If REMP is successfully implemented, it is envisaged to create about 220,000 jobs and make GHG emissions savings of 11 million tonnes by 2030.

As discussed earlier in the thesis Ghana set a target to add a 10% share of non-hydro RE into the electricity generation mix in 2020 which was not met and now extended to 2030. As earlier acknowledged the implementation of these legal instruments has been poor. Following the government's inability to meet the target in 2020, it has gone further to formulate the REMP framework making a new modest RE target to be achieved by 2030 and expects that 80% of the funding which is US$ 5.6 billion to come from the private sector whilst GoG provides incentives as the attraction. GoG has also provided the enabling environment for the smooth implementation of REMP.

The main enabling instruments deployed in REMP comprise, the Renewable Energy Act, 2011 (Act 832), RE sub-code to connect variable RE plants to transmission system and distribution network, the operation of a purchase obligation that compels utilities to procure a percentage of their electricity from RES, net-metered systems will be given priority to connect to the distribution grid according to the net-metering code, financial incentives to be provided by the GoG to private sector RE investors who engage in the local assembly and manufacture of RETs including other related services (the incentives include exemptions on import duties, tax and Vat) and the then FIT policy that was repealed in 2020.

Unfortunately, following this intervention, private sector participation falls far below expectation even with the enabling environment provided for investors to thrive in the RE subsector. In 2020 out of 198.3 MWp expected generation capacity to be added just 42.5 MWp was achieved. An indication Ghana had fallen short of its REMP target and has entered the second cycle with a deficit. If this is replicated in the rest of the cycles to 2030, then the target is likely to be missed. It appears that the buzz about private sector participation has not happened.

The poor participation of the private sector can be attributed to many factors as follows: The FIT policy that guaranteed premium price for the sale of electricity from RES was repealed in 2020. The reasons that were adduced can be found in subsection 3.11.1 below. As acknowledged in the thesis, REPO is a laudable policy, but it has not been implemented yet allowing the utilities freedom to ignore RE electricity. The Ghanaian currency the Cedi fluctuates massively against international currencies like the US dollar which affects doing business in the local currency which can lead to huge losses in investment. Some other forms of incentives are not incentivising enough to motivate private investors to come to the RE subsector. These factors bedevilling REMP are likely to cause its principal objective from not been met in 2030. About 3.5% of what REMP has achieved so far which is less than the 14%

[463] Energy Commission of Ghana, Ghana Renewable Energy Master Plan (n 457).
[464] Anthony Afful-Dadzie, Stephen Kobby Mensah, and Eric Afful-Dadzie, 'Ghana Renewable Energy Master Plan: The Benefits of Private Sector Participation' (2022) 17 Scientific African e01353 <https://doi.org/10.1016/j.sciaf.2022.e01353>.accessed 16 January 2023
[465] Energy Commission of Ghana, Ghana Renewable Energy Master Plan (n 461).
[466] Afful-Dadzie, Mensah, and Afful-Dadzie (n 464).

envisaged 90% is coming from the private sector an attestation that it could play a critical role in the success of REMP.[467]

It is apposite at this juncture to point out similarities of the poor performance of the RE Act and supporting policies which led to the missing of the 10% target in 2020 with that of REMP. With the poor implementation of the REMP which has already missed its first cycle target in 2020 and has started the second cycle with a deficit, if this pattern is replicated in the second and third cycles, then the target may be missed in the year 2030.

3.11 Results of the Empirical Research

In relation to all that has been discussed in the preceding sections, the results of the empirical research further shed light on the theoretical issues raised above and give the current state of affairs and what is pertaining on the ground with regards to issues concerning most aspects of the RE Act. Through semi-structured interviews, the evaluation of the effectiveness of the RE Act and policies of Ghana to address ES challenges has been provided. The results of the interviews confirm the theoretical arguments made in the well-established literature on the poor implementation of the RE Act and policies. Based on the data collected from the in-depth interviews, four constraints have been identified that militate against the development of RE in Ghana. These challenges were identified from participants' answers and grouped under legislation and regulatory constraints, bureaucracy in licence acquisition constraint, ES and climate change constraints and effectiveness constraint. The results affirm most of the constraints captured in the literature and further proffer solutions to overcome the challenges, which are included in the recommendation section of the thesis.

Concerning the target of a 10% share of non-hydro RE that was to be added to the electricity generation mix in 2020, it was missed and now extended to 2030. Participants were asked if they were sure the target could be achieved in 2030. Most of the participants took a conditional approach, meaning GoG can fully implement the RE Act and stop adding more thermal to the generation mix. It is possible that the 2030 target will also be missed if the status quo remains. ***A senior official from ACEP had this to say, the RE Act is good however, the problem is the implementation; government agencies tasked with the responsibility of implementing some sections of the Act have not done that. For instance, PURC has been mandated to set the percentage for utilities to procure their electricity from RES; up till now, this has not been done. The government takes the majority of the blame for most of these things, e.g., the RE Authority and RE Fund, have not been established. Funding to the RE subsector has been limited due to the non-establishment of these institutions. It shows a lack of will on the part of the government to provide the much-needed funds; all these are key to the success of the RE agenda. However, here we are; they have not been implemented yet, as envisaged in the RE Act. GoG, since the enactment of the RE Act in 2011, hydro RE was dominating the electricity generation mix. However, the GoG has taken another pathway and added more thermal into the generation mix to solve electricity generation and supply challenges.***

Now, in 2021, thermal is more than hydro and non-hydro RE in the electricity generation mix. At this point, the participant is cautious about saying whether the target could be met or not, but at the same time, the participant had the belief that it could be missed if things are not done differently from now moving forward. Nevertheless, the researcher remained neutral whether the new date of 2030 could be met or not but leaving that to

[467] Anthony Afful-Dadzie, Stephen Kobby Mensah and Eric Afful-Dadzie, 'Ghana Renewable Energy Master Plan: The Benefits of Private Sector Participation' (2022) 17 Scientific African e01353 <https://doi.org/10.1016/j.sciaf.2022.e01353>.accessed 16 January 2023

the facts that will emerge at the end. From the field study, an official from the MOEn was optimistic that more IPPs' generation is in the pipeline. When all come on stream, the share of non-hydro RE will increase. Therefore, the target can be met, but this optimism is yet to be translated into practical terms.[468]

3.11.1 Legislation and Regulatory Constraints

The principal instrument being implemented with the policy was FIT which has now been phased out by the Renewable Energy (amendment) Act, 2020 (Act 1045). The RE market has matured due to rapid technological development, which has witnessed a rapid fall in price. Furthermore, the FIT regime, which is now a burden on consumers, should be amended so that consumers can benefit from the reduced cost of electricity generation from RES through competitive procurement in Ghana.[469] The participants were of the view that the other two thus Renewable Energy Purchasing Obligation (REPO) and Net Metering are better instruments than FIT. The reason for this is, the RE Act mandates utilities to procure a percentage of their electricity from RES. It could lead to a large intake of RE. Net metering though also yet to be implemented, can increase generation. It allows customers to generate electricity from variable sources, which is fed into the grid, which can then be retrieved later for use through a favourable mechanism. Net metering in the Ghanaian context allows consumers to self-generate electricity from RES to reduce their electricity bills or combat climate change and not for income generation.[470]

On the issue of full implementation of the RE Act, most of the participants agreed that the Act had not been fully implemented as envisaged, which is the cause of the less penetration of non-hydro RE in the electricity generation mix. It is attributed to the non-incentivisation posture to the development of RE in Ghana. RE is somehow not seen as a priority by policymakers compared to thermal. The narrative from participants lends credence to the poor regulatory environment that exists in the RE subsector:

"We have a situation where the MOEn is promoting RE by enacting the RE Act to increase generation capacity. The same ministry is busy adding thermal into the generation mix at the same time. Today, thermal using natural gas and light crude oil (fossil fuel) is now dominating the electricity generation mix. The government is talking about exploring nuclear for energy generation purposes. The independent RE Authority has not been established, including the RE Fund and these key bodies are yet to come on stream maybe one day. These government actions have contributed immensely to making the RE law and policies less effective in achieving ES and climate change mitigation as envisaged in the Act. It sends the wrong signals to investors whom the RE Act is relying upon to bring in private finance to propel the development of RE in the country". (A senior academic)

Furthermore, other obstacles that hinder the development of RE in Ghana is the implementation and enforcement constraints of RE law, policies, and regulations. Some of the regulatory frameworks and policies included in the RE Act are: RE Fund, net metering, REPO, licence acquisition and RE Authority. These instruments are vital to the development of RE, but their implementation and enforcement have been poorly executed, which has posed a severe challenge to the RE subsector.[471]

When participants were asked how full implementation of the RE Act can be achieved, this is a summation of what participants had to say, "***there is the need to show political will on***

[468] Participant 1 interview held via zoon 26 October 2021.
[469] Ghana's Renewable Energy (Amendment) Act, 2020 (Act 1045) sec. 51.
[470] ibid
[471] Ghana's Renewable Energy (Amendment) Act, 2020 (Act 1045) sec. 51.

the part of government, commitment from all stakeholders, the regulators and policymakers. In addition, the government must increase its supervision and monitoring and inject more funding into the RE subsector".

3.11.2 Bureaucracy in Licence Acquisition

On the issue of licensing, in Ghana, it takes sixty-five days before an application for a licence may be granted; in other cases, it takes a much longer time for permits and certificates to be issued. These bureaucratic process takes longer processing time to complete. Most of the participants bemoan this long time it takes to acquire permits, certificates, and licences, which is totally unnecessary and has become a clog in the wheels of RE development in the country. Though due process is necessary, but the length of time involved is the source of concern. More so, these permits, licences and certificates are not issued by the same institution, and these institutions and bodies all have their requirements which have become frustrating and a challenge for RE developers. This is a response from a senior ACEP official, ***the official had not compared the sixty-five days coupled with the required submissions with other jurisdictions but said, if it takes such a daunting process for a licence to be acquired, then it does not speak well of Ghana, it comes back to the business environment; due diligence has nothing to do with bureaucracy and red tape. It can be short whilst the standards are still maintained. Ghana can check and see what other countries are doing regarding licence/permit acquisition and have a comparative analysis of other jurisdictions to see the best practice.*** This lengthy process frustrates and delays the acquisition of other certifications like land title deeds, which, when combined, can further prolong the time into months and even a year or more. From the perspective of prospective RE developers, this time is somewhat wasted on bureaucracy instead of the time being spent on moving equipment to the site to begin generation. It mostly delays the start of many RE projects and impedes progress towards generation. It may have discouraged many prospective RE investors from coming to the Ghanaian RE subsector, therefore, contributing to the small penetration of non-hydro RE.

3.11.3 Energy Security and Climate Change Challenges

On the issue of ES and climate change, in the RE Act, the GoG has indicated that it has turned its attention to RES because of these challenges. From the interviews, the participants also agreed that these challenges over the last decades have been troubling as such, GoG's attempt to solve the problem using RE is a good thing. However, the participants were not convinced that GoG's approach could surmount these challenges. As the RE Act has not been fully implemented, it leaves other key areas affected, which in totality leads to the problem still lingering. For example, the RE Act envisaged the establishment of the RE Fund and Authority, which have not been implemented over the last eleven years. The establishment of these bodies is fundamental to the success of the RE agenda in Ghana. The RE Fund, if established, would have provided the necessary financial support and incentives to the RE subsector. The RE Authority would have been an independent body overseeing the day-to-day operations of the RE subsector and free from GoG's control. These key bodies are yet to be established, a situation which impedes the deployment and development of RETs. "***On paper, yes ES and climate change are captured as the reasons, e.g., island communities which cannot be connected to the national grid as such standalone or mini-grids are better options in terms of connectivity. Most of these mini-grids and standalone systems use RE thereby providing ES and increasing competitiveness. Ghana attempts to use RE penetration to combat climate change, however, it is difficult to judge the government's real intentions. One can infer from how far we have gone with the implementation and how the government has approached certain policies. There seems to arise a conflict, as GoG is increasing thermal generation more than RE, which raises concerns about the pathway the government wants to take. It is not surprising that non-hydro RE penetration was less than 1% in 2020. However, the government needs to balance the***

trade-off between oil and gas extraction and RE generation. Ghana needs to put in place policies that fairly allow it to extract its oil and gas resources in an environmentally friendly manner as well as its RES". (Senior official of ACEP)

Furthermore, participants were asked whether the RE Act has addressed ES, and climate change challenges. The results show that the RE Act so far has not been fully implemented as such, the challenges have not been addressed at all and persist. There are varied views on this, but a participant captured a rather exciting approach which could be the underlining issue which is not often talked about openly. The narrative is as follows: ***The Act's implementation is what matters, but our posture, like in Africa, we do not really contribute much to climate change. We contribute a little to the menace; as such, we have absolved ourselves from the problem hence our lack of seriousness with how to use RE to solve the challenge. The excuse is that we generate fewer carbon emissions compared to developed countries. Moreover, we have not caused climate change***, ***so we are free to approach it this way. So, one can see that since 2011 when the RE Act was enacted, the GoG has relatively concentrated on adding thermal to the electricity generation mix and within five years, thermal surpassed hydro (RE). From the above, the challenges mentioned for the enactment of the RE Act have not been addressed. According to the EC of Ghana, the statistics speak for themselves as non-hydro RE penetration in the electricity generation mix was 0.3% in 2020.***

Participants were asked about transmission and distribution losses. All the participants were unanimous that it was one serious challenge confronting the electricity generation sector. Over 34% of the power generated is lost according to EC in 2021, through transmission and distribution due to aged infrastructure. One participant made a remark that he could not understand the way things are done in Ghana. How can one spend plenty of money to generate electricity, and when transmitting and distributing it, plenty of it is allowed to go to waste? Then the cost of these losses is passed on to consumers, which is included in their energy bills. The burden of the companies' inefficiency is put on customers. No wonder our electricity bills are just too high. It was acknowledged that the main problem is old, weak transmission and distribution infrastructure that has not been upgraded, since they were first built and cannot efficiently evacuate any power. The transmission and distribution companies need to invest in the upgrading of their network systems in order to stop these losses. A participant indicated that some transmission and distribution networks have started to be upgraded, but another challenge is funding for the upgrading, which is limited as such the progress is slow.

Participants were asked whether there were other alternatives to RE that could be used to tackle ES and climate change challenges. In this, answers and opinions varied, but three alternatives came to the fore thus nuclear, energy efficiency and biomass. Those in favour of nuclear identified it as a clean and cheap energy source, which could efficiently address ES and climate change challenges, but the problem with nuclear is that it is not an RE source; it is a mineral derived from uranium and the concern for its safety in the event of an accident is very high. A participant said, "if that happens like in the case of Chornobyl and Fukushima, it will be very devastating. We are just a developing country; we simply do not have the resources for the clean-up and the aftermath consequences". Some participants mentioned energy efficiency practices as a way that could minimise waste in electricity consumption in the country if observed. Those in favour of biomass say it is the primary energy source used for cooking and heating in Ghana, either in the form of firewood or charcoal, and it is an RE source.[472] They contend that it is readily available, and it needs technology to improve upon its use and to prevent its use in enclosed dwellings which brings about indoor air pollution

[472] Ghana's Renewable Energy Act, 2011 (Act 32).

which kills millions of people in Sub-Saharan Africa. Ghana is endowed with plenty of forests that have been depleted, but woodlots can be planted for the purposes of energy use.

3.11.4 Effectiveness Constraint

After the interviews, participants were asked to evaluate whether the RE instruments deployed effectively addressed ES and climate change challenges and if there was any evidence of that. One of the most important evaluative criteria of a policy is how the projected outcome will solve the policy challenges the policy set out to achieve within the stipulated time frame. Further, implementation of the provisions of the RE Act as stipulated is vital in measuring whether these have been achieved or not. In this research, the RE Act came into force in 2011 with the target of adding a 10% share of non-hydro RE into the electricity generation mix in the year 2020. It was envisaged that; its deployment will help address ES and climate change challenges and the implementation of key provisions such as the establishment of the RE Fund and RE Authority. However, as seen earlier these key expectations have not come to fruition. At the end of the interview, it became abundantly clear that due to the general problem of the poor implementation of the RE Act, the effectiveness of the instruments has been poor. It can be argued that since the RE Act has not been fully implemented, it would be hard to judge whether the instruments could have been effective or not if they were fully implemented but so far, the results depict them as less effective.

However, since the coming into force of the RE Act eleven years ago, the penetration of non-hydro RE in the electricity generation mix has been very little, pegged at 0.3% in 2020. A participant has this to say in response to the question of whether the instruments were effective in addressing ES challenges, ***so far, no, and when the interview is finished, one would realise that many of the instruments deployed for the development of RE have not been effective and have achieved little and some of the policies are yet to be implemented. There are many challenges that need to be surmounted before the RE Act can be evaluated as effective. However, as things stand now, it has been less effective, which has led to the country achieving less than 1% addition of solar and wind RE in the electricity generation mix in 2020 (Senior academic).***[473] Furthermore, it has been identified that Ghana's policy design adopts a top-down approach, thus focusing on policymakers (formulation and implementation). This approach neglects perspectives from the people whom these policies will impact and their acceptance of RE; this top-down policy approach is replicated across most African countries' policy designs, this observation has also been confirmed by Agyekum, Ali and Kumar.[474]

3.12 Effectiveness of the Renewable Energy Act, 2011 (Act 832)

There are many reasons why the performance of a policy is crucial to policymakers and stakeholders. Therefore, evaluation of the legal and policy instruments is crucial to know the costs and benefits relating to the environment, ES, and economy. This research is concerned with the effectiveness of the RE Act and policies deployed to add a 10% share of non-hydro RE in the electricity generation mix in 2020. To achieve the above target involves a substantial financial cost of US$ 5.6 billion which 80% is expected to come from the private sector, with

[473] Participant 3 interview held via zoon on 19 November 2021

[474] Ephraim Bonah Agyekum, Ernest Baba Ali and Nallapaneni Manoj Kumar, 'Clean Energies for Ghana—An Empirical Study on the Level of Social Acceptance of Renewable Energy Development and Utilization' (2021) 13 Sustainability (Switzerland) <https://doi.org/10.3390/su13063114> accessed 24 December 2021

the government providing incentives as the attraction.[475] The research critically examines the RE Act and policies to ascertain their effectiveness to address ES challenges.

In the literature, five common criteria can be used for the evaluation such as effectiveness, efficiency, equity, institutional feasibility. The thesis will focus on the effectiveness criterion first because it is part of the main research question. “Effectiveness is the extent to which intended objectives are met, for instance, the actual increase in the output of renewable electricity generated or shares of renewable energy in total energy supplies within a specified time period”.[476] The main objective of the RE Act is to deploy non-hydro RETs for the generation of heat and power in an efficient environmentally sustainable manner.[477] A target of 10% share of non-hydro RE to be added to the total generation mix in 2020 was set. However, in 2020 the target was missed and now extended to 2030.

To evaluate the effectiveness of the RE Act and policies, the suitable indicators to apply will be installed capacity and the amount of RE electricity generated. Taken alone, however, they provide little on the policy's success, especially when a comparison is not made regarding intent. This notwithstanding, it is a simple, straightforward, and useful approach to measuring the extent to which a pre-defined target has been met within a given time frame by the individual country. To establish whether a policy has been effective or not, it is also prudent to investigate contextual factors that contribute to distracting the effectiveness in any given case, such as the type of policy being implemented, non-economic barriers, and policy design. Certainty is important to investors, especially if there are perceived risks that exist, such as risks in policy and regulatory environment and technical risks, when these conditions exist, then there will be less investment in RE.[478]

Poor policy effectiveness is reflected in the failure to address non-economic barriers, such as bureaucratic processes in licence acquisition and impediments to getting access to the grid, studies have argued that such barriers need to be addressed so that legal instruments deployed can be effective in addressing the challenges facing the RE subsector.[479]

3.12.1 Assessment of the Performance of the Renewable Energy Act, 2011 (Act 832) using the Effectiveness Criterion

For an instrument to be considered effective, it is assessed against its objectives and particularly against pre-defined indicators of success. For example, the main policy objective in Ghana is to deploy non-hydro RETs in the electricity generation mix to achieve the 10% target that was set to be met in 2020. Then it should fulfil the indicator requirements such as installed capacity and share of electricity generated within a given time period. Furthermore,

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[475] Energy Commission of Ghana, ‘Ghana Renewable Energy Master Plan’ [EC, February 2019] < https://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf> accessed 10 May 2022

[476] Catherine Mitchell and others, ‘Chapter 11: Policy, Financing and Implementation’, in Ottmar Edenhofer and others (eds), *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge University Press 2011) < https://doi.org/10.1017/CBO9781139151153.015> accessed 20 June 2020

[477] Ghana’s Renewable Energy Act, 2011 (Act 832).

[478] Corinna Klessmann, ‘Increasing the effectiveness and efficiency of renewable energy support policies in the European Union’ <file:///C:/Users/samny/Downloads/Increasing_the_effectiveness_and_efficiency_of_ren.pdf> accessed 15 May 2020

[479] International Renewable Energy Agency, ‘Evaluating Policies in Support of the Deployment of Renewable Power’ (IRENA, 2012) <https://www.globalccsinstitute.com/archive/hub/publications/138193/evaluating-policies-support-deployment-renewable-power.pdf> accessed 24 November 2021

contextual factors include the type of policy being implemented, non-economic barriers, and policy design. The literature on effectiveness suggests the most important factor to consider is the extent to which the instruments have comprehensively addressed the challenges for their deployment in the case of Ghana, they are ES and climate change.

According to the EC of Ghana's energy statistics 2020 edition, the installed capacity of non-hydro RE in the electricity generation mix was 60.10 MW, with a share of 0.3% in 2020. The statistics show the requirement has not been met, which is installed capacity, share (10%), and year.[480] An indication the target has not been met which has now been shifted to 2030.[481] With contextual factors, the type of policy being implemented, Ghana implemented FIT, it guaranteed a premium fixed price of electricity generated from non-hydro RES for ten years. Investors were discontented with it and pointed out that the ten years were too small for them to recoup their investment. It was poorly executed until it was repealed in 2020.

On non-economic barriers, the RE Act envisaged the establishment of the RE Fund and Authority. However, these key institutions have not yet come on stream because the GoG has no funding to implement these policies. Furthermore, transmission and distribution losses are high at 5% and 29.7%, respectively, due to the weak and aged network. With policy design, regulatory complexities such as the conditions of the licences are determined by the Minister of Energy whilst the licence is issued by EC. The Act has a bureaucratic, lengthy licence acquisition process which involves other permits, certifications from other institutions before an applicant would receive a decision on the outcome of the application. Grid connection poses obstacles to RE developers as the cost of connecting to the metering point of the grid is borne by generators of electricity from RES. Furthermore, a cap of 20 MW is imposed on RE generators of solar electricity to connect to the grid, this has therefore limited the generation of large quantum of electricity from solar.

No funding is provided to the RE subsector, the RE Fund would have provided the needed financial support to the subsector, but it has not been established. Instead, the GoG relies on private sector investment of about 80% of the estimated US$ 5.6 billion and seeks to use incentives to attract IPPs. It is, however, worth noting that fiscal incentives such as loans, loan guarantees and public finance are generally thought to promote deployment effectively when it is linked to production instead of investment.[482] The assessment of the effectiveness of the RE Act and policies cannot be done in isolation without further highlighting other criteria that give more insights to their poor performance. A further discussion is going to be made on the remaining criteria namely: efficiency, institutional feasibility, and equity.[483]

3.12.2 Assessment of the Performance of the Renewable Energy Act, 2011 (Act 832) using the Efficiency, Institutional feasibility, and Equity Criteria.

In this assessment, efficiency is focused on evaluating whether the policy being implemented is done in an economic efficient way with regards to the resources spent on deploying RE in

[480] Energy Commission of Ghana, '2020 National Energy Statistics' (EC, April 2021) < http://energycom.gov.gh/files/National%20Energy%20Statistics%202021.pdf > accessed 20 October 2021

[481] Aboagye and others (n 426).

[482] International Renewable Energy Agency, 'Evaluating Policies in Support of the Deployment of Renewable Power' (IRENA, 2012) <https://www.globalccsinstitute.com/archive/hub/publications/138193/evaluating-policies-support-deployment-renewable-power.pdf> accessed 24 November 2021

[483] International Renewable Energy Agency, 'Evaluating Renewable Energy Policy: A Review of Criteria and Indicators for Assessment' (UK Energy Research Centre, 2014) < https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/icept/Evaluating_RE_Policy.pdf.>. accessed 2 June 2022

financial terms or social costs. Simply, it is concerned with whether the policy objectives are reached in a cost-effective way as the costs involved in supporting a policy is a source of concern to many governments worldwide so that the financial burden on consumers can be reduced.[484] It uses the simple indicator of how much installed capacity (electricity generated) has been achieved. As seen above in subsection 3.12.1 installed capacity of non-hydro RE in the electricity generation mix was 60.10 MW with a share of 0,3% that was added in 2020 the target year. These figures both installed capacity and share fell far below what was targeted. As seen above GoG has not committed financial support to its renewable agenda like Australia and Cape Verde but relies on the private sector to bring in the needed investment and only using incentives as the attraction.

Institutional feasibility is focused on pollical factors that are prevailing which give support to a policy deployment, including the institutions tasked with the responsibility to deliver the outcomes and the human capacity to implement and monitor the interventions for the policy's success. It is regarded as important because it is impossible to implement a policy without it regardless of the policy's potential performance as envisaged, it creates the enabling environment for private sector and other actors to participate in the RE space. Policies designed without taking into cognizance political factors may not perform as expected. In most cases institutional feasibility determines the performance of other criteria discussed here. It is difficult to measure institutional feasibility. However, in the Ghanaian context it can be pointed out that in part, the poor performance of the RE Act can be attributed to the GoG taking a different pathway of adding more thermal into the generation mix for a quick fix to the energy crisis the country was going through to the neglect of RE. The poor implementation and monitoring of RE policies are as a result of internal institutions and human capacity failures which has led to a paltry penetration of non-hydro RE in the electricity generation mix.

Equity is concerned with the fair distribution of the policy impacts in terms of the opportunities and burdens. It may also entail stakeholders participating in the policy making process. This participation can improve the policy and potential difficulties can be mitigated and this would minimise opposition to policies on grounds of equity. For example, the policy impact for consumers, it was envisaged that a 10% addition of RE was going to bring affordable power which is environmentally friendly. Unfortunately, the share that was added was 0.3% so the benefits that electricity consumers were expecting did not materialised.

A critical look at the criteria shows that some other important considerations may be left out such as jobs, implementation, monitoring, ES), for example the REMP projected that if the RE Act is fully implemented, it would lead to the creation of 220,000 jobs, ES is an essential challenge that the Act wants to address, as it is one of the reasons why Ghana has turned to its RES. Implementation and monitoring are important in the deployment process as monitoring can identify any challenges which can be addressed as early as possible to bring about success. Furthermore, when a target date is passed, there is the need to set new targets. Regular reviews are needed to ascertain whether the driver of the target is still valid and relevant to contemporary times. So, these other variables can play an important role in the success of the RE Act.

The RE Act and supporting instruments have been less effective because they have failed to meet the effectiveness, efficiency, institutional feasibility, equity indicators, and contextual factors since their deployment, and have registered a small share of 0.55% in the electricity generation mix at the end of 2021. However, it should be pointed out that the evaluation has

[484] Pablo Del Río and Emilio Cerdá, 'The Policy Implications of the Different Interpretations of the Cost-Effectiveness of Renewable Electricity Support' (2014) 64 Energy Policy 364 <http://dx.doi.org/10.1016/j.enpol.2013.08.096> accessed 12 November 2019

focused on immediate deployment effects as the target that was set was to be met in 2020. However, on a broader consideration impact, it may take time for the target and the successful implementation of the Act to manifest as many RETs may take time to make the desired impact. Moreso, the repeal of the FIT policy in 2020, such withdrawal of financial support is likely to bring some immediate effect on the achievability of the target especially when it has been extended to 2030.

3.13 Legal and Regulatory Barriers to Renewable Energy Deployment in Ghana

Legal and regulatory policies on RE are needed to aid its wide deployment and development however, in some situations, inadvertently these instruments themselves constitute barriers to RE. Deployment of RE is important not to meet energy demand alone but also to address ES and climate change concerns. However, there are some barriers that impede its wide development and penetration globally and in Ghana. This section focuses on policy and regulatory barriers. Some main barriers to be discussed include less effective national policies, bureaucratic and administrative requirements, over-ambitious targets, lack of incentives, planning permission acquisition and environmental impact assessment hurdles.

Government policies are often not effective and complex, strong regulatory frameworks within the RE subsector are needed and also to provide clarity so as to avoid regulatory complexities, for instance in Ghana the terms of an operational licence are determined by the Minister of Energy, but the licence is issued by EC which is unnecessary as the EC could discharge both duties. Government's commitment to take decisive decision to promote RE is sometimes in doubt, a case for reference is, after the enactment of the RE Act in 2011, the government then took a different pathway by adding more thermal into the electricity generation mix until it surpassed hydro and non-hydro RE in 2016 for a quick fix to the country's energy crisis. Government policies such as SNEP and NEP as discussed have not yielded the desired results as envisaged in the policies themselves due to their ineffectiveness. The country's RE endowment is huge and if developed effectively can meet the energy requirement of the citizenry but this requires the political will and commitment from the GoG and state institutions for this to happen.[485] The lack of political will from government is demonstrated in its approach to the implementation of the RE Act, Unstable RE policies do not help in the integration of RE e.g., FIT was in force but was repealed in 2020 a development that has affected the expansion of RE subsector. The absence of good policies to integrate RETs and inadequately equipped government agencies act as barriers to RE deployment.[486]

Bureaucratic and administrative complexities where a licence is required to operate in the RE subsector and this process takes time with so many requirements that need to be fulfilled, which also incorporates additional permits and certifications acquisition from other government agencies, these prolong the process and increase the gestation period of RE projects There is also lack of coordination between government agencies which prolong the process of authorisation and sometimes leads to duplication of each other's roles. All the

[485] Md Fahim Ansari and others, 'Analysis of Barriers to Implement Solar Power Installations in India Using Interpretive Structural Modeling Technique' (2013) 27 Renewable and Sustainable Energy Reviews 163 <http://dx.doi.org/10.1016/j.rser.2013.07.002>.accessed 10 January 2023

[486] Huiming Zhang and others, 'Political Connections, Government Subsidies and Firm Financial Performance: Evidence from Renewable Energy Manufacturing in China' (2014) 63 Renewable Energy 330 <http://dx.doi.org/10.1016/j.renene.2013.09.029>.accessed 10 January 2023

above factors lead to prolong start-up period and invariably lead to the reduction of motivation required to invest in RE.[487]

Over-ambitious targets, the targets sometimes set by governments are not realistic and achieving these targets become problematic. This is in view of the results that come after the implementation which in most cases are woefully inadequate.[488] There is lack of understanding on setting realistic targets in relation to government's resources and the institutions to implement the required policies to meet the targets. For example, Ghana set a target of adding a 10% share of non-hydro RE into the electricity generation mix in the year 2020, however in 2020 the share that was added was 0.3% a clear sign that much was not done, and the target remains an illusion and this could be an example of unrealistic target setting. Unrealistic targets which are not achievable could lead to loss of credibility with RE industry players.

Insufficient fiscal incentives, GoG has provided some kind of incentives such as the removal of taxes on imports of RE equipment and components for RE projects. FIT was used for some time to guarantee the sale of the price of electricity generated from RES, but it was repealed in 2020 this in part was a kind of support for RES to make them competitive with fossil fuels. However, the repeal can be seen as a setback to actors in the RE subsector. Overall, these crucial incentives for RE development are absent and inadequate as the initial cost of RETs is capital intensive. This leads to high cost in generating electricity from RES which is not cost competitive with conventional energy sources and does not augur well for RE development.[489]

Political interference with RETs projects is one of the barriers to RE deployment. Politicians who have little or no knowledge and experience in energy sometimes meddle unnecessarily with RET projects for political expediency. Instead of allowing the technocrats the free hand to handle the projects professionally. The end result is that this interference leads to the failure to achieve the goals or when the tenure of the politician expires, the policy also expires which makes it difficult for projects to be carried out from start to finish.

Land acquisition in Ghana is a cumbersome and complex process due to the land tenure system. To acquire land for RE development in Ghana is quite expensive especially for RE project developers who require large hectares of land for solar PV farms, bioenergy crops and wind farms. Sometimes some unscrupulous landowners can sell or lease a parcel of land to multiple project developers and if a developer falls into this trap, it can take so many months or years in litigation. A such in acquiring land, the developer needs to do due diligence with the land commission of Ghana before going ahead to acquire the land.

Planning law is a barrier to RE as planning permission is required for physical development which means to carry out a building, engineering, mining, or any other operations on, in, under or over a piece of land or the material changes in the existing use of the land…[490] Thus planning permission will be required to install a utility-scale solar power plant or the installation of a wind turbine or the construction of a mini hydro dam. As such a prospective RE developer would have to meet all the requirements before the permit can be granted if not the project

[487] Helene Ahlborg and Linus Hammar, 'Drivers and Barriers to Rural Electrification in Tanzania and Mozambique - Grid-Extension, off-Grid, and Renewable Energy Technologies' (2014) 61 Renewable Energy 117 <http://dx.doi.org/10.1016/j.renene.2012.09.057>. accessed 10 January 2023
[488] Seetharaman and others, 'Breaking Barriers in Deployment of Renewable Energy' (2019) 5 Heliyon e01166 <https://doi.org/10.1016/j.heliyon.2019.e01166>. accessed 5 January 2023
[489] Peng Sun and Pu yan Nie, 'A Comparative Study of Feed-in Tariff and Renewable Portfolio Standard Policy in Renewable Energy Industry' (2015) 74 Renewable Energy 255 <http://dx.doi.org/10.1016/j.renene.2014.08.027>.accessed 20 December 2022
[490] Land Use and Spatial Planning Act, 2016 (Act 925).

may not go ahead. In recent times too, a new movement has emerged NIMBY, which are concerns raised by society about the presence of such RE infrastructure in their backyard and sometimes this opposition can lead to the stalling of some RE projects or even kill them. Planning Permission can be both a barrier in terms of installation and use of an RE system. So, the uncertainty and inconsistency and planning requirements for RE systems development put some barriers for people who want to own them such as solar PV.

Environmental Impact Assessment (EIA) is considered as a barrier as a result of the requirements that are demanded to be fulfilled before a planning permit is granted before an RE project can commence. In Ghana, the Environmental Protection Agency is charged with the duty under section 2 (i) of the EPA Act 1994 to enforce compliance with any laid down EIA assessment procedures in the planning and execution of development projects, which includes compliance in respect of existing projects. Section 12 (1) obligates the agency to serve notice in writing that requires any person responsible for any undertaking, which in the agency's opinion, has or is likely to have an adverse effect on the environment to submit to the agency in respect of the undertaking an EIA containing such information within such period as shall be specified in the notice. This assessment is applied stringently and so if an RE developer's proposal does not meet the environmental impact requirement unfortunately, the proposed undertaking cannot go ahead. Many RE projects have stalled following the assessment due to this rigid process and has affected RE expansion. Under such circumstances the RE project which would have protected the environment is being stopped on environmental grounds paving the way for the continuous use of fossil fuels which continue to degrade the environment which EIA is seeking to protect.

3.13.1 Breaking the Barriers to the Deployment of Renewable Energy in Ghana

The above barriers pose a real challenge to the deployment of RE and so overcoming them would go long way to expand the RE subsector in the country.

User-friendly procedures which are simple can counter the hurdles posed by bureaucratic processes in the deployment of RE. Bureaucracy tends to demotivate investors from coming to invest in the RE subsector. The implementation of poorly designed policies fails to attract investors, like the FIT which was not properly implemented and only guaranteed the premium price for ten years whilst countries like Kenya, applying the same FIT policy guaranteed price for twenty years. It is established that countries with excessive bureaucratic and administrative procedures show less RE penetration compared to countries with simple and straight forward procedures.[491]

Research and Development (R&D) can play a crucial role in technological advancement to effectively generate electricity from RE which can be cost-competitive.[492] In contrast, R&D for RE is inadequate compared to fossil energy. International fossil fuel extraction has received a lot of research making it possible to explore and exploit it in areas that hitherto were seen as inaccessible but made possible due to research, but the same level of attention is not given to RE. Funding for RE research is insufficient and this could slow down progress even though the solar industry has seen much improvement which brought cost down due to research.

[491] Shih Chieh Huang, Shang Lien Lo and Yen Ching Lin, 'To Re-Explore the Causality between Barriers to Renewable Energy Development: A Case Study of Wind Energy' (2013) 6 Energies 4465.< https://doi.org/10.3390/en6094465> accessed 12 January 2022

[492] M Absi Halabi, A Al-Qattan and A Al-Otaibi, 'Application of Solar Energy in the Oil Industry - Current Status and Future Prospects' (2015) 43 Renewable and Sustainable Energy Reviews 296 <http://dx.doi.org/10.1016/j.rser.2014.11.030>.accessed 16 January 2022

Cost savings, one of the challenges of RE is, it faces competition from low-cost fossil fuels. RE projects are capital intensive initially and require large chunks of land which is expensive in terms of financial capital required to make the purchase. As such negotiation for community lands to be lease for a period of time at affordable price for the RE developer would reduce the cost component of the project drastically. Tax breaks and removal of import duties are not sufficient to attract RE investors, GoG needs to go further with more attractive incentives such as guaranteeing for loans. Furthermore, the GoG should begin to make budgetary allocation for RE instead of the current approach of relying on private sector investment to promote RE development in the country. Setting up of the RE Fund can provide some subsidies to RE the same way as fossil fuels. The implementation of the net metering and REPO policies can give renewables competitive edge which can improve upon their uptake.

In terms of licensing regulation, the solution is to consolidate the terms of the licence assessment with issuance in EC and reduce the complexities encountered in the process. The licensing permits and certification requirements could be reduced whilst the standards are still maintained. Planning laws and EIA process need reviewing to make RE projects a priority to any other consideration as these projects would serve the interest of the environment in the long run and mitigate climate change to protect the environment instead of them being stalled.

Realistic targets should be set which can be achieved within the time frame envisaged. This requires the government's commitment, resources and well-skilled human power that can deliver the policies as formulated. The success of most RE policies will need budgetary allocation from government to make the implementation process a success. Government should also avoid setting targets that are too easy to meet. In order to safeguard an RE infrastructure like a wind turbine or solar panel, the authority should ensure that no property is developed near it to reduce the speed of the wind or obscure the sun from reaching the panels.

3.14 Economic Community of West African States (ECOWAS) Renewable Energy Policy

The introduction to ECOWAS has already been provided under subsection 2.7.1 in chapter two as such the focus of this section is going to be on barriers to RE development in the subregion. Many of these countries are endowed with plenty of both RES and non-RES, such as hydro, solar, geothermal, wind, biomass, coal, natural gas, and crude oil. However, only 52.3% of the population had access to electricity in 2017.[493] Those who have access pay among the highest prices in the world.[494] These countries have not been able to harness these abundant energy resources to the benefit of their citizens. There is a big gap between energy demand and supply due to a deficit in generation.[495] Over the years, almost all Member States have suffered from power outages which have impeded their socio-economic development. This situation has still not improved because of lack of infrastructure, lack of sufficient legal

[493] ECREEE, 'Regional Progress Report on Renewable Energy, Energy Efficiency and Energy Access in ECOWAS Region, Monitoring Year: 2017' (ECREEE, July 2019) <http://www.ecreee.org/sites/default/files/regional_progress_report_2017.pdf> accessed 12 January 2020

[494] The World Bank, 'Electricity Trade to Unlock Affordable and Reliable Electricity in West Africa'(WB, 28 July 2020) <https://www.worldbank.org/en/news/press-release/2020/07/28/electricity-trade-to-unlock-affordable-and-reliable-electricity-in-west-africa#:~:text=Currently%2C%20only%2050%20percent%20of,of%20consumers%20in%20East%20Africa.> accessed 20 May 2021

[495] Ifeoluwa Wole-Osho and others, 'Comparison of Renewable Energy Potential in Relation to Renewable Energy Policy in ECOWAS Countries' (2016) HONET-ICT <https://doi.org/10.1109/HONET.2016.7753441> accessed 16 May 2021

and policy frameworks, lack of skilled workforce, insufficient funding, and lack of investment in energy systems that will meet the increase in demand for energy.[496]

3.14.1 Barriers to Renewable Energy Deployment in the ECOWAS Subregion

As seen in subsection 2.7.1 in chapter two, most of the targets set were going to be missed in 2020 according to the 2017 monitoring report. The subsections below explore the challenges that militate against the exploitation of RE in the subregion. The challenges fall into the following categories: economic, political and security, technical and non-technical, and institutional and regulatory. These challenges impede the development of RE in the region. The discussion on the challenges are as follows:

3.14.2 Economic Challenges

Many of the utility companies involved in the transmission and distribution of electricity under West African Power Pool (WAPP) do not have access to adequate funding to run the capital intensity of their operations. The lack of finance affects the quality of the service they render to their numerous customers, including the inability to meet the growing demand for electricity.[497] The tariff regimes are poor; revenue collection is ineffective and illegal power connection is rampant. These factors deny the utilities the revenue needed to invest in improving their services, including upgrading their transmission and distribution networks. However, in recent years funding has begun trickling in; for example, the World Bank in 2017 provided an International Development Assistance grant of US$22.66 million to Liberia for the WAPP. Further, the ECOWAS sub-region lacks a single currency which continues to be a stumbling block in efforts to do business among the Member States. Many countries have different currencies, which make trading among each other difficult. However, ECOWAS is working towards the use of a single currency to be called ECO, which will be used to transact business across the region when it is finally launched.[498]

3.14.3 Political and Security Challenges

Political and security challenges pose a threat to the region's cooperation and integration, and this could prevent the fulfilment of many of the objectives of ECOWAS. In an environment where there is no peace, this can invariably affect the power sector. As such, it is difficult for commercial activities to take place in an atmosphere of insecurity, war, and upheavals.[499] The insecure environment created by extremist groups such as Boko Haram in Nigeria and Mujao in Mali, does not augur well for the harmonisation and commercialisation of the energy resources of the region. The region's geopolitics is a source of focus and concern for energy distribution as some of these issues can sometimes flare up and mar the integration agenda.

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[496] Edgard Gnansounou and others, 'Strategies for Regional Integration of Electricity Supply in West Africa' (2007) 35 Energy Policy 4142 < https://doi.org/10.1016/j.enpol.2007.02.023> accessed 19 April 2021

[497] E. Agbodo and others, 'Transforming the West African Regional Electricity Market - Lessons and Experiences' (2017) <https://doi.org/10.1109/PowerAfrica.2017.7991223> accessed 10 January 2021

[498] ECOWAS, 'West African regional bloc adopts new plan to launch Eco single currency in 2027' (Franc24, 19 June 2021) < https://www.france24.com/en/africa/20210619-west-african-regional-bloc-adopts-new-plan-to-launch-eco-single-currency-in-2027> accessed 21 June 2022

[499] Nkiruka Avila and others, 'The Energy Challenge in Sub-Saharan Africa: Generating Energy for Sustainable and Equitable Development' [2017] Oxfam Research Backgrounder series 100 <https://www.oxfamamerica.org/static/media/files/oxfam-RAEL-energySSA-pt1.pdf>.accessed 10 May 2021

3.14.4 Technical and Non-technical Challenges

Technical challenges limit the ability to provide reliable electricity supply, which results in transmission and distribution losses. Technical losses entail the dissipation of power in the transmission and distribution networks, transformers, and measurement systems and non-technical losses are caused by actions that are unrelated to the power system, such as electricity theft, non-payment of bills by customers, accounting, and record-keeping errors.[500] Most of the transmission and distribution networks in the region are obsolete and have not been upgraded due to a lack of funding. Hence this has led to transmission and distribution losses of 39.5% for technical losses and 12.9% for non-technical losses in 2017.[501] Many of the utilities are grappling with operational inefficiencies and a lack of trained and qualified technical personnel. Also, the inequality between the countries' energy systems is huge; for example, about 96% of the electricity generated in the region comes from Ghana, Nigeria, Ivory Coast and Senegal.[502]

3.14.5 Institutional and Regulatory Challenges

In the ECOWAS sub-region, Member States have a weak legal and regulatory framework, a lack of rules for accessing the transmission grid, a weak institutional framework, limited interconnection for cross border electricity and poor implementation of regional NREAPs. Furthermore, the transition to the electricity market under the WAPP arrangement is not encouraging; no market governance structure is in place, lack of communication and data communication infrastructure and less reliable WAPP interconnected network.[503]

Despite the challenges, ECREEE is determined to carry through the ECOWAS RE agenda to surmount the challenges and bring about a coordinated RE deployment and development in the region. The monitoring is making an impact on this goal. ECOWAS has made a positive impact on Ghana's RE agenda; this stems from the fact that Ghana being a member of ECOWAS, has received technical support from ECREEE. The support received from ECREEE is towards the formulation of its RE policy to develop its RES.[504] Ghana benefits from WAPP by exporting surplus power to member states like Togo and Benin. which is a single electricity regional market created by ECOWAS to ensure regional power system integration.[505]

3.15 Conclusion

Humankind will continue to rely on natural resources, whether they are conventional sources or renewable sources to meet their energy needs. However, the consumption of fossil fuels can lead to the release of GHG emissions, thereby causing climate change. It is based on the important role that RE can play to stem climate change that its adoption at this time in world's history has become necessary. Ghana has an abundant endowment of RES. Exploiting these

[500] ECREEE (n 493).
[501] ibid
[502] Agbodo and others (n 497).
[503] Babatunde Adeyemo, 'South Asia Regional Workshop on Competitive Electricity Markets' West Africa Power Pool (2014) < https://usea.org/sites/default/files/event-/West%20African%20Power%20Pool.pdf> accessed 12 May 2021
[504] ECREEE Ghana, 'National Renewable Energy Action Plans (NREAPs)' (NREAPs of Ghana, November 2015) < https://www.se4all-africa.org/fileadmin/uploads/se4all/Documents/Country_PANER/Ghana_National_Renewable_Energy_Action_Plans.pdf > accessed 17 March 2021
[505] Agbodo and others (n 497).

resources will play a crucial role in the economic development of the country as well as protect the environment and provide ES. The most important of these resources are hydro, solar, biomass and wind. The country has already exploited hydro by building three large hydro dams, which have been the country's energy backbone in the past decades. Solar and wind hold much potential for the country. So, the government has embarked on enacting laws and policies to entice the private sector to play a critical role in the deployment of the two sources mentioned above. The main intervention has been the enactment of the Renewable Energy Act, 2011 (Act 832), the formulation of RE policies and setting the target to add a 10% share of non-hydro RE into the electricity generation mix in 2020.

In this chapter, there have been discussions on the various legal frameworks and policies on RETs to ascertain their effectiveness in the deployment and development of RE in Ghana. The adoption of these technologies will lead to sustainable energy generation and consumption. However, the analysis has revealed the relatively poor performance of these instruments against what was envisaged. Following the coming into force of the RE Act, it was envisaged that it was going to bring about rapid diffusion of non-hydro RE, but this did not materialise. An in-depth analysis has established many constraints which have militated against Ghana's RE agenda, which has led to its poor performance. For instance, the RE Act is ambiguous and disintegrated in its planning and implementation; this is according to Atuguba and Tuokuu because critical policies such as the establishment of the RE Fund and RE Authority that were to support most of the policies remain unimplemented.[506] The licensing regime is bureaucratic, it takes a long time to acquire a licence. The process involves many institutions, so many permits and authorisations, and the root cause of this problem can be traced to the lack of an RE Authority to supervise the RE subsector, as stated earlier.[507]

IPPs have no standardised pricing for the generation of RE electricity. The government's subsidies render many tariff regimes susceptible to unfair prices, and this sometimes compels IPPs to factor this into PPAs negotiations with representatives of government. As observed, the grid network is old and weak, and this causes a lot of transmission and distribution losses estimated to be over 34% in 2021. Furthermore, the legal and regulatory loopholes discovered demonstrate that the RE Act, which was enacted with the hope of incorporating a 10% share of non-hydro RE into the electricity generation mix, has not yielded the expected results. The target of adding a 10% share of non-hydro RE into the electricity generation mix in 2020 was not met. This target has become a mirage and has now been extended to 2030.[508] The penetration of non-hydro RE is less than 1% and has been attributed to many factors already discussed.[509] The empirical research that was conducted around these issues confirms the challenges the literature has captured. Participants in the research gave further insights into the constraints of the RE Act in their responses. In evaluating the RE Act and its supporting instruments, the overwhelming conclusion was that the RE policies had been poorly implemented and made them less effective, leading to little penetration of non-hydro RE in the electricity generation mix. It also came to light that the authorities in Ghana have started reviewing some of the policies, e.g., FIT has been reviewed and now repealed. The effectiveness criteria was used to assess the effectiveness of the Renewable Energy Act, 2011 (Act 832) and supporting policies and the conclusion is that they failed the indicators, contextual factors and therefore are less effective in addressing ES challenges in Ghana.

[506] Atuguba and Tuokuu (n 294).
[507] Kekel Bina-Agboda, 'Renewable Energy Authority in the Offing' Graphic Online (Accra,6 June 2017) < https://www.graphic.com.gh/news/general-news/renewable-energy-authority-in-the-offing.html> accessed 10 January 2020
[508] ibid
[509] Ministry of Energy Ghana, 'Sector Overview' (MOEn, Ghana) < https://www.energymin.gov.gh/sector-overview > accessed 10 January 2020

Issues such as the lack of policy direction for the RE subsector have contributed to RE's slow development in Ghana. Some policies are not clear, and, in some cases, there is an overlap of regulatory duties. The lack of a robust transmission and distribution infrastructure, which causes a lot of losses has contributed to the little penetration of non-hydro RE in the country's electricity generation mix. Furthermore, a brief discussion on ECOWAS RE policy has been made as it has played a role in the adoption of RE in the West African sub-region, which includes Ghana. Ghana is a member of ECOWAS and is obliged to implement EREP in its national RE agenda.

Nevertheless, the RE Act of Ghana has sparked a renewed interest in RE investment among IPPs, which is positive. As many of the provisions of the RE Act are gradually being implemented, the hope is that non-hydro RE deployment will increase substantially in the future, with some adjustments to some of the policies and legal frameworks that are currently in operation.

The following discussion is on chapter four which provides a comparative analysis of the renewable energy polices of Australia, Ghana, and Cape Verde.

CHAPTER FOUR

COMPARATVE ANALYSIS OF RENEWABLE ENERGY POLICIES OF AUSTRALIA, GHANA, AND CAPE VERDE

4.1 Introduction

Chapter four provides a comparative analysis of the RE laws and policies of Australia, Ghana, and Cape Verde. Comparison can be used as a method to explain scientifically and explore how political processes work.[510] Hill argues that it is important to compare policies for the development of policy theory since comparative analysis has the capability of looking at more than one situation which is separated by policy issues, time, and space rather than a particular case at the same time even in the same place.[511] A comparative study affords the researcher the opportunity to observe the extent to which learning can be done between different countries over a period of time. As such, comparing the RE policies between different countries would go a long way to contribute to the global RE policy study and help in the development of RE to fulfil the worldwide agenda of curbing carbon emissions to stem climate change.

In choosing the countries for the comparative analysis, the human development index (HDI) ranking is one of the factors considered, alongside the others which are all mentioned in this section. According to the UNDP human development report 2019, Australia is ranked 8th with an HDI value of 0.944, Ghana is ranked 138th with an HDI value of 0.611, and Cape Verde is ranked 126 with an HDI value of 0.665.[512] Sometimes the HDI is also used to distinguish whether a country is developed or a developing one.[513] The choice also demonstrates a typical example of comparing the RE policy of a developed country with those of developing countries. In addition, the countries have demonstrated interest in integrating RE into their energy mixes. However, fossil fuels dominate due to more funding for these sources to the neglect of RE. Further, the three countries have an abundant endowment of RES especially solar. Ghana and Cape Verde are all in West Africa with almost the same endowment in RES, especially solar and wind energy. Finally, since the countries started to introduce RE into their generation mixes, Australia has made steady progress by adding 418.8 PJ of RE to its energy mix by the end of 2020 as seen in table 6.

In contrast, Ghana only added a 0.55% share of non-hydro RE to its electricity generation mix in 2021 and Cape Verde has made strides by adding a share of 20% of RE which comes mostly from wind and solar to its energy mix in 2020. The comparison will attempt to unearth the causes of the disparity for lessons to be learnt. Australia, Ghana, and Cape Verde have set RE targets to increase the scale of RE adoption and have promulgated laws, policies, and regulations to that effect. They have also pursued and implemented different programmes and strategies and provided incentives and funding to enable them to meet the targets they have set. A top-down approach is used to implement RE programmes and policies in Ghana as the MOEn coordinates all matters relating to energy in the country, which applies to Cape Verde. In the case of Australia, because of the lack of one central ministry, decision-making on RE policies is taken at the federal, state, and local levels. The comparison will enable the

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[510] G. A. Almond and others, *Comparative Politics Today: A World View* (8th edn, Pearson, Longman, New York 2004) 31

[511] Michael Hill, *The Public Policy Process* (4th edn, Pearson, Longman 2005) 91-92

[512] UNDP, 'Human Development Insights' (UNDP) <http://hdr.undp.org/en/content/latest-human-development-index-ranking> accessed 25 June 2021

[513] Marion W Jenkins and Steven Sugden, 'Human Development Report 2006 Human Development Report Office Rethinking Sanitation: Lessons and Innovation for Sustainability and Success in the New Millennium' [2006] Tropical Medicine < <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.422.5099&rep=rep1&type=pdf> accessed 10 April 2021

recommendation of successful policies implemented in the compared countries for Ghana's adoption to improve its RE policy.

The chapter is divided into six main sections with subsections. Section 4.2 follows the introduction, and it discusses the energy statistics of Australia, Ghana, and Cape Verde. Section 4.3 discusses the institutional set-up that promotes renewable energy development in Australia, Ghana, and Cape Verde. Section 4.4 provides a comparison of the renewable energy strategies of Australia, Ghana, and Cape Verde. Section 4.5 discusses the current state of renewable energy development in Australia, Ghana, and Cape Verde. Section 4.6 draws the conclusion of the chapter by summarising the major issues that have been discussed.

4.2 Energy Statistics of Australia, Ghana, and Cape Verde

Australia is endowed with abundant fossil fuel resources. That gives it the advantage of generating relatively cheap electricity, but dependence on fossil fuels has made Australia one of the big emitters of GHG emissions globally. With this background, the government has pledged to reduce its emissions according to international commitment. Furthermore, Australia is also endowed with abundant RES and is one of the countries in the world with high solar potential. Therefore, it has the potential to tap these resources to curb GHG emissions and mitigate climate change. The energy mix of Australia is found in table 6 below.[514]

Table: 6 Australian Energy Consumption by Fuel Type 2019 to 2020

Fuel type	PJ	Share in percentage
Oil	**2,241.2**	**37.3**
Coal	**1,706.6**	**28.4**
Gas	**1,647.2**	**27.4**
Renewable	**418.8**	**7.0**
Total	**6,013.8**	**100.0**

Source: Source: Department of Industry, Science, Energy and Resources (2021), Australian Energy Statistics

In the case of Ghana, the country's energy mix is dominated by fossil fuels. The big hydro dams hitherto dominated the electricity generation mix and were the source of clean energy but have fallen behind thermal due to the GoG's increased use of natural gas to generate electricity. So, relying on thermal is a source of pollution to the environment. The government has pledged to look for alternatives (RE) to add to the energy mix to provide ES and stem climate change. The energy mix of Ghana is provided in table 7 below:[515]

[514] Australian Government, 'Australian Energy Consumption Update' (Australian Government) <https://www.energy.gov.au/data/energy-consumption> accessed 09 June 2022

[515] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022.

Table: 7 Ghana Final Energy Consumption by Fuels (ktoe) - 2021

Fuel type	Ktoe	Share in Percentage
Electricity	**1,553**	**17**
Petroleum	**4,630**	**50**
Biomass	**3,162**	**34**
Total	**9,345**	**100**

Source: Ghana Energy Commission (2022)

Fortunately, Ghana is endowed with RES such as solar, biomass, wind, and mini hydro. Therefore, it gives Ghana the opportunity to integrate RE into its energy mix to shore up its ES and mitigate climate change. With Cape Verde, in 2020 the overall electricity capacity and generation was 176 MW, dominated by non-RES with a share of 80%, and RE's share as 20%.[516]

RE has become an important alternative for both developing and developed countries because of its benefits (locally available and provides ES, emits less GHG emissions and mitigates climate change). Comparing the RE policies of countries is an important endeavour so that they can learn from each other and share their experiences so that collectively GHG emissions can be reduced to protect the environment. The countries have similar and dissimilar approaches to RE development which will be discussed.

4.3 Institutional Set-up that Promotes Renewable Energy Development in Australia, Ghana, and Cape Verde

There are many similarities in the legal, regulatory and policies between Australia. Ghana and Cape Verde. In order to meet the increasing demand for energy and at the same time reduce carbon emissions to stem climate change, the countries have enacted national RE laws, regulations, and policies and set RE targets to promote the development of RE. However, the countries have different political systems. Further discussions are going to be made on the systems and their impact on RE development.

4.3.1 Institutional Set-up Instruments Deployed for the Development of Renewable Energy in Australia

The Australian Government in the year 2000 set up the Mandatory Renewable Energy Target (MRET), which was to encourage investment in RE using tradable renewable energy certificates (RECs, 1 REC= 1 MWh of electricity) to add 9500 GWh to the energy mix by 2010, This target was met in 2007 before the due year of 2010. In 2009, it brought in the Renewable Energy Target, expanded from the MRET. This target was to ensure that RE will contribute 20% of the total electricity generated in the energy mix in 2020 whilst at the same time meeting the target of 41,000 GWh. It was later reviewed in 2015 to 33,000 GWh and this target was met in 2019.[517] RET was divided into two, thus the Large-scale Renewable Energy Target

[516] International Renewable Energy Agency, 'Energy Profile -Cape Verde' (IRENA, 24 August 2022) <https://www.irena.org/IRENADocuments/Statistical_Profiles/Africa/Cabo%20Verde_Africa_RE_SP.pdf > accessed 20 January 2023

[517] Clean Energy Council, 'Renewable Energy Target' (Clean Energy Council) <https://www.cleanenergycouncil.org.au/advocacy-initiatives/renewable-energy-target> accessed 10 June 2021

(LRET) and Small-scale Renewable Energy Scheme (SRES). This change provided separate incentive package for the two to reduce competition in the RET scheme.[518] Other policies include Feed-in tariffs (FIT), R&D programmes and emerging renewables programmes. Prominent among these policies are the national RET and FIT.

No federal FIT, but the states make use of it; they vary from one state to the other and territories across Australia.[519] In collaboration with SRES, most states and territories in Australia have implemented various FITs to promote the generation of renewable electricity, especially with rooftop solar PV systems. The FIT policy has been found to have increased PV installation.[520] About 20% of households in Australia have solar rooftop systems installed in their homes, and about 2.5 million solar PV systems have been installed. The customers who have these solar PV systems benefit from state FITs. Some of the main institutional set-up, legal and policy frameworks on RE development are presented in table 8.

4.3.2 Institutional Set-up Legal and policy Frameworks for the Development of Renewable Energy in Ghana

The GoG plays a crucial role in the development of RE. In order to increase the share of non-hydro RE in the electricity generation mix, the GoG set a target of 10% share of non-hydro RE to be added to the electricity generation mix in 2020 which was missed and now extended to 2030. The reason for this is that the country has been grappling with a power crisis for the past decade as a result of a lack of generation capacity to meet the ever-increasing demand for energy in the country.

In chapter two institutional set-up in Ghana was discussed under subsection 2.3 and will not be repeated. These institutions are assigned various responsibilities to deliver GoG's programmes and strategies in the energy sector and the RE subsector. Some of the main institutional set-up, legal and policy frameworks on RE development in Ghana are presented in table 8.

4.3.3 Institutional Set-up Legal and Policy Frameworks for the Development of Renewable Energy in Cape Verde

Cape Verde is an archipelago made of ten Islands, nine of them inhabited and lies 650 km west of Senegal. In Cape Verde, the government plays a crucial role in the development of RE. The country relies primarily on imported fossil fuels for its electricity generation, and this is a burden on the economy coupled with high electricity prices, and this is a constraint on its green growth agenda.[521] In order to increase the share of RE in the energy mix, the government in 2008 through its National Energy Policy set a target of obtaining 50% of its electricity from RES in 2020. The Government has also set a conditional goal of 100% of the energy mix to be RE, and this is to be achieved by 2025 if it gets the necessary credit to invest in RE.[522] The government has enacted a law thus DL 1/2011 which allows interconnectivity to the national grid. Fossil fuels dominate Cape Verde's electricity generation mix. Diesel generators are used to generate electricity. Cape Verde's energy portfolio comprises four main sources: petroleum products, wind and solar, butane gas and firewood. Some of the main

[518] ibid
[519] Liam Byrnes and others, 'Australian Renewable Energy Policy: Barriers and Challenges' [2013] Renewable Energy < ttp://dx.doi.org/10.1016/j.renene.2013.06.024> accessed 10 February 2021
[520] Hong Xian Li and others, 'A Review on Renewable Energy Transition in Australia: An Updated Depiction' (2020) 242 Journal of Cleaner Production 118475 <https://doi.org/10.1016/j.jclepro.2019.118475>.accessed 10 December 2020
[521] Erik Nordman and others, 'Options for Achieving Cape Verde's 100% Renewable Electricity Goal: A Review' (2019) 14 Island Studies Journal 41 <https://doi.org/10.24043/isj.73> accessed 15 May 2021
[522] ibid

institutional set-up, legal and policy frameworks on RE development in Cape Verde are presented in table 8.

4.4 Comparison of the Renewable Energy Strategies of Australia, Ghana, and Cape Verde

All the three countries, namely Australia, Ghana, and Cape Verde, have made great strides in the promotion of RE through different policy approaches under their institutional arrangements. Nevertheless, with the three countries one can see several similarities and differences in their RE policies.

The three countries have made provisions for funding to promote RE. For example, in the case of Australia, Clean Energy Finance Corporation has been established, and it provides financial support for RE development. However, it must be stated that the funding has not been consistent due to differences in policies by successive governments.

Compared with Australia, Ghana has not got a specific source of funding for the integration of RE to incentivise all the stakeholders involved in the RE subsector due to its weak financial position. Ghana, however, recognises the importance of funding for the deployment of RE and has legislated for the establishment of the RE Fund. This Fund is envisaged to draw funding from different sources. However, Government itself has no budgetary allocation for it.[523] In the Ghanaian context, the GoG relies on the private sector's participation in the RE subsector. According to the REMP, funding of US$ 5.6 billion is needed to execute the RE development programme, and 80% of this amount is envisaged to come from the private sector. [524] Unlike Australia, which has financial incentives from several sources, in the case of Ghana, the GoG is relying on the private sector investment.

The GoG, however, instead provides economic incentives like tax reliefs and FIT to attract private sector investors but FIT was repealed in 2020. Australia does not have a policy on FIT at the federal level, and the state-based FITs are applied to small-scale RE systems, mostly for solar PV. Therefore, large-scale RE applications are not covered. In 2016 the GoG introduced the National Rooftop Solar PV Programme Policy to provide intervention of 200 MW peak load relief on the national grid using solar PV in the medium term. In addition, the GoG provided a capital subsidy of GH₵1,900.00, which is equivalent to US$338.00 to each of the participants in the programme.[525] Australia is one of the leaders globally in rooftop solar PV systems, and about three million of such installations are deployed.[526] In addition, the

[523] UNDP, 'China-Ghana South-South Cooperation on Renewable Energy Technology Transfer' (UNDP, May 2014) <https://info.undp.org/docs/pdc/Documents/CHN/ProDoc%20-%2091276.pdf> accessed 18 December 2019

[524] Energy Commission of Ghana, 'Ghana Renewable Energy Master Plan' [EC, February 2019] <https://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf> accessed 10 May 2022

[525] Frederick K. Appiah, 'The National Rooftop Solar Programme' (EC of Ghana, 25 April 201) <https://www.transparency-partnership.net/sites/default/files/u2612/1-the_national_rooftop_solar_programme_ghana_appiah_25.04.17.pdf> accessed 12 January 2021

[526] The Hon Angus Taylor MP, 'Australia leads world in rooftop solar as share of renewables jumps to 35%' (Minister of Industry Australia, March 2022) < https://www.minister.industry.gov.au/ministers/taylor/media-releases/australia-leads-world-rooftop-solar-share-renewables-jumps-35#:~:text=This%20brings%20the%20total%20to,MacIntyre%20Wind%20Farm%20in%20Queensland.> accessed 20 June 2022

states use FIT to promote solar RE, and more households are encouraged to subscribe to the policy to save their energy bills and protect the environment.

Unlike Ghana, Cape Verde contracts loans to finance its RE development programme, e.g., the solar PV projects at Santiago and Sal, with generation capacities of 5 MW and 2.5 MW, respectively, were funded through a concessional credit facility from Portugal. In addition, a credit facility from Portugal funded a public building solar PV initiative. Cape Verde also uses Public-Private Partnerships (PPP) to develop its RE. This arrangement with the private sector allows collaboration to deploy wind energy, e.g., the government and Cabeolica (energy company) deployed wind power projects at Santiago, Boa Vista, Sal, and Sao Vicent with an installed capacity of 25.5 MW. Furthermore, tax exemption allows the importation of RE equipment such as solar PV panels and turbines into the country without paying tax to increase private sector participation in the RE subsector.

Australia does not have a federal government body equivalent to the MOEn. As such, energy policies are subject to regulation and fiscal influence by three levels of government, namely, federal, state, and local.[527] Ghana, on the other hand, has a ministry responsible for energy matters called the MOEn. It is the body that coordinates all energy matters in the country and collaborates with the country's energy development partners. Finally, Cape Verde has a ministry responsible for the coordination of energy-related issues, which makes all the important decisions in the energy sector, known as the Ministry of Tourism, Industry and Energy.

There are also differences between the countries, thus the approach employed in the implementation of their main target policies. Australia uses RECs to implement RET, which puts a legal obligation on electricity retailers and other large wholesale buyers to procure a percentage of their electricity from recognised RES and this helps competitiveness. Compared to Australia, Ghana uses tax exemption for the importation of RE equipment and REPO (yet to be implemented) requires bulk distributing companies to source a percentage of their electricity from RES or pay a premium price determined by PURC. The percentage has not yet been assigned, but the setting was referred to PURC to do in consultation with EC. The problem with this arrangement is that off-takers may take advantage of not buying RE electricity and opt to pay the premium. This arrangement is a potential barrier to the development of RE in Ghana. Cape Verde also uses tax exemption, thus no import duties for RE equipment. In addition, Cape Verde designates areas as RE development zones which eases the land acquisition process for potential RE investors to undertake RE projects quickly. Furthermore, DL 1/2011 guarantees a Power Purchase Agreement for RE power generators for fifteen years.

Hua, Oliphant, and Hu argue that there is a lack of coordination at the federal and state levels in Australia; because sometimes schemes pursued by the states are not coordinated with federal schemes, as a result, it has become a barrier to the development of RE.[528] However, in the case of Ghana, all energy policies and strategies are coordinated by the MOEn with technical assistance from EC. In Ghana, the regions and districts implement what has been decided by the MOEn with technical support from EC officials. In Cape Verde, the Ministry of Tourism, Industry and Energy coordinates all RE policies and strategies, just like in Ghana. However, the drivers of RE policies in the three countries are different; Ghana and Cape Verde have formulated RE policies to promote the integration of non-hydro RE for ES, economics,

[527] Rena Kuwahata and Carlos Rodríguez Monroy, 'Market Stimulation of Renewable-Based Power Generation in Australia' (2011) 15 Renewable and Sustainable Energy Reviews 534 < https://doi.org/10.1016/j.rser.2010.08.020> accessed 20 January 2020

[528] Yaping Hua, Monica Oliphant and Eric Jing Hu, 'Development of Renewable Energy in Australia and China: A Comparison of Policies and Status' (2016) 85 Renewable Energy 1044 <http://dx.doi.org/10.1016/j.renene.2015.07.060>.accessed 20 January 2020

and climate change mitigation. On the other hand, Australia uses RE to stem climate change as its consumption of fossil fuels produces a lot of carbon emissions that pollute the environment. Table 8 below provides a summary of the comparison of key institutions, legislation and policies on RE in Australia, Ghana, and Cape Verde.

TABLE: 8 Summary of the Comparison of some Key Institutions, legislation and Policies on Renewable Energy in Australia, Ghana, and Cape Verde

Legislation/Policy/ Goal/Target/Institution	**Australia**	**Driver of Policy/Role**	**Ghana**	**Driver of Policy/Role**	**Cape Verde**	**Driver of Policy/Role**
Renewable energy target 20% to be met in 2020	Renewable Energy Target (i) Large-scale Renewable Energy Target (LRET) (ii) Small-scale Renewable Energy Scheme (SRES)	Environmental concerns	Non-hydro renewable energy target 10% to be met in 2020	Energy security and climate change mitigation.	Renewable energy goals: - 35% to be achieved by 2016-2018 - 50% to be achieved by 2018-2020 - 100% to be achieved by 2020-2025	Energy security, economics, and climate change mitigation.
Government Institutions	(i) Federal government, State government, Local government (ii) Australian Renewable Energy Agency	-Responsible for energy matters. -To improve the competitiveness of renewable energy technologies and increase supply of funds for renewable energy projects. -Oversees to carbon emissions reduction and increase the use of clean energy.	(i) Ministry of Energy (ii) Energy Commission (iii) Public Utilities Regulatory Commission (iv) Volta River Authority (v) Ghana Grid Company (vi) Electricity Company of Ghana (vii) Northern Electricity Distribution Company	-Responsible for policy formulation. -Technical regulation -Market regulation -Power generation -Power transmission -Electricity distribution -Electricity distribution	(i) Ministry of Tourism, Industry and Energy (ii) ELECTRA (iii) Economic Regulatory Agency	Responsible for the development of government policies related to tourism, industry, and energy. -Responsible for generation, transmission, and distribution of electricity. -Responsible for the regulation of energy, water, and transport sectors.

	(iii) Clean Energy Regulator (iv) Clean Energy Finance Corporation	-Responsible for investment in renewable energy, energy efficiency and low emissions technologies. -it provides financial support for RE development.	(viii) Enclave Power Company Ltd	-Electricity distribution	(iv) ECOWAS Centre for Renewable Energy and Energy Efficiency (v) Renewable Energy Research Group (vi) General Directorate of Energy	-Provides guidance on renewable energy policies of ECOWAS. -Research into sustainable energy development. -Formulates new policies and legislation and implementation of energy saving initiatives.
Legislation /Policies	(i) Renewable Energy (electricity) Act 2000 (ii) Renewable Energy (electricity) (Large-Scale Generation Shortfall Charge) Act 2000 (iii) Renewable Energy (Electricity) Regulation 2001 (iv) Renewable Energy (electricity) (Small-scale Technology Shortfall Charge) Act 2010 (vi) Renewable Energy Target	Environmental concerns -Ensures 20% of Australia's electricity is	(i) Strategic National Energy Plan (2006 to 2020) (ii) National Energy Plan (2010) (iii) Renewable Energy Act, 2011 (Act 832) (iv) National Rooftop Solar PV Programme (2015) (v) Renewable Energy Purchase Obligation	Energy security and climate change mitigation. -To provide peak relief of 200 MW on the grid. -Obligates utilities to buy a percentage of their power from renewable energy sources.	(i) Sectoral Renewable Energy plan (ii) ECOWAS Renewable Energy Policy/Treaty (iii) Renewable Energy Master Plan (iv) National Energy Plan 2003-2012 (v) National Energy Policy of 2008 (vi) DL No.26/2003 (created ARE) (vii) DL No.14/2006 and DL No.54/99 (encourages the use of	Economic, Energy security and climate change mitigation. .

	(vii) Feed-in tariff	generated from renewable energy sources in 2020. -Guarantees payments of renewable energy electricity supplied to the grid.	(vi) Tax exemption (vii) Net metering	-For renewable energy development. -Provides credits for prosumers who supply electricity to the grid.	renewable resources) (viii) DL No.4/vii/2007 (granting of duty-free on imported renewable energy equipment) (ix) DL No.1/2011 (promotion of renewable energy use) (x) Energy Security Fund	
Non-governmental organisation	(i) Australian PV Institute (ii) Clean Energy Council	- Devoted for the development of the PV industry. -Promotes clean energy industry.	Energy Foundation	Promotes energy efficiency and renewable energy.	The European Union	Provides technical support for the energy sector under SE4ALL initiative.

Source: Adapted from Hua, Oliphant, and HU (2015) plus author's own elaboration

Ghana has policies implemented in Australia and Cape Verde, as shown in the table above, despite slight differences. Ghana, Australia, and Cape Verde have RE targets set, and the difference is the percentages. In the case of Ghana, it is 10% and it was to be achieved in 2020, whilst Australia's target is 20% and it was to be achieved in 2020, and Cape Verde's target is 50% which was to be achieved in 2020. Further, the target is divided into LRET and SRES in the case of Australia. Australia uses FIT, but it is implemented at the state and local levels, not at the federal level. It is used to promote rooftop solar PV installations at the state and local levels. Ghana used FIT initially but repealed it in 2020. Finally, the three countries have enacted Acts for RE development, Australia and Cape Verde have many Acts whilst Ghana has only one Act.

4.5 Current State of Renewable Energy Development in Australia, Ghana, and Cape Verde

After implementing the policies by the three countries, tables 6 and 7 in section 4.2 above depict the status of the energy mixes of Australia and Ghana respectively. A brief highlight is given from the data provided by Australia Energy Statistics (AES), EC of Ghana and Cape Verde's latest installed capacity statistics. According to AES, in terms of energy consumption during the period between 2019 to 2020, the total energy consumption in Australia rose to reach 6,013.8 petajoules, and RE accounted for 7% in the period, driven by solar and wind.[529] In 2020 total electricity generation rose to 955 petajoules, and renewables contributed 24%.[530]

In the case of Ghana, recent statistics according to EC of Ghana, show that in 2021, the country's total final energy consumption by fuel was 9,345 ktoe an increase over the 2020 figure.[531] As a result, total electricity generation increased to 22,051 GWh in 2021, and the share of hydro in the total electricity generation mix decreased to 34.1%. However, thermal increased to 65.3% in 2021 due to the government's continuous increase in using natural gas to fire thermal plants to generate electricity and slowed down RE investments. The total electricity generated from non-hydro RES in the country by the end of 2021 was 0.55%.[532] With Cape Verde, the electricity installed capacity is 176 MW with thermal still dominating whilst wind improved to 28% and solar 8% at the end of 2020, but more wind and solar initiatives are being explored to increase capacity.

4.6 Conclusion

The development of RE to meet the citizens' energy needs and mitigate climate change has become an important issue in the development agendas of both developed and developing countries. Australia, Ghana, and Cape Verde have set RE targets to increase the scale of RE adoption and have promulgated laws, policies, and regulations to that effect. They have also pursued and implemented different programmes and strategies and provided incentives and funding to enable them to meet the targets they have set.

A top-down approach is used to implement RE programmes and policies in Ghana as the MOEn coordinates all matters relating to energy in the country, which applies to Cape Verde. In the case of Australia, because of the lack of one central ministry, decision-making on RE policies is taken at the federal, state, and local levels. Due to a shortfall in electricity generation, Ghana is determined to use RE to shore up its ES and combat climate change. Cape Verde relies heavily on imported oil and wants to harness locally available RES to improve on its economics, reduce its carbon emissions, and shore up its ES. However, that is not the case with Australia, because it relies heavily on its fossil fuels endowment. Ghana and Cape Verde have similar drivers for adopting RE, thus energy security, economics, and climate change mitigation. Australia also has a similar driver, which is the reduction of GHG emissions to mitigate climate change. Ghana's RE development is similar to Australia and Cape Verde. All the three countries have shown little non-hydro RE penetration in their energy mixes though Australia and Cape Verde have chalked higher penetration percentages than Ghana. Australia, however, provides a lot of funding and incentives for different RE programmes. Cape Verde uses credit and PPP for its RE development. Whilst the GoG does

[529] Australian Government, Australian Energy Consumption Update (n 514).
[530] Australian Government, 'Electricity generation' (Australian Government) <https://www.energy.gov.au/data/electricity-generation> accessed 14 June 2022
[531] Energy Commission of Ghana (n 515).
[532] ibid

not have any budgetary allocation to fund its RE development but relies on the private sector to champion this through investment with some government incentives as the attraction.

The Australian RE certificate mechanism for RE integration is well implemented but Ghana's REPO is yet to be implemented. All the countries' electricity grid networks are very poor, and in the case of Ghana and Cape Verde, it leads to a lot of transmission and distribution losses. Hence the grid network needs upgrading and improvement in these countries. The learning curve in this comparison for Ghana is to emulate the Australian government's injection of funds for the development of RE which has seen a steady increase in RE electricity generation, which has risen to 24% in 2020. Ghana can also adopt Cape Verde's approach of using loans and PPP, which has given it 28% and 8% of wind and solar penetration respectively.

As noted above, Ghana should begin to provide funding for RE development just like Australia is doing as well as soliciting for credit facilities like Cape Verde. Cape Verde has a policy of identifying areas called RE development zones that have gone through the necessary certification and approval and are ready for use when needed for RE projects. So, Ghana can emulate this policy by acquiring suitable lands for the different RES and going through the necessary documentation and other processes and designate such locations for RE development in the future. However, as seen in chapter one under transition theory subsection 1.6.3 Ghana should avoid failing policy transfer especially, 'inappropriate transfer' this happens when the transferred policy is incompatible with the political, social, economic, and cultural contexts that exist between the source country and the destination country. Any policy to be adopted should be done to suit Ghana's peculiar situation. Land acquisition has always been a challenge for RE generators in the country, as such emulating this policy could boost investors' confidence.

The Australian RE certificate mechanism, which is well implemented, is worth studying and exploring for adoption by Ghana as it has led to an increase in the development of RE. In addition, the Australian solar rooftop initiative has been successfully implemented. Though Ghana has a similar policy, its implementation has not been widely deployed compared to Australia, so Ghana can emulate the successful implementation of the Australian programme to further rollout a more considerable rooftop solar PV initiative. Finally, in reference to the transition theory discussed in chapter one, the comparison has shown how the transition process has progressed so far after the three countries launched their RE programmes. The regime represented by fossil fuels still dominates, and the niche represented by new RETs is improving gradually but not radical enough to overtake the regime now, However, the landscape, which includes ES and climate change concerns, puts pressure on the three countries to transition from fossil fuels to renewables.

The next discussion is on chapter five which will consider the legal and policy frameworks supporting RETs to make them environmentally friendly in Ghana.

CHAPTER FIVE

LEGAL AND POLICY FRAMEWORKS SUPPORTING RENEWABLE ENERGY TECHNOLOGIES TO MAKE THEM ENVIRONMENTALLY FRIENDLY IN GHANA

5.1 Introduction

Chapter five examines the legal frameworks and policies that provide support for the development of RETs so that humankind can gain from the environmental benefits they bring along and the drive towards sustainability in energy generation and consumption. Environmental concerns have links with sustainable development (SD), and activities that continue to degrade the environment are not sustainable.[533] To achieve SD will require the supply and consumption of energy from RES, which have minimal carbon emissions and no negative impact on the environment.[534]

Recent interest in renewables is encouraging; over so many years, there has been sluggish progress toward sustainable energy supply, but now it has gathered momentum and is catching up steadily. This new interest may look good but transitioning from conventional energy sources to renewables has encountered much public opposition. The most frequently raised reservations are about the changes to the landscape, land use and the value of properties in the close vicinity of some RE infrastructure, e.g., wind turbines. On the other hand, renewables have long been seen as the panacea to environmental degradation due to their advantages; they are locally available, emit low or zero GHG emissions and are sustainable. Knowing these advantages, why has it taken long for their development? One of the challenges is social barriers impeding their deployment; thus, people create the challenges and not the technologies themselves. This resistance has been well documented, and societal opposition to new technologies is not entirely new, as seen in places like Scotland. This is intriguing as RE has been identified as a replacement of conventional energy sources, but why are they opposed? Other noticeable barriers that have been mounted against RE are politics and economics.

There has been links between energy consumption and the quality of the environment. For example, it is seen that deforestation is a result of biomass consumption for firewood which is a primary source of energy in most developing countries. Moreover, the consumption of fossil fuels has caused air pollution, water pollution, and global warming in developed countries and other parts of the world. In the discussion on SD, the environmental aspect of the concept has most often centred on the effects of fossil fuel exploitation and consumption on the environment. Environmental law of the 1970s narrowly focused most at times on fundamental pollution issues such as the production and disposal of waste. Whilst, the consumption of fossil fuels, one of the major contributors to environmental damage, was discounted.[535] The Brundtland Commission's definition of SD has widened the scope of environmental development to include the sustainable consumption of energy resources. Opponents of RETs most often advance arguments that these technologies, too, have an adverse impact on the

[533] Ibrahim Dincer and Marc A Rosen, 'Thermodynamic Aspects of Renewables and Sustainable Development' (2005) 9 Renewable and Sustainable Energy Reviews 169 <https://doi.org/10.1016/j.rser.2004.02.002> accessed 14 April 2020

[534] Ibrahim Dincer and Marc A Rosen, 'Energy as a Driver for Achieving Sustainability' (2004) 1 International Journal of Green Energy 1 < https://doi.org/10.1081/GE-120027881> accessed 12 June 2020

[535] James Salzman, 'Sustainable Consumption and the Law' (1997) 27 Environmental Law 1243 <https://heinonline.org/HOL/P?h=hein.journals/envlnw27&i=1257> accessed 19 July 2020

environment, which needs to be considered. The cost of environmental externalities of fossil fuels will be critically reviewed in relation to their alternative counterparts, RETs.

The chapter will look at the environmental benefits accrued from RETs and make the case that these technologies can positively impact the environment with the support of the evolving legal frameworks. To fully understand the environmental advantages of RETs over conventional energy sources, a comparative analysis of the 'external costs' (environmental externalities) of both sources is made to establish this fact. This comparison is made using the Life Cycle Assessment (LCA) technique which will form part of the discussion in this chapter. The brief analysis will seek to establish the benefits of these technologies in the fight against climate change and highlight the perceived challenges posed by them. This measure will attempt to underscore the better appreciation of the fact that the environmental impact of conventional energy sources is by far greater than the minimal or negligible impact of RETs. Dincer asserts that to achieve SD in part would require this comparison of this sort; thus, the environmental impact of all human activities to get a clear picture.[536] The concept of SD will be established as a legal principle that forms part of the discourse on the sustainable consumption of energy for now and in the future. The legal instruments in place have the potential to drive the environmental protection agenda forward.

The chapter is divided into nine main sections with subsections, following the introduction is section 5.2, which discusses the transition from conventional energy generation to RETs and their impact on the environment. The following section is 5.3 and is centred on laws on concerns for the environment associated with the deployment of RETs. It is followed by RETs and the environment in context in section 5.4 Section 5.5 discusses the harmful effects of RETs on the environment. Section 5.6 discusses the ability of legal tools to promote RETs to make them competitive to sustain the Ghanaian economy. Section 5.7 considers Sustainable Development as a conceptual framework. Section 5.8 assesses Sustainable Development as a legal tool that supports RETs. Section 5.9 is the final section that draws the conclusion of the chapter by summarising the major issues that have been articulated.

5.2 Transition from Conventional Energy Generation to Renewable Energy Technologies and their Impact on the Environment

The continuous emission of anthropogenic GHG will cause further warming and long-lasting irreparable changes to our climate system. It will result in irreversible impact on our ecosystems and people.[537] To stem climate change, substantial and sustained CO_2 reduction is needed over the next decades to near-zero-emissions to limit the risks and devastation by the end of the century.[538] It is recognised that fossil fuels will continue to play a role in the global energy supply to meet the world's ever-increasing demand for energy, but this is not sustainable. The emissions emitted raise many concerns about their continuous use. It has also been recognised that RE will stem the impacts of GHG emissions on the environment, but its deployment is not growing fast enough to replace fossil fuels. In 2020 coal accounted for 35.2% of global power.[539] Whilst RE provided 23.2%; as such, renewables would have to

[536] Ibrahim Dincer, 'Environmental Issues: I-Energy Utilization' (2001) 23 Energy Sources 69 < https://doi.org/10.1080/00908310151092191> accessed 10 May 2020
[537] Rajendra K Pachauri, 'Climate Change 2014 Synthesis Report Summary Chapter for Policymakers' [2014] IPCC 31 <https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_SPM.pdf>.accessed 12 July 2020
[538] ibid
[539] International Energy Agency, 'Coal' (IEA, 15 November 2022) <https://www.iea.org/fuels-and-technologies/coal> accessed 20 January 2023

grow strongly over the next decades to decarbonise the power sector.[540] As such, carbon capture, and storage (CCS) has come into the picture as a bridging technology that can buy time for society to prepare, develop and deliver other alternative energy sources at scale.[541]

The reality is that the boom days of fossil fuels may be coming to an end, given the fact that the exploitation of these resources has led to their depletion and the forecast of their reserves paints a gloomy picture.[542] A recent review of fossil fuels reserves globally has revealed that the reserves are low, and this raises concerns of the rate of depletion and calls for the development of alternative energy sources to replace them. The global reserves to production ratio for fossil fuels in 2019, according to BP, by type in years, are as follows: oil-50 years, natural gas 49.8 years and coal-132 years at current production.[543]

As there is an increase in demand for new technologies, the shift from fossil fuels to more environmentally friendly alternatives (RE) should be seamless, and this shift from fossils fuels to RES should enhance economic development.[544] It is increasingly becoming clear that the economic benefits to be derived from switching to RE are immeasurable. RE offers many advantages in order to mitigate the climate change challenge. Despite the advantages RES offer, they have drawbacks too. The advantages of fossil fuels cannot be overlooked, and a brief highlight of them is as follows: the technology used to exploit fossil fuels is well developed. It is because the technology has been used over decades to provide for the world's energy needs and therefore has become mature and widely deployed. They are cheap because they are heavily subsidised. Their main downside includes they emit GHG emissions, which has been a significant contributor to global warming. Fossil fuels are non-renewable; they are finite and have been over harnessed that they have a few years left, as seen above. Their exploitation is unsustainable because the rate at which we exploit them is faster than the rate at which they are replenished, so their reserves have been largely depleted. They appear to be cheap because they have been incentivised to the level that they are seen as such. The subsidies fossil fuels receive annually are into trillions of U.S.A dollars against RE which receives just a fraction.

A comparison of fossil fuels with renewables by Kaberger using price as a factor concluded that renewables have become competitive with some of the energy carriers, for instance, RE has outcompeted oil and natural gas, whilst coal is the only fuel out of the fossil trio still relatively cheaper than RE due to the subsidies it receives.[545] The study has, however, recognised that comparing the cost of energy is not the only criterion to determine competitiveness. However, that notwithstanding demonstrates that a decrease in costs for RE is an essential indicator of the opportunities that renewables hold. The urgent need to reduce carbon emissions calls for interim measures that include CCS technology which can help capture global emissions to between 20-40% by 2050 to such a time that RE is widely

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[540] International Energy Agency, 'Renewables' (IEA, 12 December 2022) <https://www.iea.org/fuels-and-technologies/renewables> accessed 16 January 2023

[541] Stephen A. Rackley, *Carbon Capture and Storage* (2nd edn, Elsevier Butterworth-Heinemann 2017) 4

[542] Hermann Scheer, *Energy Autonomy: The Economic, Social and Technological Case for Renewable Energy* (Earthscan, 2007) 37

[543] BP, 'Global Reserves to Production Ratio for Fossil Fuels in 2019' (BP) <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/oil.html> accessed 20 July 2020

[544] Brett Buchheit, 'The Economics of Alternative Energy: Decisions following the IPCC's Report on Climate Change' (2008) 38 Texas Environmental Law Journal 73 <https://heinonline.org/HOL/Page?handle=hein.journals/txenvlw38&collection=journals&id=77&startid=&endid=128> accessed 12 June 2020

[545] Tomas Kåberger, 'Progress of Renewable Electricity Replacing Fossil Fuels' (2018) 1 Global Energy Interconnection 48 <https://doi.org/10.14171/j.2096-5117.gei.2018.01.006>.accessed 16 June 2020

diffused.[546] In view of this, CCS can fill in the gap with current demand and allow time for the development and deployment of RETs to address the situation.[547] A portfolio of approaches is needed for the time being to address the challenge which includes RE, nuclear, energy efficiency measures and more especially CCS technology can help in substantial CO_2 reduction, these can provide secure affordable energy that does not impact the environment.[548]

5.3 Laws on Concerns for the Environment Associated with the Deployment of Evolving Renewable Energy Technologies

5.3.1 Planning Laws and Renewable Energy Technologies

Over time planning laws have helped in addressing environmental concerns emanating from the use of RETs. Crawford and French have perfectly captured the important role planning laws play in making RETs to be agents of environmental protection and development.[549] Legislation on planning balances the right of property and the public good, and this allows decisions on development to be settled expeditiously outside the court through processes that are in tandem with the rule of law, probity, and accountability.[550] In the above statement, it can be inferred that there is the need to balance the property rights of government and energy generators to that of the public good in Ghana. The property rights here entail the right to establish an RE project in a particular location in accordance with the existing title documents, whilst public good calls for the need to make sure that these rights are exercised in a way that is beneficial to the environment. However, this notwithstanding, it must be noted that the siting of an RE project in a particular location may actually be in the interest of the public good.

It is significant because most RE projects are sited onshore; such planning laws are of much importance as they support RETs' penetration and ensure the protection of the environment. This protection, to a larger extent, is absent in the fossil fuel industry. Wildermuth asserted that most of the environmental regulations governing the fossil fuel industry only begin to work later at the processing stage or refinery stage.[551] Wildermuth further states that environmental statutes are framed in a way that they provide a narrow, end-of-the process solution which does not address the problem holistically.[552] Environmental law most often is focused on outputs and pays less attention to the prevention of pollution, and this approach ignores the problem of emissions. Contrary to the end of the process approach of environmental law, planning laws consider environmental issues from the outset before RE projects commerce. It is generally a practice to see that an RE project is located in remote areas that usually have less human activity because siting RE projects in built-up areas or towns presents enormous

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[546] Philippe Mathieu, The IPCC Special Report on Carbon Dioxide Capture and Storage (2006) < https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_wholereport-1.pdf> accessed 12 January 2020
[547] Scott Foster and David Elzinga, 'The Role of Fossil Fuels in a Sustainable Energy System' (U.N Chronicle, December 2015) <https://www.un.org/en/chronicle/article/role-fossil-fuels-sustainable-energy-system> accessed 12 March 2020.
[548] Hong-Hua Qiu and Lu-Ge Liu, A Study on the Evolution of Carbon Capture and Storage Technology Based on Knowledge Mapping in José Carlos Magalhães Pires (ed), *Carbon Capture and Storage* (MDPI 2019).
[549] Jenny Crawford and Will French, 'A Low-Carbon Future: Spatial Planning's Role in Enhancing Technological Innovation in the Built Environment' (2008) 36 Energy Policy 4575 < https://doi.org/10.1016/j.enpol.2008.09.008> accessed 18 April 2020
[550] ibid
[551] Amy J Wildermuth, 'Is Environmental Law a Barrier to Emerging Alternative Energy Sources' (2009-2010) 46 Idaho Law Review 509. <https://heinonline.org/HOL/P?h=hein.journals/idlr46&i=515> accessed 24 May 2020
[552] ibid

environmental challenges. The issues RETs have relating to built-up areas have to do with the design, such as availability of roof area, fuel storage capacity or incompatibility with other technologies.[553] This is so because many buildings in Ghana do not satisfy environmental concerns or energy matters requirements.

Buildings globally account for about 45% of the energy that is consumed today. This high consumption is due mainly to design flaws, thus making buildings to contribute the most significant anthropogenic climate change.[554] It is envisaged that building designs begin to take into consideration energy consumption so that future buildings are energy efficiency compliant. However, the fact is that in developed countries, this new approach can be implemented through well-crafted planning laws. However, this new approach cannot be said about Ghana being a developing country.

5.3.2 Environmental Impact Assessment for Renewable Energy Technologies

Environmental Impact Assessment (EIA) plays a crucial role in the work of Environmental Protection Agency (EPA) in Ghana. It is performed to ascertain whether any RE project meets the required standard criteria before the project can be approved. This importance has been captured by Crowhurst and Davidson as follows:

> The key factor in the EIA is the emphasis on using the best available sources of objective information and carrying out a systematic and holistic process, which should be bias-free and allow the local planning authority and the whole community to understand the impact of the proposed development properly. The EIA should lead to better standards of development but, in some cases, will prevent the development from happening. Where developments do go ahead, EIAs should help to propose mitigation measures.[555]

By implication, RET projects are supposed to meet EIA qualifying criteria before being granted planning approvals. It would result in any risks associated with adverse environmental impact to be mitigated before the project commences. In Ghana, pursuant to environmental assessment regulation 9 (4) an applicant shall submit an environmental impact statement in respect of the proposed undertaking, which shall be outlined in a scoping report to EPA. A scoping report shall set out the scope or extent of the environmental impact assessment to be carried out by the applicant and shall include draft terms of reference, which shall indicate the essential issues to be addressed in the environmental impact assessment.[556]

Furthermore, in fulfilment of environmental assessment regulation, a developer or applicant will prepare a report and submit it to EPA on the undertaking and indicating in the report the following under regulation 5 (2) (a-d):[557]

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[553] A. R Day and others, 'The Use of the Planning System to Encourage Low Carbon Energy Technologies in Buildings' (2009) 34 Renewable Energy 2016 <http://dx.doi.org/10.1016/j.renene.2009.02.003>.accessed 19 June 2020

[554] Butler, Declan. "Architects of a low-energy future: low-and zero-energy buildings could have a huge impact on energy use and carbon emissions. We have the technologies, but if they are to mitigate climate change, green-building design must hit the mass market." (2008) (452, no. 7187) Nature <https://www.nature.com/news/2008/080402/full/452520a.html> accessed 16 March 2020

[555] Georgina Crowhurst and Simone Davidson, "Planning: A Roadblock to Renewable Energy in the UK" (2008).10 (3) Environmental Law Review 181–199 < https://doi.org/10.1350/enlr.2008.10.3.021> accessed 14 April 2020

[556] Ghana Environmental Assessment Regulations 1999 <https://www.bcp.gov.gh/acc/registry/docs/ENVIRONMENTAL%20ASSESSMENT%20REGULATIONS,%201999%20(LI%201652).pdf> accessed 30 June 2022

[557] ibid

(a) the environmental, health and safety impact of the undertaking,

(b) a clear commitment to avoid any adverse environmental effects which can be avoided in the implementation of the undertaking,

(c) a clear commitment to addressing unavoidable environmental and health impacts and steps where necessary for their reduction; and

(d) alternatives to the establishment of the undertaking.

In Ghana, the EPA is the body that regulates matters relating to activities that have the potential to adversely impact the environment.[558] Some of the relevant functions of the EPA are captured as follows:[559]

(i) Under section 2 (f) of the EPA Act 1994 (Act 490), EPA is responsible for the granting of environmental permits and serves pollution abatement notices for controlling waste discharges, emissions, deposits, or other sources of pollutants.

(ii) The EPA is charged with the duty under section 2 (i) of the EPA Act 1994 to enforce compliance with any laid down EIA assessment procedures in the planning and execution of development projects, which includes compliance in respect of existing projects.

(iii) Section 2 (h), the EPA is responsible for prescribing standards and guidelines relating to air, water, land, and other forms of environmental pollution, including the discharge of wastes, and controlling toxic substances.

(iv) Section 12 (1) obligates the agency to serve notice in writing that requires any person responsible for any undertaking, which in the agency's opinion, has or is likely to have an adverse effect on the environment to submit to the agency in respect of the undertaking an EIA containing such information within such period as shall be specified in the notice.

(v) Section 15 (2) (a), states that the EPA working through Environmental Protection Inspectors, referred to in the Act as ''Inspectors'' would have the power to enter and inspect at a reasonable time any premises for the purpose of ensuring compliance with the law for environmental protection.

Similar arrangements put in place for conventional energy sources have not dealt with the elimination of environmental hazards usually associated with these sources. EIAs for the conventional energy industry focus on the early stages of the exploration process. They neglect the production and consumption stages. Many analysts have adopted the Life Cycle Assessment (LCA) as a tool that will help discover the potential of RETs in environmental protection.[560] The LCA tool is used to test new technologies before their penetration in the market to investigate their impact on the environment as well as their superiority over competing or existing technologies.[561]

Using the LCA tool Pehnt discovered that GHG emissions from the consumption of non-RES are high, whereas emissions from RE are far lower or negligible.[562] Varum. Bhat and Prakash also applied the LCA instrument to assess the environmental impact of RETs, observing from the production stage to the decommissioning stage, after which they made a comparison with

[558] Ghana's Environmental Protection Agency Act ,1994 (Act 490) sec.12.
[559] Ghana's Environmental Protection Agency Act, 1994 (Act 490).
[560] Martin Pehnt, 'Dynamic Life Cycle Assessment (LCA) of Renewable Energy Technologies' (2006) 31 Renewable Energy 55 < https://doi.org/10.1016/j.renene.2005.03.002> accessed 16 January 2020
[561] ibid
[562] Pehnt (n 560).

some non-RETs.[563] The conclusion was that RETs had a far less environmental impact than conventional sources.[564] LCA technique is also valuable for comparative analysis relating to land use for RETs and non-RETs. It has been observed that RETs use less land than conventional technologies. To test this observation, Turney and Fthenakis applied comparative analysis for the life cycle of a coal power plant and a solar photovoltaic power plant.[565] They saw that as the lifetime of the solar power plant gets longer, the land transformation per capacity remained unchanged, however, the land occupation per energy generated decreases.[566] Whilst the life cycle of the coal plant shows, mining is required to get the fuel, about 70% of coal in the U.S.A is produced through strip mining which increases land intensity.[567] In short, a solar power plant occupies less land per kW/h when compared to a coal plant. When a RET reaches the end of its life span, the next thing is decommissioning the technology in an environmentally friendly way as required and replacing it with new ones on the same land with no increases in land intensity. The EIA regulation in Ghana does not require any comparative analysis between new and existing technologies, but rather it is centred on the particular technology that is being assessed. LCA is a comprehensive tool that incorporates the various stages of the assessment, which include goal and scope definition, inventory analysis, impact assessment and interpretation.[568] It is worth noting that LCA does not take into account technical performance, cost or political and social acceptance. As such it must be applied in conjunction with these other relevant variables.

LCA is an important instrument that helps evaluate the environmental consequences of the different options available in fulfilling a specific obligation and find a cost-effective way to reduce pollution and gravitate toward a more sustainable economy. It assesses the potential impact of energy projects on the environment, ecosystem, resources, and people before they begin, especially RETs. However, this tool has some weaknesses that need highlighting; one main challenge of LCA is the task of collecting actual data; data sets have different input and very high variations, which involves temporal and spatial variations. LCA can be resource and time-intensive depending on the information intended to be included. There are no precise methods to capture all the relevant environmental impact as there are too many methodological choices to determine which environmental impact are more important than the others, inventory data gathering is sometimes challenging to obtain, and the availability of accurate data is crucial to the final results.[569]

Analysts have underscored the importance of the LCA tool in addressing environmental concerns, which is crucial for this study. In addition to that, the purpose of considering it in this thesis is to use it to establish the contribution RETs can make to the protection of the environment and mitigate the harm caused by conventional sources. The findings from several studies already alluded to on earlier, point to the fact that RETs have more environmental advantages than fossil fuels, which buttresses the point why they should be widely deployed

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[563] Varun, IK Bhat, and Ravi Prakash, 'LCA of Renewable Energy for Electricity Generation Systems-A Review' (2009) 13 Renewable and Sustainable Energy Reviews 1067 < https://doi.org/10.1016/j.rser.2008.08.004> accessed 14 April 2020

[564] ibid

[565] Damon Turney and Vasilis Fthenakis, 'Environmental Impacts from the Installation and Operation of Large-Scale Solar Power Plants' (2011) 15 Renewable and Sustainable Energy Reviews 3261 <http://dx.doi.org/10.1016/j.rser.2011.04.023> accessed 19 February 2020

[566] ibid

[567] Turney and Fthenakis (n 565)

[568] Herib Blanco and others, 'Life Cycle Assessment Integration into Energy System Models: An Application for Power-to-Methane in the EU' (2020) 259 Applied Energy 114160 <https://doi.org/10.1016/j.apenergy.2019.114160>. accessed 14 July 2020

[569] World Energy Council, 'Comparison of Energy Systems Using Life Cycle Assessment' (WEC, July 2004) <https://www.worldenergy.org/assets/downloads/PUB_Comparison_of_Energy_Systens_using_lifecycle_2004_WEC.pdf> accessed 10 January 2020

to reduce emissions and mitigate climate change. In furtherance of the above, the tool has aided EIA in making it possible to identify the benefits RETs have to offer, which invariably has led to make them environmentally friendly.

The success of EIA will depend to a large extent on how the regulations are monitored and enforced. It is necessary to ensure that any adverse impact that is detected can be ameliorated with new technological innovation to mitigate the impact on the environment from the outset.[570] The EPA of Ghana is charged with the responsibility to enforce the EIA regulation; the EPA Act 1994 gives the EPA the power under section 2 (i) to enforce compliance with any laid down procedures. In addition, section 15 (2) (a) grants EPA inspectors the power to monitor how the procedures are implemented.

5.4 Renewable Energy Technologies and the Environment in Context

RETs can contribute to the reduction of the impact on the environment caused by energy generation and consumption and achieve the goals of sustainable development (SD) as well.[571]

Kemp has made an important statement about RETs in relation to the SD of the economy; thus, the environmental side of the concept as follows:

> Certainly, installing pollution control devices and reuse systems, using more environmentally benign materials, and reformulating existing technologies are necessary if a sustainable economy is achieved. However, such changes alone will be vastly insufficient for achieving the ultimate goal of SD. In achieving that, more fundamental changes in technology are needed, such as a shift away from hydrocarbon-based energy supply…towards the use of renewables…[572]

Interpreting the above quote means that achieving sustainability in the environment is more than the mere enforcement of environmental laws such as recycling or energy efficiency and pollution control. It can also mean a reduction in relying on fossil fuels and gradually shifting to green technologies. Some experts in environmental law have also realised the important role RETs can play in the fight against environmental damage, for example, Heaton and Banks have intimated that:

> The pivotal place a new technology holds in solving environmental problems has by now assumed the status of almost-conventional wisdom. In an arena not noted for consensus, the worldwide community concerned with environmental policy is in remarkable agreement about the need for a new generation of technology.[573]

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[570] Theocharis Tsoutsos, Niki Frantzeskaki and Vassilis Gekas, 'Environmental Impacts from the Solar Energy Technologies' (2005) 33 Energy Policy 289 < https://doi.org/10.1016/S0301-4215(03)00241-6> accessed 20 March 2020

[571] Dincer and Rosen (n 533).

[572] René Kemp, 'Technology and the Transition to Environmental Sustainability. The Problem of Technological Regime Shifts' (1994) 26 (10) Futures 1023 <https://doi.org/10.1016/0016-3287(94)90071-X> accessed 10 January 2020

[573] George R Heaton and R Darryl Banks, 'Toward a New Generation of Environmental Technology - The Need for Legislative Reform' (1997) 1 Journal of Industrial Ecology 23 < https://doi.org/10.1162/jiec.1997.1.2.23> accessed 15 February 2020

World leaders of G8 at their G-8 leaders' summit in Genoa also accepted the fact that RETs can contribute to SD of the environment and jointly released a communique in recognition of that as follows:

> We recognised the importance of RE for SD, diversification of energy supply, and preservation of the environment. We will ensure that RES are adequately considered in our national plans and encourage others to do so. We encourage continuing research and investment in RETs throughout the world.[574]

5.5. Harmful Effects of Renewable Energy Technologies on the Environment

5.5.1 Environmental Hazards of Renewable Energy Technologies

GHG emissions have impacted the environment due to the consumption of fossil fuels.[575] Hazards, including emissions to a large extent, have been responsible for air pollution, heavy metals that pollute water bodies and lands, particulates, global warming, and climate change. All these have degraded the environment and have threatened the survival of biodiversity.[576] The current situation can be traced to when pre-industrial biomass was substituted for coal and other fossil fuels.[577] The profligate exploitation of fossil fuels and their use for the generation of heat and electricity has led to the high concentration of GHG emissions in the atmosphere which has impacted the environment. Energy generated from RES is considered to be environmentally friendly.[578] The dominant RES in Ghana's energy mix is biomass and hydropower, but recently attention has been focused on solar energy and wind energy.[579]

However, it is surprising that environmentalists who have been campaigning for the use of RE and calling for the phasing out of fossil fuels have turned against RETs on environmental grounds. This situation has given mixed signals about the benefits of RE. Therefore, it is important to consider the grievances of the environmentalists and review the real impact of renewables, whether the environmental hazards raised can substantially negate the benefits they offer, and whether there exist other beneficial alternatives apart from them (RE).

Some scholars have argued that RETs are not totally emission-free as it has been portrayed in the literature, the effects of some RETs on the environment are equated to those of fossil fuels.[580] Rybach has observed that any type of energy generation would have some kind of impact on the environment but the degree of impact depends much on the technology

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[574] Communique Released at the end of the G-8 Leaders' Summit Held in Genoa Italy, July 2001 <http://www.g7.utoronto.ca/summit/2001genoa/finalcommunique.html> accessed 10 May 2020

[575] W Bach, 'Fossil Fuel Resources and Their Impacts on Environment and Climate' (1981) 6 International Journal of Hydrogen Energy 185 < https://doi.org/10.1016/0360-3199(81)90007-0> accessed 12 August 2020

[576] A.G Chmielewski, 'Environmental Effects of Fossil Fuel Combustion' in Jose Goldemberg (ed), *Interactions: Energy/Environment: (encyclopedia of Life Support Systems)*. (EOLSS Publishers UNESCO 2009)

[577] Bassam Fattouh, Rahmatallah Poudineh and Rob West, 'The Rise of Renewables and Energy Transition: What Adaptation Strategy Exists for Oil Companies and Oil-Exporting Countries?' (2019) 3 Energy Transitions 45 <https://doi.org/10.1007/s41825-019-00013-x> accessed 12 December 2019.

[578] Ayhan Demirbas, 'Biofuels Securing the Planet's Future Energy Needs' (2009) 50 Energy Conversion and Management 2239 <http://dx.doi.org/10.1016/j.enconman.2009.05.010> accessed 12 June 2020

[579] Embassy of The Kingdom of The Netherlands, 'Business Opportunities for Renewable Energy in Ghana' 1 <http://www.rvo.nl/onderwerpen/internationaal-ondernemen/mvo> accessed 20 March 2020

[580] Carolyn Fischer and Louis Preonas, 'Combining Policies for Renewable Energy: Is the Whole Less than the Sum of Its Parts?' [2012] SSRN Electronic Journal <https:// ssrn.com/abstract=1569634> accessed 18 June 2020

involved.[581] For instance, the solar photovoltaic (PV) industry holds a lot of promise for the environment, but the material used in the manufacture of solar panels come from highly toxic and hazardous sources that may pose public health and environmental risks when they are decommissioned and are not properly disposed of.[582] The International Renewable Energy Agency (IRENA), in its 2016 report, estimated that there were about 250,000 metric tonnes of solar panel waste globally, and this was projected to reach 78 million metric tonnes by the year 2050; the concern here is that these solar panels contain lead, cadmium and other toxic chemicals, whose current disposal is not properly done and the toxic materials can leach into the soil thus posing a public health issue.[583] Cadmium, for instance can be washed out of solar modules by rainwater which raises a lot of environmental concerns.

These challenges can be overcome by R&D as solar PV systems begin to use semi-conductor material such as silicon which can convert sunlight to solar energy. Research is being used to improve quality and efficiency, reduce the quantity of material and cost and it helps avoid using toxic materials in the manufacture of the panels.[584] As indicated earlier, R&D can be used to solve a myriad of challenges relating to RETs; thus, they can be improved upon to make them very efficient and environmentally friendly and less hazardous. Also, in finding solutions to the challenges RETs face from political and institutional set-up, the role of the law becomes crucial as these technological innovations cannot solely rely on business and market forces to make them advance and become competitive. They would need environmental regulations and policies in order to be environmentally friendly and competitive. R&D, with the support of the law, can help deliver the desired environmental protection that RETs have to offer, and the process is ongoing. RETs are growing and maturing and can overcome the environmental challenges that have been raised. For example, R&D has led to the discovery that methane can be produced from anaerobic digestion of energy crops and organic waste, which serves as a clean fuel with virtually no emissions that affect the environment.[585]

As some of the hazards of RETs have been highlighted, it is apposite to draw attention to their significant benefits; thus, they eliminate hazards associated with fossil fuels such as GHG emissions and the chemical pollution of land and water bodies. In the processes leading to the exploration of conventional energy sources, chemicals are used at the various stages in the life cycle of the energy carrier, for example, oil, and these have an impact on the environment. It must be pointed out that attempts have been made to stem the impact, but they have not eliminated the GHG emissions that have caused climate change. To buttress the importance of RES, they are generally safer sources to the population, property, and are natural resources which are sustainable, whereas conventional sources pose risks to life and property and are a major contributor of GHG emissions.[586]

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[581] Ladislaus Rybach, 'Geothermal Energy: Sustainability and the Environment' (2003) 32 Geothermics 463 < https://doi.org/10.1016/S0375-6505(03)00057-9> accessed 20 December 2019

[582] Stephanie Weckend, Andreas Wade and Garvin Heath, 'End-of-life management: Solar Photovoltaic Panels' (IRENA, June 2016) <https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels> accessed 12 May 2020

[583] ibid

[584] Dexter Johnson, 'Perovskite Solar Cell Production Gets Environmentally Friendly' IEEE Spectrum <https://spectrum.ieee.org/nanoclast/green-tech/solar/perovskite-solar-cell-production-gets-environmentally-friendly> accessed 14 April 2020

[585] David P Chynoweth, John M Owens and Robert Legrand, 'Renewable Methane from Anaerobic Digestion of Biomass' (2001) 22 Renewable Energy 1 < https://doi.org/10.1016/S0960-1481(00)00019-7> accessed 12 December 2019

[586] Gonzalo Escribano Francés, José María Marín-Quemada and Enrique San Martín González, 'RES and Risk: Renewable Energy's Contribution to Energy Security. A Portfolio-Based Approach' (2013) 26 Renewable and Sustainable Energy Reviews 549 <http://dx.doi.org/10.1016/j.rser.2013.06.015>.accessed 19 May 2020

5.5.2 A Brief Discussion on Landscape Impact Issues

On the surface, it is most often concluded that RETs tend to occupy more land than conventional energy technologies, as depicted in Table 10 below.[587]

Table: 9 Land Use by Electricity Source in Acres/MW Produced

Electricity Source	Access per (acres)Megawatt Generated
Coal	**12.21**
Natural Gas	**12.41**
Nuclear	**12.71**
Solar	**43.50**
Wind	**70.64**
Hydro	**315.22**

Source: Stevens and Others (2017)

The table above shows that coal, natural gas and nuclear all demonstrate small use of land, about 12 acres per megawatt of electricity generated, and all come from non-renewable sources. On the other hand, solar and wind feature more land use of about 43.50 and 70.64 acres per megawatt of electricity generated respectively. In addition, hydroelectric dams have a more significant land intensity than other generating technologies using about 315.22 acres per megawatt of electricity generated.

With a cursory look at the acreage of conventional energy sources and RES, the simple conclusion is that the former requires less land than the latter. However, a deeper probe reveals that may not be the case. Take, for instance, coal which uses 12.21 acres of land from the table above, may use more land that is not conspicuous when one takes a holistic approach in analysing the actual land used. According to the U.S.A Energy Information Administration (EIA), coal travels averagely 628 miles by train from the mine to the plant.[588] However, because trains are used for other purposes, it is difficult to quantify the land explicitly used to transport coal reasonably. Transporting electricity in the U.S.A is estimated to require about 450,000 miles of high voltage transmission lines with safety buffers on each side, approximating a requirement of 4,800.000 acres of land.[589] Coal accounted for about 22% of U.S.A electricity supply in 2021.[590] In 2015, it required about 1,592,160 acres of land.[591] It has also been observed that about 640 to 1280 acres of land would be required to generate 1000 megawatts of electricity from a coal plant whereas 6,000 acres of land would be required by a

[587] Landon Stevens and others, 'The Footprint of Energy: Land use of U.S. Electricity Production' (Strata, June 2017) <https://www.strata.org/pdf/2017/footprints-full.pdf>.accessed 12 May 2020
[588] Landon Stevens and others, 'The Footprint of Energy: Land Use of U.S Electricity Production' (Strata, June 2017) <https://docs.wind-watch.org/US-footprints-Strata-2017.pdf> accessed 16 June 2020
[589] Harries Williams and others, 'Transmission and Distribution Infrastructure' <http://www.harriswilliams.com/sites/default/files/industry_reports/ep_td_white_paper_06_10_14_final.pdf> accessed 16 June 2020
[590] U.S Energy Information Administration, 'Electricity Explained: Electricity in the United States' (EIA, 15 July 2022) <https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php#:~:text=Natural%20gas%20was%20the%20largest,power%20plants%2020steam> accessed 16 January 2023
[591] ibid

concentrating solar thermal plant to generate the same amount of electricity.[592] The U.S.A has been used in this illustration because it is one of the major consumers of energy in the world and has large deposits of coal and its exploitation requires much land. So, when it comes to land use for the two main energy sources. It is better to have a holistic approach to understand which source uses more land than the other and its impact on the environment and landscape. In doing this, it brings to the fore land use, landscaping issues and visual impact in the process of generating energy. For instance, energy generation brings to the fore issues such as, the destruction of the natural habitats of some species, disruption of the ecosystem and land preparation which could lead to the loss of vegetation and habitats for wildlife, all these things have a negative impact on the environment.[593]

So far, the arguments have been that conventional energy sources use less land when compared to RES, which is debatable, especially when there is no holistic analysis conducted on the two sources. It is arguable that onshore conventional energy infrastructure equally requires large chunks of land comparable to the scale of RE. For example, in Europe, fracking has received much opposition due to its land intensity in relation to the high density of the continent's population, water contamination, high water usage and gas leakages.[594] In Canada, tar sand exploitation takes place on the land, and this requires much land, as well as water and this, impacts the ecosystem and the environment.[595] The concerns have not been limited to land use only but have extended to landscaping issues as well, which has led to the stalling of the development of some projects. For example, in Scotland, the Buchan Wind Farm Action Group opposed a wind farm that was to be sited on a parcel of land near Peterhead. Some of the turbines were going to protrude a few meters into residential areas. The visual impact was going to have a negative impact on the residents.[596] As such, the project was not approved.

So how can land and landscaping issues be mitigated to aid the deployment of RETs? To address land-use issues of RETs, recent studies have revealed that some arable crops can be cultivated on the same piece of land that is used for wind farms and solar panels. Solar panels can be fitted on rooftops like the solar PV initiative under the capital subsidy scheme of 2015 a policy of the GoG. Under the scheme, government buildings and other residential homes are to be fitted with solar panels, including the seat of government, to provide peak load relief of 200 MW on the national grid. This initiative attempts to address land-use concerns to optimise the available roof space. Furthermore, the combination of crops with solar panels is known as dual-use farms, and they can serve the needs of both agriculture and electricity generation simultaneously. The use of agricultural lands this way has the chance to

[592] Robert Glennon and Andrew M Reeves, 'Solar Energy's Cloudy Future' (2010) 1 Arizona Journal of Environmental Law and Policy 93 <https://heinonline.org/HOL/P?h=hein.journals/arijel1&i=95> accessed 16 July 2020

[593] Robert L Glicksman, 'Solar Energy Development on the Federal Public Lands: Environmental Trade-Offs on the Road to a Lower-Carbon Future' (2012) 3 San Diego Journal of Climate and Energy Law 107 < https://heinonline.org/HOL/P?h=hein.journals/sdjclimel3&i=109> accessed 19 March 2020

[594] Lorenzo Cremonese and others, 'Shale Gas and Fracking in Europe' [2015] Potsdam Institute for Advances Sustainability Studies 1 <http://www.sciencedirect.com/science/article/pii/B9780128016060000066>.accessed 14 April 2020

[595] Sonia Yeh and others, 'Past and Future Land Use Impacts of Canadian Oil Sands and Greenhouse Gas Emissions' [2015] Institute of Transport Studie/UC Davis Research Report.UCD-ITS-15-01 <https://merritt.cdlib.org/d/ark:%2F13030%2Fm5wq26j3/1/producer%2F907319169.pdf> accessed 16 May 2020

[596] Peter A Strachan and David Lal, 'Wind Energy Policy, Planning and Management Practice in the UK: Hot Air or a Gathering Storm?' (2004) 38 Regional Studies 549 < https://doi.org/10.1080/0143116042000229311> accessed 19 March 2020

boost agriculture and improve food security whilst harnessing energy at an equivalent time, and this can maximise land use and allay land constraint concerns relating to RETs.[597]

To overcome landscaping issues and reduce local opposition, some wind developers have gone ahead to hire artists to design the turbines to look aesthetic and appealing and not industrial, it is done to mitigate the negative impact of their projects.[598] Scotland has addressed landscaping impact matters by establishing the Scottish Natural Heritage; it advises the government on landscaping issues. It assesses the project's impact on the landscape using landscape and visual impact assessment. It also designs a visualisation of the project through the Wind Farm Footprint Maps, it is in line with the Scottish Environmental Assessment Act 2005.[599]

In addition to the solutions above, Pasqualetti has proffered three steps to be adopted to minimise opposition to RETs, especially wind, solar and geothermal, the three steps include:[600]

First, re-weighting of project evaluation processes and reducing the emphasis on technical solutions. Instead, focus thoroughly on social considerations to pave the way for the smooth completion of development plans.

Second, RE project developers should endeavour in the early days to understand the human landscape of the project's proposed location, which should encompass the belief systems, perceived personal costs and benefits, the local history, and the land tenure system of the area.

Third, the local people whose lands are being used for RE projects and who are impacted should receive meaningful benefits and compensation for the landscapes they value. The benefit should be for the families and the larger community.

When these three steps are followed in Ghana, it will minimise the opposition to solar farms, which have been constructed on large swathes of land. More so, adequate compensation can win the support of the local people whose lands are being used. Understanding the land tenure system is beneficial as Ghana operates a dual land tenure system comprising statutory land and customary land ownership. When land is owned individually, the parties involved agree on the benefits to be derived by all parties whose land is being used for the solar farm. The belief systems in the Northern part of Ghana are important to the indigenes; respecting these will minimise any opposition that would otherwise arise.

5.5.3 Raw Materials Throughput and Decommissioning

RETs face two major challenges thus the throughput or materials that are used to manufacture them and the environmental impact of those that have reached the end of their life span and are ready to be decommissioned. Conventional technologies may even use more raw materials during the building stages compared to renewables. Disposal of these technologies when they have reached decommissioning presents many challenges. The challenges relating

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[597] Khyati Vyas, 'Solar Farming with Agricultural Land' (2019) 3 Acta Scientific Agriculture 23 < https://actascientific.com/ASAG/pdf/ASAG-03-0640.pdf> accessed 10 June 2020

[598] Steve Goodman, 'Wind Energy Development: Can Wind Power Overcome Substantial Hurdles to Reach the Grid?' (2012) 18 Hastings Environmental Law Journal 323 < https://repository.uchastings.edu/hastings_environmental_law_journal/vol18/iss2/4> accessed 19 April 2020

[599] Scottish Natural Heritage, 'Assessing the Cumulative Impact of Onshore Wind Energy Developments' [2012] <https://www.nature.scot/sites/default/files/2019-11/Guidance> accessed 10 June 2020

[600] Martin J Pasqualetti, 'Social Barriers to Renewable Energy Landscapes' (2011) 101 Geographical Review 201 <https://doi.org/10.1111/j.1931-0846.2011.00087.x> accessed 20 February 2020

to the complete decommissioning of offshore installation was recognised by the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) in OSPAR Decision 98/3 July 1998.[601] The manufacture of giant wind turbines entails the use of large materials such as concrete, glass fibre reinforced, steel and others in the fabrication process.[602] These components are not of any significant constraint on the environment as major parts mentioned above can be recycled and reused again, steel which is somewhat limited in reserves and used in building nacelles, towers and rotors for the turbines is recyclable as observed by Jacobson and Delucci.[603] Water use in fossil fuels is likely to be high especially in shale oil, tar sand and gas exploration than RETs.[604] Furthermore, wind turbines use less water compared to a conventional power plant for example a wind turbine will consume 0.1% of water to generate 1 megawatt hour (MWh) of electricity, PV technology will use 2% of water to generate the same whilst nuclear and coal plants will use 15% of water to generate the same 1 MWh of electricity.[605]

What is the legal framework governing the decommissioning of energy technologies? Most jurisdictions rely on the U.N Convention on the law of the Seas 1982, the 1989 International Maritime Organisation guidelines, OSPAR Convention and national laws, provide guidelines on the decommissioning of energy projects. Most of the guidelines focus on offshore petroleum installations; However, Ghana is not a signatory to OSPAR; its guidelines nevertheless are of benefit to the Jubilee Project and compatible with the laws of Ghana. It is envisaged that the Jubilee Project in Ghana will be decommissioned in accordance with national laws, good international practice and licence requirements in force at the time.[606] In Ghana, in terms of decommissioning a project, the Petroleum (Exploration and Production) Act, 1984 (Act 84) requires that all steps be taken to remove any infrastructure that is no more required for petroleum production, including the closure of abandoned rigs and all procedures to be undertaken for the decommissioning must meet internationally accepted good practice.[607] The Petroleum (Exploration and Production) (E&P) Act, 2016 (Act 919) and Model Petroleum Agreement (MPA) require strict compliance by a contractor who operates a petroleum facility, to submit a decommissioning plan to the Minister of Energy for approval five years in advance of the actual date intended for the facility to cease permanent operation.[608] The contractor is further obliged to implement an approved decommissioning plan in

[601] OSPAR Commission, 'OSPAR Decision 98/3' [1998] OSPAR Commission Ministerial Meeting of the OSPAR Commission Sintra, 22-23 July 1998 Programmes and Measures' (OSPAR Commission, July 1998) <https://www.ospar.org/documents?v=6875>.accessed 12 February 2020

[602] Christopher Moné and others, '2015 Cost of Wind Energy Review NREL/TP-6A20-66861' [2015] Nrel <https://www.nrel.gov/docs/fy17osti/66861.pdf> accessed 29 July 2020

[603] Mark Z Jacobson and Mark A Delucchi, 'Providing All Global Energy with Wind, Water, and Solar Power, Part I: Technologies, Energy Resources, Quantities and Areas of Infrastructure, and Materials' (2011) 39 Energy Policy 1154 <http://dx.doi.org/10.1016/j.enpol.2010.11.040>.accessed 18 January 2020

[604] Ed Struzik, 'With Tar Sands Development, Growing Concern on Water Use' (Yale Environment 360, 5 August 2013 <https://e360.yale.edu/features/with_tar_sands_development_growing_concern_on_water_use#:~:text=That%20quantity%20exceeds%20the%20amount,from%20th> accessed 30 July 2020

[605] Alena Lohrmann and others, 'Global scenarios for significant water use reduction in thermal power plants based on cooling water demand estimation using satellite imagery' (2019) 4 Nature Energy, 1040–1048 <https://doi.org/10.1038/s41560-019-0501-4> accessed 12 June 2020

[606] Ente Nazionale Idrocarburi (ENI) S.P.A, 'Ghana Offshore Cape Three Points Oil Block Development. Phase 2. Final Environmental Impact Statement' (ENI, July 2015) < http://documents1.worldbank.org/curated/en/817641467997610071/pdf/E4834-v2-EA-P152670-PUBLIC-Disclosed-9-21-2015-Box393209B.pdf> accessed 10 August 2020

[607] The Petroleum (Exploration and Production) (E&P) Act, 2016 (Act 919) and Model Petroleum Agreement (MPA).

[608] Ghana's Exploration and Production Act, 2016 (Act 919) sec. 43.

accordance with the law and is strictly liable for any loss or damage arising from the decommissioning of the facility.[609]

RETs are mostly located onshore, and their decommissioning procedures are considered during the planning and approval stages under EIA, where these issues are noted. However, at the planning stage the report that is submitted to the Ghana EPA may not be all that comprehensive in addressing problems that may arise from decommissioning. Therefore, it is expected that the widespread diffusion of RETs will lead to the enactment of legislation that will adequately take care of the decommissioning of RE projects in Ghana. OSPAR has provided some guidelines on the decommissioning of offshore RE infrastructure, which includes the removal of cables, but the fact remains that most RE projects are sited onshore. It is, however, important to underscore the fact that in the decommissioning process of RE installations, the waste is not toxic and less damaging to the environment because the overwhelming majority of the material used in their construction, about 95%, are recyclable.[610] Turbine decommissioning is somewhat relatively a straight forward process and can leave the sea bed in conditions similar to the ones before the installation was initiated especially with tidal turbines.[611]

5.5.4 Renewable Energy Technologies and Competition for Land

The increased demand for food and bioenergy from the world's explosive population has put a strain on how humankind and nature use land upon which agriculture depends on. In Ghana, communities have been dispossessed of their lands for biofuel investments in recent times. Large hectares of land in Bono, Bono East and Ahafo regions are allocated for the cultivation of jatropha to the neglect of cocoa and oil palm plantations.[612] The development of RETs may lead to the use of land otherwise meant for the cultivation of crops, recreational parks, and game reserves. In modern-day agriculture, food production is facing severe pressure arising from high demand from industrial countries for biomass in the face of population growth which puts pressure on the resources mentioned above and causes some disruption in communities.[613] The impact of bioenergy crops on cropland conversion is well known and an established phenomenon but the conversion of croplands for solar PV and CSP is a recent development and land use for solar was traditionally considered to be negligible but a review of global PV land sites has shown that this assumption was underestimated in reference to the actual land requirement.[614] Therefore more land will be required to build infrastructure for RETs to harvest the needed energy and this has brought about the energy versus food, landscape conflict.

So why are people opposed to the use of croplands for RETs and bioenergy? At the heart of the conflict is the concern about decreasing food security and sometimes property value. This is when farmlands are used to install solar panels or wind turbines that could otherwise be used to cultivate crops. In addressing this concern, it is recognised that the use of domestic

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[609] Ghana's Exploration and production Act, 2016 (Act 919) sec. 48.
[610] Brice Tremeac and Francis Meunier, 'Life Cycle Analysis of 4.5 MW and 250 W Wind Turbines' (2009) 13 Renewable and Sustainable Energy Reviews 2104.> https://doi.org/10.1016/j.rser.2009.01.001> accessed 19 December 2019
[611] Peter L Fraenkel, 'Tidal Current Energy Technologies' (2006) 148 Ibis 145 < https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1474-919x.2006.00518.x> accessed 17 January 2020
[612] Festus Boamah, 'How and Why Chiefs Formalise Land Use in Recent Times: The Politics of Land Dispossession through Biofuels Investments in Ghana' (2014) 41 Review of African Political Economy 406 <http://dx.doi.org/10.1080/03056244.2014.901947>.accessed 23 June 2020
[613] Edward S. Cassedy, *Prospects for Sustainable Energy: A Critical Assessment* (Cambridge University Press 2000) 102
[614] Carlos De Castro and others, 'Global Solar Electric Potential: A Review of Their Technical and Sustainable Limits' (2013) 28 Renewable and Sustainable Energy Reviews 824 <http://dx.doi.org/10.1016/j.rser.2013.08.040>.accessed 12 May 2020

land to produce biofuel has the potential to increase ES, especially when this energy replaces imported fossil fuels. Investment in land for modern bioenergy can have some synergies such as food security, innovation, helping farmers to diversify their income sources and thereby stabilise prices and promote rural development.[615]

Furthermore, opposition to RETs named as Not-In My-Backyard (NIMBY) may have partly been due to concerns about land use for non-agricultural and building purposes. The question is whether NIMBY is grounded in society's rejection of RETs or is just a selfish agenda of a few who oppose RETs. For example, it has been observed that there is a 'social gap' between the level of high support for wind energy technology and the local rejection of the technology by people living in the immediate vicinity where the RE project is located.[616] What can be inferred from this is that the opposition is generally coming from people living close to the project. It has been discussed in chapter one in subsection 1.6.2.5 under energy justice. Warren and others have observed that the level of opposition to RE projects depends on the distance, how far the opposers live away from the location of the project, and this goes to underscore the selfishness displayed in some of the rejections of RE installations.[617]

To address the issue is the suggestion by Endres that biomass cropping can be cultivated on "degraded lands", "abandoned lands", "'idle lands" and "marginal lands".[618] Field, Campbell, and Lobell have also made a similar call for only degraded and abandoned croplands to be used for bioenergy purposes.[619] In that sense RETs would not be competing for arable land that would otherwise be used for food production or forestry, and this can forestall any conflict.

Also, addressing the problem is the cultivation of biofuels from non-food feedstock so that biofuels would not compete or pose any threat to food production.[620] Furthermore, the problem can be addressed by the conversion of rooftop space for the installation of solar PV. Capellán-Pérez, Castro and Arto found that in the U.S.A 8.8% of total electricity demand could be supplied by rooftop PV, however, this is reduced to 4.5% in Germany a more densely populated country.[621] This is an indication that much cannot be generated from rooftop to meet the high demand hence a shift from rooftop towards land-based solar installations in the real world.[622] This shift is either due to limited availability of appropriate rooftop space in many countries, insufficient policies promoting their development or land-based installations offer

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[615] Keith L Kline and others, 'Reconciling Food Security and Bioenergy: Priorities for Action' (2017) 9 GCB Bioenergy 557 <https://doi.org/10.1111/gcbb.12366> accessed 19 June 2020

[616] Derek Bell, Tim Gray and Claire Haggett, 'The "social Gap" in Wind Farm Siting Decisions: Explanations and Policy Responses' (2005) 14 Environmental Politics 460 < https://doi.org/10.1080/09644010500175833> accessed 16 March 2020

[617] Charles R Warren and others, '"Green on Green": Public Perceptions of Wind Power in Scotland and Ireland' (2005) 48 Journal of Environmental Planning and Management 853 < https://doi.org/10.1080/09640560500294376> accessed 19 July 2020

[618] Jody M Endres, 'Bioenergy, Resource Scarcity, and the Rising Importance of Land Use Definitions' (2012) 88 North Dakota Law Review 559 <https://heinonline.org/HOL/P?h=hein.journals/nordak88&i=575> accessed 20 June 2020

[619] Christopher B Field, J Elliott Campbell, and David B Lobell, 'Biomass Energy: The Scale of the Potential Resource' (2008) 23 Trends in Ecology and Evolution 65 < https://doi.org/10.1016/j.tree.2007.12.001> accessed 23 July 2020

[620] David Tilman and others, 'Beneficial Biofuels-The Food, Energy, and Environment Trilemma' (2009) 325 Science < https://science.sciencemag.org/content/325/5938/270/tab-pdfl> accessed 14 May 2020

[621] Iñigo Capellán-Pérez, Carlos de Castro and Iñaki Arto, 'Assessing Vulnerabilities and Limits in the Transition to Renewable Energies: Land Requirements under 100% Solar Energy Scenarios' (2017) 77 Renewable and Sustainable Energy Reviews 760 <http://dx.doi.org/10.1016/j.rser.2017.03.137>. accessed 19 August 2020

[622] RR Hernandez and others, 'Environmental Impacts of Utility-Scale Solar Energy' (2014) 29 Renewable and Sustainable Energy Reviews 766 <http://dx.doi.org/10.1016/j.rser.2013.08.041>.accessed 18 July 2020

higher efficiency than the rooftop.[623] This shift towards ground-based solar installation has caused much opposition to RETs on the grounds of croplands concerns. Furthermore, the cultivation of crops can coexist with solar PV and wind farms to maximise land use. Barron-Gafford and others have confirmed that shading provided by solar PV panels has resulted in additive and synergistic benefits, including greater food yield, reduction in plant water drought when crops are grown on a solar farm.[624]

Regarding NIMBY, Environmental Assessment Regulations 1999, and EPA Act,1994 (Act 490) have taken care of some of the issues associated with it. Rules have also been formulated to guide the construction and installation of RETs so that they are relatively acceptable by planners and the general public.[625] It has also been observed that although wind farms occupy large portions of land, the actual footprint is between 1%-2% of the total site area thereby making the land space left between the towers to be available for other purposes. There is evidence collected from operational wind farms in Scotland that shows that they do not have any negative impact on property values, as this has been one of the reasons for the opposition to wind turbines.[626]

5.6 The Ability of Legal Tools to Promote Renewable Energy Technologies in Ghana

The perception is that RETs have a high cost compared to fossil fuel sources. RETs require heavy government subsidies to survive and become competitive or else they would have high tariffs for consumers for their energy. As far back in 2006, Clean Edge, in its report, suggests the opposite and holds that RETs can survive without government's support and can compete favourably with other energy carriers.[627] IRENA has also confirmed that onshore wind and solar PV are less expensive than their fossil fuel counterparts without financial support and now the most frequent cheapest source of energy generation in recent years.[628]

The IRENA report has further recognised that the initial stumbling block, which is the cost of installation and maintenance of renewables which was a barrier to their mass deployment, continues to witness a downward trajectory decline.[629] These low costs are expected to propel the mass adoption of renewables further. As discussed earlier in the thesis, various policies have been adopted to help tackle the initial challenges RETs faced to aid in their rapid deployment.[630] In Ghana, these legal and regulatory frameworks include Renewable Energy Act, 2011 (Act 832), REPO, and net metering. These legal tools that were deployed in their aid (RETs) have helped to overcome some of the challenges to a certain extent and RETs are expected to develop and become independent without the support of the legal tools that aided

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[623] Capellan-Perez, de Castro and Arto (n 621).
[624] Greg A. Barron-Gafford and others, 'Agrivoltaics Provide Mutual Benefits Across the Food -Energy-Water Nexus in Drylands' (2019) (2) Nature Sustainability < https://doi.org/10.1038/s41893-019-0364-5> accessed 31 July 2020
[625] James Keirstead, 'What Changes, If Any, Would Increased Levels of Low-Carbon Decentralised Energy Have on the Built Environment?' (2008) 36 Energy Policy 4518 < https://doi.org/10.1016/j.enpol.2008.09.019> accessed 28 June 2020
[626] Gwilym Pryce and Chris Timmins, 'Impact of Wind Turbines on House Prices in Scotland'.< https://www.climatexchange.org.uk/media/1359/cxc_wind_farms_impact_on_house_prices_final_17_oct_2016.pdf> accessed 29 March 2020
[627] Joel Makower, Ron pernick and Clint Wilder, 'Clean Energy Trends 2006' (Clean Edge, March 2006) < https://cleanedge.com/sites/default/files/trends2006_0.pdf> accessed 15 February 2020
[628] International Renewable Energy Agency, 'Renewable Power Generation Costs in 2018' (IRENA, May 2019) <https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018> accessed 15 May 2020
[629] ibid
[630] Chapter 3, subsection 3.6.8, sections 3.8 and 3.9

their penetration. However, an in-depth analysis of these legal tools, as seen earlier in chapter three, has revealed that they have not performed satisfactorily as envisaged, which in part has informed the carrying out of this project. It is for these reasons that the MOEn, of Ghana has set out to amend the RE Act to address the challenges that have been identified.[631]

For RETs to continue to be independent and further generate energy at lower costs, they would require further technical development, improvement in manufacturing design and mass production of the technologies.[632] As seen in the IRENA report, the costs of commercially available renewable power generation technologies for instance onshore wind and solar PV power continue to decline.[633] On the contrary, prices of oil and gas continue to fluctuate and soar in the world market.[634]

It is also projected that future energy prices and the additional costs of fossil fuel sources will increase considerably in the coming years, and competitiveness will peak in the next ten years. In its 2014 World Energy Outlook, the IEA forecast that in the short term, an oil market that depends on conventional energy sources for its supplies runs the risk of shortages of supply in the future as the global energy sector will face energy challenges.[635] IEA in its 2015 World Energy Outlook intimated that there is a shift towards the consumption of low carbon technologies which includes RETs as well, but the cost of extracting the remaining fossil fuels reserves is increasing whilst the cost of low carbon technologies, including renewables, continues to decline.[636]

Scholars like Walley and Whitehead assert that the curbing of environmental externalities in energy generation is likely to add more operational costs to companies.[637] However, this view is contrasted by Gelbspan, who states that the real economics involved in supplying the world with clean energy is not cost-related. but rather labour-related.[638] Geibspan further intimates that the process of generating clean energy with RETs will demand a large workforce which invariably leads to the creation of job opportunities.[639] In Ghana, the EC has forecast that the renewable energy sector can create about 220,000 jobs in conjunction with the broader economy and cut down carbon emissions by 11 million tonnes.[640] Cohen and Winn have indicated that switching from conventional technologies to RETs that are able to cancel and

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631 Ministry of Energy, 'Ghana: Renewable Energy Act to be Amended' (Africa Energy Portal, November 2018) <https://africa-energy-portal.org/news/ghana-renewable-energy-act-be-amended-energy-ministry> accessed 31 August 2020

632 H Müller-Steinhagen and J Nitsch, 'The Contribution of Renewable Energies to a Sustainable Energy Economy' (2005) 83 Process Safety and Environmental Protection 285 < https://doi.org/10.1205/psep.05084> accessed 19 July 2020

633 International Renewable Energy Agency, 'Renewable power generation costs in 2018' (IRENA, May 2019) <https://www.irena.org/publications/2019/May/Renewable-power-generation-costs-in-2018> accessed 25 May 2020.

634 AK Akella, RP Saini, and MP Sharma, 'Social, Economic and Environmental Impacts of Renewable Energy Systems' (2009) 34 Renewable Energy 390 <http://dx.doi.org/10.1016/j.renene.2008.05.002>.accessed 18 April 2020

635 International Energy Agency, 'World Energy Outlook 2014' (IEA, November 2014) < https://iea.blob.core.windows.net/assets/e6f58562-203e-474c-97a3-486f409aa7ff/WEO2014.pdf> accessed 31 July 2020

636 International Energy Agency, 'World Energy Outlook 2015' (IEA, December 2015) <https://eneken.ieej.or.jp/data/6508.pdf> accessed 12 July 2020

637 Noah Walley and Bradley Whitehead, It's Not Easy being Green' (1994) Harvard Business Review < https://hbr.org/1994/05/its-not-easy-being-green> accessed 12 February 2020

638 Ross Gelbspan, 'Addressing Climate Chaos' in Herbert Girardet (eds), *Surviving the Century: Facing Climate Chaos and other Global Challenges* (Earthscan 2007).

639 ibid

640 Energy Commission of Ghana, 'Ghana Renewable Energy Master Plan' [EC, February 2019] <https://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf> accessed 10 May 2022

nullify the externalities caused by fossil fuels creates new opportunities and businesses in the supply chain.[641] Additionally, improvement comes by remediating polluted ecosystems which brings about positive impacts on the environment, and making it more sustainable.[642] Furthermore, they state that innovative businesses can recognise it and create opportunities that can reverse the negative externalities and produce beneficial results like economic prosperity, a cleaner environment, and social benefits for both the present and future generations.[643]

Another perception that has been created is that conventional energy sources are more economical than RES, which is not grounded on any full analysis. A critical examination of the complete supply chain for conventional energy shows the advantages RES possesses, which have shorter supply chains as such RETs have become more attractive to energy investors.[644] In view of this, RES can be harnessed in a more efficient, economical, and environmentally friendly manner than fossil fuel sources. Laws and policies have been drawn to facilitate the accessibility and deployment of RETs, as seen in the RE Act. The regulatory framework's objective is to support the development, management, and utilisation of RES in an environmentally sustainable manner.[645] Pursuant to these objectives, the RE Act has granted some special treatment to RE developers like REPO which compels utilities to purchase a percentage of their electricity from RES.

In chapter three, the discussion made on the RE Act revealed many shortcomings emanating from it by some scholars.[646] These identified challenges need addressing to rectify those pitfalls by putting proper regulatory frameworks in place and provide incentives to improve and increase non-hydro RE adoption. The RE Act relies on the private sector to champion the RE revolution in Ghana. Therefore, some pertinent policies need to be in place to attract investment in the RE subsector, so that cost of generation and distribution is relatively kept low at affordable prices. Also, to allow small investors to be able to connect to the grid with ease and eliminate the 20 MW cap imposed on solar PV electricity generators to connect to the grid. The cap is unattractive to large scale investment in solar PV and would discourage many potential investors. The RE Act employs policies like REPO (yet to be implemented) to help increase the uptake of electricity generated from RES. The shortcomings in the RE Act as observed, the regulatory aspect of the Act has introduced bureaucratic procedures in the acquisition of licences that makes investment in the RE subsector unattractive to investors.[647] The time-wasting licensing procedures need overhauling to accommodate the concerns of prospective RE investors so that the daunting requirements are reduced. Lessons should be learnt from the UK's complex licensing system that led to high cost in electricity generation for energy generators which includes small generators as well.[648]

The president of Ghana, in his state of the nation address in 2017, alluded to these regulations to be anti-investor friendly and indicated that the RE Act needs reviewing to streamline things

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[641] Boyd Cohen and Monika I Winn, 'Market Imperfections, Opportunity and Sustainable Entrepreneurship' (2007) 22 Journal of Business Venturing 29 < https://doi.org/10.1016/j.jbusvent.2004.12.001> accessed 16 March 2020
[642] ibid
[643] Cohen and Winn (n 641).
[644] Hermann Scheer, *The Solar Economy: Renewable Energy for a Sustainable Global Future* (Earthscan 2002) 29
[645] Ghana's Renewable Energy Act, 2011 (Act 832).
[646] Atuguba and Tuokuu, Ismael Ackah, and Sakah and others.
[647] Raymond A Atuguba and Francis Xavier Dery Tuokuu, 'Ghana's Renewable Energy Agenda: Legislative Drafting in Search of Policy Paralysis' (2020) 64 Energy Research and Social Science 101453 <https://doi.org/10.1016/j.erss.2020.101453>.accessed 10 August 2020
[648] Grant Allan and others, 'The Economics of Distributed Energy Generation: A Literature Review' (2015) 42 Renewable and Sustainable Energy Reviews 543 <http://dx.doi.org/10.1016/j.rser.2014.07.064>.accessed 12 May 2020

to attract investors.[649] Take Spain, for instance, which has considerable wind resources in addition to sound government policies and the maturity of the wind technology, has successfully created the enabling environment for technological competition which has resulted in good projections for investors and this has led to private investment attraction in the RE sector.[650] Although the RE Act has the potential to address the ES issues of the country, in its current state as alluded by the president needs amendments to address the challenges identified. Transitioning to a low carbon economy, is not going to happen without costs. The possibility is that it is going to draw away resources in investments from other equally important sectors like health and education.[651] Flavin, in his analysis, traced the history of economic change to the 1860s, the period oil was discovered, it was far more expensive than coal and virtually useless, that is before the development of technologies like refineries came into being, it was not even suitable for transportation.[652] Flavin further observed that even when oil was used for lighting in the late nineteenth century, it was inconceivable that it would become a dominant energy source and even reshape the global economy.[653] He further posits that new technologies and businesses enter a niche of the market and offer services which are costly to specialised needs, however, with time the newcomer becomes economical, takes over a large share of the market, overtakes the dominant players and asserts itself to meet its own needs.[654] The transition from one generation of technology to another, in the beginning, is slow but gradually picks up and accelerates as economic advantages flip.[655] RETs are going through the same footpath as Flavin observed.

At this stage, the question is whether the Ghanaian economy can subsist on the consumption of RETs only and sustain the economy just as fossil fuels have done for a long time. Armaroli and Balzani have pointed out that energy is a very important national issue and all others, like health, education and many more, depend on its availability.[656] The availability of energy affords the country (Ghana) the ability to carry out its economic and social functions. This question is being asked having in mind that the consumption of RE is envisaged to contribute to economic growth and development.[657] Before coming to answer the question, it is worthwhile to consider the situation where the Ghanaian economy is currently dominated by fossil fuels imported from overseas with rising energy bills and its sustainability, this is in view of the fact that prices of fossil fuels continue to soar. As a result, reserves are depleted due to rising consumption.

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[649] Nana Akuffo Addo, 'State of the Nation Address 2017' (Parliament of Ghana, February 2017) <https://www.parliament.gh/epanel/docs/pub/SONA%20Feb%202017.pdf#viewer.action=download> accessed 19 January 2020

[650] Carmen Navarro, 'Spain: Greening Electricity while Growing the Economy' in William M. Lafferty and Audun Ruud (eds), *Promoting Sustainable Electricity in Europe: Challenging the Path Dependence of Dominant Energy Systems* (Edward Elgar Publishing limited 2008).

[651] Yacob Mulugetta and Frauke Urban, 'Deliberating on Low Carbon Development' (2010) 38 Energy Policy 7546 <http://dx.doi.org/10.1016/j.enpol.2010.05.049>.accessed 19 June 2020

[652] Christopher Flavin, 'Building a Low-Carbon Economy'
Featuring in 'State of the World: Innovations for a Sustainable Economy' (2008) 84-85 < http://www.urba2000.com/THNS2/IMG/pdf/low_carbon_economy.pdf> accessed 24 July 2020

[653] ibid

[654] Christopher Flavin, 'Building a Low-Carbon Economy'
Featuring in 'State of the World: Innovations for a Sustainable Economy' (2008) 84-85 < http://www.urba2000.com/THNS2/IMG/pdf/low_carbon_economy.pdf> accessed 24 July 2020

[655] ibid

[656] Nicola Armaroli and Vincenzo Balzani, 'The Future of Energy Supply: Challenges and Opportunities' (2007) 46 Angewandte Chemie - International Edition 52 < https://doi.org/10.1002/anie.200602373> accessed 18 July 2020

[657] Ertugrul Yildirim, Şenay Saraç and Alper Aslan, 'Energy Consumption and Economic Growth in the USA: Evidence from Renewable Energy' (2012) 16 Renewable and Sustainable Energy Reviews 6770 < https://doi.org/10.1016/j.rser.2012.09.004> accessed 16 August 2020

It has been observed that the full cost of relying on conventional energy sources is impacting negatively on the world economy.[658] This is the case because oil and gas generators now spend more resources on exploration to reach the remote areas where the remaining reserves are which hitherto were inaccessible but made possible by technology. This high expenditure on exploration is reflected in the prices of crude oil, which eventually is passed on to the final consumer, as evidenced in retail prices.[659] Coming back to RETs, their penetration is important. It should be supported by hard laws that will lead to their widespread diffusion. More hard laws like the RE Act and regulatory frameworks are needed to address the challenges observed by Flavin earlier. The new technologies will take over the conventional energy sources and become the dominant energy source. It has become clear that any technological improvement in the existing conventional energy sources would not be able to satisfy global energy requirements, and World Energy Outlook has projected that consumption will grow by near 50% from 2018 to 2050, and this will have to be bolstered by RETs.[660]

To answer the question posed earlier, whether RETs can perform the role of fossil fuels or not, on the global front a study conducted by LUT University in Finland and Energy Watch Group a non-profit organisation in Germany has confirmed that it is possible to transition to a 100% RE system by 2050, RE can cater for all sectors from power, transport, heating, and water sanitation/ desalination which will be more efficient and cost effective than the current energy system.[661] It is certainly possible that a regime of RETs can sustainably run the Ghanaian economy with RE based energy system without any issues. This is evidenced in the fact that until recently in 2016, renewables (hydro and biomass) powered both the electricity and heat sectors and provided electricity and heat needed for the economy. Energy for electricity and heat was mainly derived from hydropower and traditional biomass (woodfuels) respectively and fossil fuels catered for the transport sector.[662] The REMP of Ghana states that if the policies contained in the RE Act are effectively implemented for the country to achieve a 10% share of non-hydro RE in its electricity generation mix, many jobs will be created.[663] As already discussed, adoption of RE and implementing the REMP, would lead to ES, foreign exchange savings, socio-economic development and climate change mitigation these benefits will accrue on a sustainable basis for the growth of the economy.[664] Sen and Ganguly have reiterated the benefits of RE which includes bringing about climate change mitigation and foreign exchange savings which can lead to sustainable, social and economic development.[665] A renewable energy-based economy can propel and be the real

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[658] Mikael Höök, Robert Hirsch and Kjell Aleklett, 'Giant Oil Field Decline Rates and Their Influence on World Oil Production' (2009) 37 Energy Policy 2262 <https://doi.org/10.1016/j.enpol.2009.02.020> accessed 10 August 2020

[659] Aidan Meyler, 'The Pass through of Oil Prices into Euro Area Consumer Liquid Fuel Prices in an Environment of High and Volatile Oil Prices' (2009) 31 Energy Economics 867 <http://dx.doi.org/10.1016/j.eneco.2009.07.002>. accessed 27 July 2020

[660] U.S Energy Information Administration, 'International Energy Outlook 2019: with projections to 2050' (U.S EIA, 24 September 2019) <https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf> accessed 12 September 2020

[661] Manish Ram and others, Global Energy System Based on 100% Renewable Energy – Power, Heat, Transport and Desalination Sectors. Study by Lappeenranta University of Technology and Energy Watch Group (2019) <http://energywatchgroup.org/new-study-global-energy-system-based-100-renewable-energy>.accessed 14 September 2020

[662] Energy Commission of Ghana, 'National Energy Statistics 2007 – 2016 Revised' (EC, April 2017) <http://www.energycom.gov.gh/files/ENEERGY_STATISTICS_2017_Revised.pdf> accessed 10 September 2020

[663] Energy Commission of Ghana, Ghana Renewable Energy Master Plan (n 640).

[664] ibid

[665] Souvik Sen and Sourav Ganguly, 'Opportunities, Barriers and Issues with Renewable Energy Development – A Discussion' (2017) 69 Renewable and Sustainable Energy Reviews 1170 <http://dx.doi.org/10.1016/j.rser.2016.09.137>.accessed 20 September 2020

engine and driver of economic growth.[666] Lin and Ankrah have intimated in their study that RE has stimulated positive and higher economic growth than non-renewable energy, and this has confirmed that Ghana depended more on renewable (hydro) power than non-renewable (thermal) power for the period covered in their work and recommended that government should switch gradually to RE in the long term.[667]

As pointed out above, Ghana can rely on renewables to power the economy as it is endowed with an abundance of these resources.[668] One can draw parallels from the success stories of countries that have chalked significant strides in the deployment of RE. Iceland, for example, generates 100% electricity from renewables which is enough to power every household and is a vital contribution to the sustainability of the economy.[669] Also, the Renewable Energy Policy Network for the 21st Century (REN21), in its 2019 report indicated that in 2017 RE accounted for an estimated 18.1% of total final energy consumption globally and opportunities continue to grow for the increased use of RE electricity.[670] A Cambridge economics study revealed that a comparison of large-scale investments in offshore wind technology with investments in gas the former would impact positively on the UK economy by 0.8% by 2030, which has the capability of generating about £20 billion and bringing about 100,000 additional jobs by 2025 which then falls to about 70,000 by 2030.[671] The same benefit can accrue to other countries who commit similar investments in offshore wind technology instead of gas. It is very clear that an RE-based energy system can sustain Ghana's economy; therefore, it is incumbent on policymakers to formulate policies that would attract investors, especially the private sector, to invest in RES to harness them for economic growth and development. Investments in RETs will have a rippling effect on other subsectors of the Ghanaian economy; it will lead to high demand for goods and services for the construction, operation, and management of these RETs, as observed by Markaki and others for Greece.[672]

5.7 Sustainable Development as a Conceptual Framework

For Ghana to attain sustainable development (SD), conscious efforts must be put into the sustainable development of its RES, and this should be reflected in the energy policy. Energy takes centre stage in the SD paradigm as energy exploitation and consumption impact the

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[666] CBI, 'The Colour of Growth: Maximising the Potential of Green Business' <http://is4profit.com/wp-content/uploads/2012/07/cbi-the-colour-of-growth-maximising-the-potential-of-green-business.pdf> accessed 12 August 2020

[667] Boqiang Lin and Isaac Ankrah, 'Renewable Energy (Electricity) Development in Ghana: Observations, Concerns, Substitution Possibilities, and Implications for the Economy.' (2019) 233 Journal of Cleaner Production 1396 <https://doi.org/10.1016/j.jclepro.2019.06.163>. accessed 14 September 2020

[668] Dayann Obeng-Darko, 'Renewable Energy in Ghana and the Lessons from the EU: An Examination of the Regulatory Support Schemes' <https://www.jstor.org/stable/10.2307/26256506> accessed 15 May 2020

[669] EcoWATCH, 'Iceland: World's Largest Clean Energy Producer Per Capita' (EcoWATCH, 1 October 2015) <https://www.ecowatch.com/iceland-worlds-largest-clean-energy-producer-per-capita-1882105880.html> accessed 10 September 2020

[670] REN21, 'Renewables 2019 Global Status Report' (REN21, 2019) <https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf> accessed 14 September 2020

[671] Cambridge Economics, 'A Study into the Economics of Gas and Offshore Wind' (2012). A Report for Greenpeace and WWF.UK. <http://assets.wwf.org.uk/downloads/a_study_into_the_economics_of_gas_and_offshore_wind_nov2012.pdf> accessed 31 August 2020

[672] M Markaki and others, 'The Impact of Clean Energy Investments on the Greek Economy: An Input-Output Analysis (2010-2020)' (2013) 57 Energy Policy 263. <https://doi.org/10.1016/j.enpol.2013.01.047> accessed 10 August 2020

environment.[673] SD is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.[674] SD as a concept has been used as a conceptual framework in the study, this is because it lays the foundational premise for international energy and environmental law.[675] The concept of SD places the duty on the present generation to preserve energy resources and also protect the environment for future generations. SD stands on three key pillars thus economic development, social development, and environmental protection. The development of RETs revolves around the concept and falls in line with its key dimensions (economic, social, and environmental) and serves the interests of present and future generations, which are the cardinal goals of the concept. Therefore, the use and management of our natural resources will be viewed in light of SD. Furthermore, the development of a sustainable energy legal framework can be linked to the concept of SD, and as seen earlier in the chapter, the use of legal tools has helped in the deployment and development of RETs.

Using LCA analysis earlier in the chapter, it was demonstrated how RE addressed economic, social, and environmental development issues in the context of SD. It was also shown that RE is the panacea to climate change mitigation and other challenges. However, RES is not completely problem-free and comes along with some issues of unsustainable development with some challenges to the environment. For example, energy derived from wind will lead to sustainable use of energy which is harmless to the environment. However, a solution to one of the challenges of unsustainable development comes with new environmental challenges, i.e., an attempt to solve one problem creates new problems. For example, in the U.K, ironically, there is opposition to wind technology on the grounds of environmental concerns such as landscape, visual impact issues and noise. Applying reflexivity enables a broader theoretical and conceptual clarification of concepts like SD and its relevance to issues that have been considered in this study, thus an evolving legal framework in a fledging area like RE.[676]

Furthermore, government subsidies to RETs developers and manufacturers to support RE projects help in the development of RE and gear towards sustainability. However, the subsidies invariably deny consumers the right to competitive and cheap energy. It is because the government uses the taxpayers' money to finance this policy. In some cases, the government imposes certain taxes on conventional energy generators, which are then passed on to final consumers, thus increasing energy bills, leading to energy poverty for the poor in society. SD involves some trade-offs in its economic, social, and environmental components, which cannot all be resolved at the same time.[677] As already alluded to in this chapter, despite the perceived challenges and the negative impacts RETs may have nevertheless, they are negligible and therefore make them offer a better alternative for sustainable energy

[673] Anna Stanford, 'A Vision of a Sustainable Energy Future' (1997) 10 Renewable Energy 417 < https://doi.org/10.1016/0960-1481(96)00099-7> accessed 20 October 2020
[674] Brundtland Report 1987, 'Report of the World Commission on Environment and Development: Our Common Future' <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf> accessed 14 August 2019
[675] Lakshman Guruswamy, 'Energy Justice and Sustainable Development' (2010) 21 Colorado Journal of International Environmental Law and Policy 231 <https://heinonline.org/HOL/P?h=hein.journals/colenvlp21&i=235> accessed 19 January 2020
[676] Heidi Rapp Nilsen, 'The Joint Discourse "reflexive Sustainable Development" - From Weak towards Strong Sustainable Development' (2010) 69 Ecological Economics 495 <http://dx.doi.org/10.1016/j.ecolecon.2009.11.011>.accessed 12 September 2020
[677] AMG Cornelissen and others, 'Assessment of the Contribution of Sustainability Indicators to Sustainable Development: A Novel Approach Using Fuzzy Set Theory' (2001) 86 Agriculture, Ecosystems and Environment 173. <https://doi.org/10.1016/S0167-8809(00)00272-3> accessed 19 August 2020

consumption now and in the future. As observed earlier, RETs are capital intensive initially but offer long-term benefits that are sustainable and invaluable.

5.8 Sustainable Development as a Legal Tool that Supports Renewable Energy Technologies

Before considering SD as a legal tool that can be used to support the adoption RETs, a brief background to it obtaining its legal status will be discussed. The evolution of the concept of SD into a legal tool is still an ongoing process; this may be due in part because of its multi-dimensional nature, which cuts across into areas of social, economic, and environmental development. SD law can be defined as a body of international legal principles which address multi-disciplinary integrated areas of economic law, social law, and environmental law.[678] Boyle agrees with the assertion that the concept of SD is still ongoing to become law which may take some time to assert its authority based on its merits to be considered by the law courts.[679] Considering SD as a legal instrument, Ruhi raised the issue of some standard of behaviour that is needed to command a binding effect on all.[680] However, getting the appropriate behaviour which encompasses social, economic and environment that the concept is made of would be hard. Bosselmann suggests that less emphasis should be placed on the concept but rather, the emphasis should be on the 'sustainability' aspect of the concept, which embodies the three components of SD (social, economic and environment), as it is sustainability that meets the standard requirement of a legal principle.[681] It is sustainability that makes the concept of SD to be normative and meets the requirement to be classified as a legal principle.[682]

Sustainability standards allow economic activities to go on as long as social and environmental considerations are taken on board as shown in EIA which is described by Robinson as the most expansive and extensively enacted system of sustainability.[683] As seen earlier, the EPA is obligated to serve notice in writing and require any person responsible for any undertaking, which in the opinion of the agency has or is likely to have adverse effect on the environment, to submit to the agency in respect of the undertaking an EIA containing such information within such period as shall be specified in the notice-this is mandatory.[684] The conduct of EIAs by countries has become an international legal requirement when activities of one state is likely to have an impact on the environment in the other.[685] Inter and intragenerational equity, polluter pays principle and precautionary principles have become the backbone of the concept of SD which have gained recognition and respect in judicial rulings and international treaties.

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[678] Marie Claire Cordonier Segger, 'Significant Developments in Sustainable Development Law and Governance: A Proposal' (2004) 28 Natural Resources Forum 61 < https://doi.org/10.1111/j.0165-0203.2004.00072.x> accessed 20 July 2020

[679] Alan Boyle, 'Soft Law in International Law-Making' in Malcolm D. Evans (ed), International Law (4th edn Oxford University Press 2014).

[680] J B Ruhl, 'Sustainable Development: A Five-Dimensional Algorithm for Environmental Law' (1999) 18 Stanford Environmental Law Journal 31 <https://heinonline.org/HOL/P?h=hein.journals/staev18&i=39> accessed 12 August 2020

[681] Klaus Bosselmann, *The Principles of Sustainability: Transforming Law and Governance* (Ashgate Publishing Ltd 2008) 46

[682] ibid

[683] Nicholas A Robinson, 'Comparative Environmental Law Perspectives on Legal Regimes for Sustainable Development' (1998) 3 Widener Law Symposium Journal 247 <https://heinonline.org/HOL/P?h=hein.journals/wlsj3&i=261> accessed 19 August 2020

[684] Ghana's Environmental Protection Act, 1994 (Act 490) sec.12 (1).

[685] Charles E DiLeva, 'International Environmental Law and Development' (1998) 10 Georgetown International Environmental Law Review 501 < https://heinonline.org/HOL/P?h=hein.journals/gintenlr10&i=513> accessed 31 July 2020

It reflects SD as a legal principle that informs the basis of their involvement in judicial judgements and laws. For example, in Canada, the precautionary principle was given the recognition as a principle of environmental law in the case 114957 Canada Ltee (Spraytech, Societe d'arrosage) v. Hudson (Town).[686]

There is no need to attempt to enact one single Act on SD, and there is no field of law as yet denoted as SD law.[687] Sustainability is not attributable to one source of law, even international environmental law, which was in existence before SD had so many sources. SD with legal status can be recognised even though it is manifested in several sources in the form of principles. These principles are capable of being used to promulgate legal frameworks having the force of a hard law with enforceability and duties. International environmental law is evolving to become SD law which falls in line with the U.N General Assembly's Resolution 44/228; one main objective of the Rio 1992 Conference was to develop international environmental law, as reflected in articles 10, 11 and 27 of the Rio Declaration. Also, at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, the concept of SD was adopted as the new paradigm for international environmental law.[688]

Furthermore, the United Nations Environmental Programme initiative 'Green Economy' has redefined growth in the context of the concept of SD; thus, a green economy is an economy that is low carbon, resource-efficient and socially inclusive.[689] A green economy also promotes a triple bottom line through the advancement of economic growth, environmental and social well-being; the green economy was approved at the Rio+20 United Nations Conference on SD in 2012.[690] In order to encourage states to commit to the affirmation of the Green Economy, there is a Global Green Economy Index (GGEI) that measures the green economic performance of the various countries. The measurement is across four dimensions climate change and social equity, sector decabonisation, markets and investments and environmental health. Out of 160 countries, Sweden topped the 2022 rankings.[691] GGEI results show that countries that rely on fossil fuels both for export and import do not perform well. The green economy approach has added a new perspective to the definition of the concept of SD, which stresses sustainability in the generation and consumption of energy.

The concept of SD cannot be discussed without considering the challenges and perceived limitations it faces. To start with, one of the challenges of SD is that people and policymakers should understand and learn from the scientific facts and evidence and adjust their views on current consumption patterns accordingly. Then the next two main challenges to the energy system transformation are highlighted, including the technology and investment challenges. It is evident that many of the technologies that would support SD are already deployed. However, how to improve them to bring about cost reduction and innovative changes is the challenge. Furthermore, how to provide incentives that would lead to innovation, knowledge-

[686] Supreme Court of Canada,114957 Canada Ltée (Spraytech, Société d'arrosage) v. Hudson (Town) (2001) 2 S. C. R. 241.
[687] Robinson (n 683).
[688] Anita M Halvorssen, 'International Law and Sustainable Development - Tools for Addressing Climate Change' (2011) 39 Denver Journal of International Law and Policy 397 <https://heinonline.org/HOL/P?h=hein.journals/denilp39&i=407> accessed 19 June 2020
[689] United Nations Environment Programme, 'Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication' (2011). <https://www.cbd.int/financial/doc/green_economyreport2011.pdf> accessed 16 June 2020
[690] U.N, 'United Nations Conference on Sustainable Development, 20-22 June 2012, Rio de Janeiro' (U.N Conference, 20-22 June 2012) <https://www.un.org/en/conferences/environment/rio2012> accessed 27 March 2022
[691] Dual Citizen, 'Results from the 2022 Global Green Economy Index (GGEI)' (Dual Citizen,18 April 2022) <https://dualcitizeninc.com/results-from-the-2022-global-green-economy-index-ggei/> accessed 19 July 2022

sharing, and diffusion remains the challenge.[692] These changes need to reflect and respond to specific local and sectoral needs. The investment challenge is seen in the global investment that is made in RE; in the last decade, there have been significant investments in RE, but the kind of investment that would lead to SD falls far below expectation. Investments needed to transform the energy system are estimated to be high, and this contends with problems of unknown or uncertain costs. The World Economic Forum in 2013 indicated that additional investments of at least US$0.7 trillion will be required to put the world on a sustainable path between 2010 and 2030.[693]

What are the limitations of the concept of SD? Haque has identified five drawbacks as follows:[694]

(1) Emphasis on economic growth, this approach has contributed to the harm that has been caused to the environment. Though it advocates for environmental sustainability, the Brundtland report continues to stress the new dawn of economic growth, which invariably diminishes the relevance of the environmental aspect. of the concept.[695]

(2) Its utilitarian tendency to view development in terms of the level of consumption, this position features in its concern that excessive consumption now would jeopardise similar consumption by future generations. This consumerism view of development in itself is a challenge to the environment.

(3) SD tends to show an indifferent attitude towards the cultural and normative dimensions of development. There are many cultures though judged in modern terms to be backward but often pay attention to the environment in pursuit of socio-economic development.

(4) The concept does not pay attention to the interclass and international inequalities that adversely affect the environment, as the rich class and nations are those that are engaged in excess consumption of fossil fuels and emit GHG emissions and deplete the ozone layer.

(5) The concept does not properly address the internal and international power structures and their implications when it comes to the adoption and implementation of treaties, conventions, agreements, regulations, and laws that concern the protection of the environment. It has often rendered some laudable initiatives weak and unimplementable. Some powerful nations can block international agreements that are seen to be against their interest, e.g., the U.S.A withdrawal from the Paris Agreement of 2015 by the Trump administration, but the Biden administration has now overturned that.

These limitations of SD, notwithstanding, have not eroded its benefits. Its main theme: the sustainable consumption of our planetary resources judiciously, which includes energy resources, is still relevant today. It calls on all to be mindful of the impact of our activities, especially energy consumption on the environment as we all live in it.

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[692] Department of Economic and Social Affairs, World Economic and Social Survey 2013: Sustainable Development Challenges (2013) <http://esa.un.org/wpp/documentation/pdf/WPP2012_ KEY FINDINGS.pdf>.accessed 20 July 2020

[693] ibid

[694] M Haque, 'Environmental Discourse and Sustainable Development Linkages and Limitations' (2000) 5 Ethics and the Environment 3 <https://doi.org/10.1016/S1085-6633(99)00034-0> accessed 14 August 2020

[695] Brundtland Report 1987, 'Report of the World Commission on Environment and Development: Our Common Future' <https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf> accessed 14 August 2019

5.9 Conclusion

The legal frameworks that have been evolved for the deployment and development of RETs can protect the environment. In this chapter, a comparative analysis has been made of the environmental impact of fossil fuels and RES. It has been established that RETs by far have less environmental impact and, as such, have a minimum net contribution of carbon emissions. The adoption of RETs also offers economic benefits as they provide jobs. From the comparative analysis, Bilen and others intimated that the external cost of a coal plant was 3-4 cents per kWh; on the contrary, the external cost of RE was pegged at 0.1-2.5 cents per kWh.[696] RETs have negligible levels of emissions which are environmentally benign and can be re-absorbed within the ecosystem. The positive impact these RETs have on the environment has motivated many countries to come out with policies and legal frameworks that will lead to their rapid adoption, like the Ghanaian Renewable Energy Act, 2011 (Act 832). The environmental benefits, as observed by Akella, Saini and Sharma, are enormous, which include a reduction in air pollution, maintenance of natural resources on a long-term basis, and lower impact on watersheds.[697] The law plays a significant role at the planning stage where some externalities of RETs, such as environmental impact issues, noise pollution, landscape issues are addressed when permits are issued for every project to be undertaken. This role is played strictly by the EPA of Ghana.

R&D would be used to eliminate the negligible externalities associated with RETs. R&D would also be used to bring improvement to make them mature. The main challenges confronting RETs do not emanate from the technologies themselves but from political and institutional biases in favour of fossil fuels which is manifested in the heavy subsidies provided. The chapter has established that RE is the alternative that can stem climate change and thereby allow countries to meet their international environmental obligations. The law could be used to overcome political and institutional challenges. The law must play a crucial part in ensuring that the environment is protected through the adoption of RE. As discussed in the chapter, planning and EIA laws tackle environmental concerns at the very beginning of every project. It is important as environmental laws only intervene at the latter stages, i.e., the processing and consumption stages. The LCA tool is employed to analyse the two energy systems, conventional and renewable and it was revealed that GHG emissions from the consumption of non-RES are high, whereas emissions from RE are far lower or negligible. LCA assesses the impact an energy project would have on the environment from the early stages to the latter stages. EIA laws in Ghana should incorporate this tool into its framework so that all environmental issues can be addressed holistically at all the stages.

When any RET infrastructure comes to the end of its useful life, it needs proper retirement and decommissioning, and the laws governing decommissioning must ensure proper and effective disposal. The fact is that, most existing laws are focused on offshore energy infrastructure, whereas most RE projects are sited onshore. It is yet to be seen how planning and EIA laws would take care of this situation concerning RETs as it has been recognised that existing laws on decommissioning are centred on offshore fossil energy sources and not RES.

The concept of SD has economic, social, and environmental dimensions to be the three pillars that establish it to be relevant in the discourse on sustainable energy. The generation and consumption of energy have a remote duty by the present generation to exploit our planetary resources to satisfy our needs without denying future generations these resources. The study set out to establish the legal status of the concept to understand how it can aid the development of RETs. Its legal status has been established in several international

[696] K Bilen and others, 'Energy Production, Consumption, and Environmental Pollution for Sustainable Development: A Case Study in Turkey' (2008) 12 Renewable and Sustainable Energy Reviews 1529. <https://doi.org/10.1016/j.rser.2007.03.003> accessed 20 August 2020
[697] Akella, Saini and Sharma (n 634).

conventions, treaties, and court cases. However, the principle's appearance in treaties and conventions has been couched in the form of a soft law which has no binding effect. However, its general acceptability gives it normative power by the global community and other actors as a legal principle which makes it worthwhile.[698] The research seeks to establish effective, new ways of formulating legal frameworks on the sustainability generation and consumption of energy as part of the sustainable energy law and policy of Ghana. The concept lays the foundation on which a successful legal framework can be built as the concept is both a conceptual framework for the development of RETs and a legal principle. Being both of the above, it can play a crucial role in energy sustainability when incorporated into the legal frameworks of existing and proposed laws. All in all, RETs, notwithstanding their perceived environmental challenges, have the potential to protect the environment by mitigating climate change than fossil fuel technologies.

The next chapter is six, and it will discuss the challenges and opportunities in adopting RE and the effectiveness of the legal and policy frameworks used in addressing energy security challenges in Ghana.

[698] Marie-Claire Cordonier Segger, Ashfaq Khalfan and Salim Nakjavani, 'Weaving the Rules for Our Common Future: Principles, Practices and Prospects for International Sustainable Development Law' 1 <http://cisdl.org/wtr/pdf/WeavingtheRulesOct2002.pdf> accessed 17 June 2020

CHAPTER SIX

CHALLENGES AND OPPORTUNITIES IN ADOPTING RENEWABLE ENERGY AND THE EFFECTIVENESS OF THE LEGAL INSTRUMENTS DEPLOYED IN ADDRESSING ENERGY SECURITY CHALLENGES IN GHANA

6.1 Introduction

This chapter discusses the challenges and opportunities in adopting RE and the effectiveness of the legal tools deployed in addressing ES challenges in Ghana. Meeting the energy needs of the citizenry without compromising economic development and environmental protection remains the biggest challenge for the development of every Country.[699] In addition to providing sufficient supply of energy to match demand, making energy readily available to every citizen to enjoy energy services, provide ES and curb the adverse impact of energy consumption on the environment are some of the fundamental challenges that confront the world. Studies have shown that energy consumption has a positive link with the indices of economic growth and wellbeing.[700] That is why the provision of energy to the population is crucial as a measure towards SD. However, many countries face a myriad of energy challenges that include inadequate energy supplies, energy supply deficits and uncertainties, energy price hikes, environmental pollution, and degradation. In developing countries, these challenges have undermined their economic development prospects and constrained the efforts to alleviate poverty. Addressing the challenges has become the centrepiece of the energy policies of many countries, and this has been framed as one of enhancing ES.[701]

Ghana as a developing country, access to available, affordable, and reliable energy services is fundamental to reducing poverty, improving health, and promoting economic growth. In the early 1970s, demand for energy in the Country was relatively low, and the hydro dams that were built generated enough to meet demand and the surplus was exported to neighbouring countries like Togo. However, in recent times demand has increased, and generation has fallen. It has put the Country in an energy crisis that necessitated the exploration of other alternatives to improve upon the situation. The other alternatives being explored are non-hydro RES, mainly solar and wind. As a result, the government enacted the Renewable Energy Act, 2011 (Act 832) to attract the private sector to invest in the RE subsector. The Act states clearly, among other objectives, that the Country is pursuing this line of action to improve its ES and combat climate change.

The discussion has underscored the benefits of RES as follows: they are being replenished constantly, provide ES, provide socio-economic development, and provide climate change mitigation. However, RE adoption faces a myriad of barriers, including the Country's poor policy and legal framework, capital costs, siting and transmission, market entry, unequal playing field and reliability misconceptions. Nuclear is seen as a clean energy source which can equally be used to support the ES of the Country and mitigate climate change. However, Ghana is yet to add it to its energy mix; the drawback of nuclear is that it is not an RE source

[699] Yaping Hua, Monica Oliphant and Eric Jing Hu, 'Development of Renewable Energy in Australia and China: A Comparison of Policies and Status' (2016) 85 Renewable Energy 1044 <http://dx.doi.org/10.1016/j.renene.2015.07.060>.accessed 20 January 2020

[700] BS Warr and RU Ayres, 'Evidence of Causality between the Quantity and Quality of Energy Consumption and Economic Growth' (2010) 35 Energy 1688 <http://dx.doi.org/10.1016/j.energy.2009.12.017>. accessed 15 November 2020

[701] Collins Ayoo, Towards Energy Security for the Twenty-First Century (2020) < http://dx.doi.org/10.5772/intechopen.90872> accessed 12 December 2020

and concerns dog it about its safety following the nuclear disasters in Chornobyl and Fukushima.

The oil crisis of the 1970s brought the concept of ES to the limelight, and interest from academia declined following the stabilisation of oil prices in the late 1980s and 1990s. However, the concept has re-emerged in the 2000s, driven by high demand for energy globally as a result of population growth, economic development and the pressure to de-carbonise energy systems.[702] The contemporary ES challenges go beyond oil supplies and now encompass other issues such as access to modern energy and climate change mitigation.

This chapter will critically discuss the ES of the Country, relying on the International Energy Agency's (IEA) definition, which is the uninterrupted availability of energy sources at affordable prices. The Asia Pacific Energy Research Centre (APERC) has expanded the IEA's definition to include availability, affordability, accessibility, and acceptability. Following this examination, it has come to light that Ghana's ES is in a precarious state. The four As espoused by APERC, have been used to measure the ES of the Country. Ghana's energy mix has partially met the availability and diversity dimensions of ES but has failed to meet its affordability and accessibility dimensions.

The chapter is divided into eight main sections with subsections, following the introduction is section 6.2, which presents the opportunities in the deployment of RE. Section 6.3 discusses the challenges in the deployment of RE. Section 6.4 discusses the mitigation actions for removing key barriers to RETs in Ghana. Section 6.5 discusses ES. Section 6.6 discusses nuclear energy in Ghana. Section 6.7 evaluates the effectiveness of the legal frameworks deployed in Ghana to address ES challenges. Section 6.8 draws the conclusion and summarises the salient issues that have been discussed in the chapter.

6.2 Opportunities in the Deployment of Renewable Energy

The world's growing demand for energy due in part to population growth has led to the continuous consumption of fossil fuels. It has brought in its wake challenges such as depletion of fossil fuels reserves, GHG emissions, armed and geopolitical conflicts and energy price fluctuations, this situation is unsustainable which could be a potential threat to human societies.[703] RES (hydro, solar, wind, biomass, geothermal) are carbon neutral and can stem the adverse impact of conventional energy sources.[704]

The opportunities that come along with RE are numerous. The major ones include: the ability to replenish naturally, the ability to increase ES and reduce dependence on energy imports, the ability to reduce GHG emissions and mitigate climate change, the ability to bring electricity to remote areas or island communities, creation of jobs and improving the living standards of people.[705] Renewables are cheap to operate as they are fuel-free, and their maintenance is minimal. RES are replenished naturally without being depleted and are reliable and

[702] Kathleen J Hancock and Vlado Vivoda, 'International Political Economy: A Field Born of the OPEC Crisis Returns to Its Energy Roots' (2014) 1 Energy Research and Social Science 206 <http://dx.doi.org/10.1016/j.erss.2014.03.017>.accessed 12 November 2020

[703] U.N, 'Adoption of the Paris Agreement' (U.N 12 December 2015) < https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf> accessed 10 June 2020

[704] G.N Tiwari and R.K Mishra, *Advanced Renewable Energy Sources* (Royal Society of Chemistry 2012) 457

[705] Phebe Asantewaa Owusu and Samuel Asumadu-Sarkodie, 'A Review of Renewable Energy Sources, Sustainability Issues and Climate Change Mitigation' (2016) 3 Cogent Engineering 1 <http://dx.doi.org/10.1080/23311916.2016.1167990>.accessed 12 November 2019

sustainable.[706] These sources are locally available and can be easily harnessed to provide ES. RE provides the ES of a country, there is no consensus on its precise meaning, but simply it involves the continuous supply of energy for the running of the economy.[707] More details on ES are provided in subsequent sections.[708]

The social and economic development provided by RE is because energy plays an important role in economic development, and there is a strong correlation between economic growth and energy consumption.[709] Globally, per capita income has a correlation with per capita energy consumption, and economic development is the driver behind the increasing energy consumption in the last decades.[710] It has also been established that RE creates jobs and employment, and it has brought about improvement in sectors like health, education, gender equality and environmental safety.[711]

Access to energy is one of the important aspects of ES. Due to its importance, it has been captured as one of the U.N Sustainable Development Goals, goal 7 (Ensure access to affordable, reliable, sustainable, and modern energy for all). This goal can only be achieved by adopting RE, bringing about sustainability in energy consumption. Access can be better understood in the local context. In Ghana, there is a difference between electrification in the rural and urban areas, the latter having more access to electricity than the former, a common feature in other Sub-Saharan African countries.[712] In Ghana, the national grid is barely extended to the rural areas, especially island communities. This problem is solved with the advent of RE-based mini grids, which extend electricity access to these rural and remote island communities. As discussed in chapter one-under subsection 1.6.2.4 on energy justice, these mini-grids and solar systems were meant to be distributed to off-grid communities. Instead, Accra, the capital city of Ghana, which has the highest access to grid power, again had the highest record of net metering and solar PV systems because most of them are wealthy and well educated, those who missed out are the uneducated and poor rural dwellers an affront to energy justice.[713]

RES brings about the reduction of GHG emissions, and this minimises the negative environmental impact and mitigates climate change. RES holds the prospect of a sustainable energy supply that supports the transition to a low carbon economy. As seen in earlier chapters, the transition from non-sustainable energy sources to RES poses the most significant challenge in the transition process, as observed by Verbruggen and others.[714]

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[706] Caleb Mensah and Mary Magdalene Mensah, 'Climate Change and the Viability of Renewable Energy in Ghana' (2018) 07 Innovative Energy & Research <https://doi.org/10.4172/2576-1463.1000196> accessed 19 October 2020

[707] Bert Kruyt and others, 'Indicators for Energy Security' (2009) 37 Energy Policy 2166 < https://doi.org/10.1016/j.enpol.2009.02.006> accessed 19 September 2020

[708] Section 6.5 and subsections 6.5.1 to 6.5.6

[709] Bosede Ngozi Adeleye and others, 'Energy Use and the Role of per Capita Income on Carbon Emissions in African Countries' (2021) 16 PLoS ONE 1 <http://dx.doi.org/10.1371/journal.pone.0259488>.accessed 10 January 2022

[710] ibid

[711] Owusu and Asumadu-Sarkodie (n 705).

[712] Abeeku Brew-Hammond, 'Energy Access in Africa: Challenges Ahead' (2010) 38 Energy Policy 2291 <http://dx.doi.org/10.1016/j.enpol.2009.12.016>.accessed 16 August 2020

[713] Festus Boamah, David Aled Williams, and Joana Afful, 'Justifiable Energy Injustices? Exploring Institutionalised Corruption and Electricity Sector "Problem-Solving" in Ghana and Kenya' (2021) 73 Energy Research and Social Science 101914 <https://doi.org/10.1016/j.erss.2021.101914>.accessed 20 March 2022

[714] Aviel Verbruggen and others, 'Renewable Energy Costs, Potentials, Barriers: Conceptual Issues' (2010) 38 Energy Policy 850 < https://doi.org/10.1016/j.enpol.2009.10.036> accessed 19 May 2020

6.3 Challenges in the Deployment of Renewable Energy

Barriers to RE are numerous, and the main ones include the Country's policy and legal frameworks barriers, capital costs barrier, siting of RE projects barrier, lack of technical expertise barrier, social-cultural and education barriers and land intermittency and landscape barriers.

6.3.1 The Country's Legal Frameworks and Political Barriers

The Country's legal frameworks, policies and political environment are crucial in adopting RE. These policies give the country the direction in its bid to explore and exploit its RES to meet its ES challenges and stem GHG emissions. It is demonstrated in Ghana by the enactment of the RE Act and other RE policies.[715] Inadequate legal and policy frameworks, such as a country's poor legal instruments and policies, affect RE deployment and development as well as technological innovation. For example, the poor implementation of the RE Act and other supporting instruments has led to little penetration of non-hydro RE in the electricity generation mix. Furthermore, the bureaucratic licensing procedures are a disincentive for potential RE investors. Also, many countries, including Ghana, still have policies and regulations that favour monopoly or near-monopoly providers; these policies protect conventional sources in the value chain of energy generation, transmission, and distribution, and this has become a hindrance in the way of the various RE forms' deployment and development in the Country.[716]

6.3.2 Capital Cost Barrier

Capital costs are related to the upfront expenditure incurred in building and installing solar and wind farms. The average cost to install solar systems ranges from US$2,000 to US$3,700 per kilowatt for residential systems.[717] Then wind comes with costs ranging from US$1,200 to US$1,700 per kilowatt, whilst a natural gas plant may cost US$1,000 per kilowatt.[718] The initial capital needed in the construction makes it look risky and expensive. All power projects have some financial risks because of uncertainties in the future relating to prices of electricity, as such private capital market demands high returns for such risky investments than their counterparts, matured technologies, and this increases the cost of RE projects.[719] However, if these costs are viewed in light of the lifespan of the RE project, then solar and wind are less expensive as being portrayed.[720]

These initial high costs in investment for RE systems make them expensive to most potential investors in most developing countries, of which Ghana is no exception.[721] Lack of access to credit, because domestic banks and other financial institutions are reluctant to provide finance for RETs, in situations when it is given it comes with high interest rates. Also, the unstable and

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[715] Owusu and Asumadu-Sarkodie (n 705).
[716] Souvik Sen and Sourav Ganguly, 'Opportunities, Barriers and Issues with Renewable Energy Development – A Discussion' (2017) 69 Renewable and Sustainable Energy Reviews 1170 <http://dx.doi.org/10.1016/j.rser.2016.09.137>.accessed 10 July 2020
[717] Union of Concerned Scientists, 'Barriers to Renewable Energy Technologies' (Lazard, 20 December 2017) <https://www.ucsusa.org/resources/barriers-renewable-energy-technologies> accessed 12 May 2020
[718] ibid
[719] Robert Gross, William Blyth, and Philip Heptonstall, 'Risks, Revenues and Investment in Electricity Generation: Why Policy Needs to Look beyond Costs' (2010) 32 Energy Economics 796 <http://dx.doi.org/10.1016/j.eneco.2009.09.017>.accessed 14 November 2020
[720] 'Levelized Cost of Energy 2017'<https://www.lazard.com/perspective/levelized-cost-of-energy-2017/> accessed 1 October 2020.
[721] Nadia S. Ouedraogo, 'Opportunities, Barriers and Issues with Renewable Energy Development in Africa: a Comprehensible Review' (2019) Current Sustainable Renewable Energy Rep 6, 52–60 <https://doi.org/10.1007/s40518-019-00130-7> accessed 15 May 2020

weak local currency (the Cedi), which fluctuates against major international currencies like the dollar, does not help in doing business which involves RE projects. Furthermore, RE projects are perceived to be risky, there is inadequate capital available to the banks to advance to RE developers and bank staff lack information about the benefits of RE.[722] To overcome this barrier, innovative ways of sourcing finance are being suggested, the establishment and resourcing of the RE Fund is much anticipated, and the operationalisation of the Fund is important as it can give soft loans, grants and provide flexible financing schemes as well as subsidies for RE development.

6.3.3 Siting of Renewable Energy Projects Barrier

Siting of RE projects involves locating wind turbines and solar farms on land. It requires the acquisition of permits, negotiations, and community relations; these processes increase costs, delay, or even kill projects. Transmission involves the power lines and infrastructure needed to move the generated electricity from the place of generation to the point of consumption. RE is a relative newcomer, as such, the infrastructure that exists today was built to suit hydro and now thermal but not solar and wind in the case of Ghana. The lack of infrastructure for transmission and distribution, as well as the lack of equipment for companies dealing in non-hydro RE generation, is a major hurdle for RE development.[723]

As is the case, solar and wind farms are not sited near these transmission and distribution networks. This arrangement presents many challenges for solar and wind as such new transmission lines are needed to evacuate the power generated, this involves capital which further increases the cost. In Ghana, the existing transmission and distribution lines are old and weak but were built for hydro and later thermal. Electricity generated from solar, and wind must comply with subcodes performance requirements to connect to the transmission and distribution networks. The regulator sets this requirement. (PURC) These weak grid lines have led to very high transmission and distribution losses, which has become a disincentive for potential RE investors.[724]

Market penetration has become a hurdle for RE as a relatively new entrant; the market is already dominated by the big players like the fossil fuel trio (coal, natural gas, and oil) and nuclear, and these existing technologies are mature and hold a lot of market share. In Ghana, the market is underdeveloped with a small size, and it is dominated and monopolised by state-owned companies. The companies are ECG, and NEDCo, who are responsible for the distribution of electricity to the Southern and Northern parts of Ghana respectively. However, Enclave Power Company Limited (a new entrant), a private company now shares the distribution of electricity with ECG and NEDCo following a change in policy. It distributes electricity to the Tema Free Zones enclave which is a very small area.[725]

6.3.4 Lack of Technical Expertise Barrier

Many RE projects have failed due to lack of technical skills to operate and manage the systems. In Ghana, there are no trained personnel to design and install solar photovoltaic systems as well as wind turbines, and this has impeded solar and wind deployment and

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[722] William Gboney, 'Policy and Regulatory Framework for Renewable Energy and Energy Efficiency Development in Ghana' [2009] Climate Policy. <https://doi.org/10.3763/cpol.2009.0636> accessed 10 July 2019

[723] Ouedraogo (n 721).

[724] Sunil Luthra and others, 'Barriers to Renewable/Sustainable Energy Technologies Adoption: Indian Perspective' (2015) 41 Renewable and Sustainable Energy Reviews 762 <http://dx.doi.org/10.1016/j.rser.2014.08.077>.accessed 18 June 2020

[725] U.S International Trade Administration, 'Ghana - Country Commercial Guide' (U.S International Trade Administration 22 July 2022 <https://www.trade.gov/country-commercial-guides/ghana-energy-sector> accessed 28 December 2022

development.[726] Furthermore, there are no local manufacturing industries to fabricate components of RETs. There is a lack of R&D facilities solely for RE.[727] However, in recent times, a Ghanaian owned company has started to manufacture solar panels locally, which gives hope that in the near future, this barrier can be surmounted. Due to the lack of a technically skilled workforce to man the country's solar and wind technologies development, skilled foreign workers have to be relied upon, thus increasing the cost of RE development in the Country.

6.3.5 Socio-cultural and Education Barriers

Coming to socio-cultural and education barriers, some cultural practices of some ethnic groups have the potential to impede the deployment of RE. For instance, many rural dwellers' occupation is farming. Their cooking is mainly done in the late evening to the night after they return from their farms, solar cookstoves were supplied to serve their cooking needs. However, at the time these cookstoves are most needed, the sun that provides solar energy is not available. As such, they rely on traditional biomass, which is readily available. The lack of information relating to the cost and benefits of RETs is an obstacle to the diffusion of RE.[728] In Africa, for that matter, in Ghana, many of the people are illiterates and uneducated, as such, they are likely not to understand either the benefits of RE or the environmental impact of conventional energy sources.[729] Therefore, the authorities in charge of energy need to organise workshops, community meetings to sensitise Ghanaians on the benefits of RE.

6.3.6 Land, Intermittency and Landscape Barriers

Solar and wind require a large expanse of land to erect solar panels and wind turbines, respectively. For example, the construction of an onshore wind farm requires large tracts of land, which in the process displaces and interferes with wildlife habitats such as birds and bats. One key technical challenge facing RE relates to intermittency; it is unpredictable to changing meteorological conditions as such solar and wind are described as intermittent in nature because generating energy from them depends much on the weather (wind speed) for wind and the time of the day for solar.[730] The energy they generate needs to be stored in storage facilities like batteries for later use. Furthermore, large RE projects face opposition due to their visual aesthetics, which change the landscape, and society sees this as an intrusion into their way of life, e.g., wind turbines. Finally, the decommissioning of wind turbines after they have reached the end of their useful life, around twenty to twenty-six years, poses logistical challenges as the material used in their construction needs to be appropriately disposed of and leave the land in the same conditions as before.

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[726] Mudasiru Mahama, Nana Sarfo Agyemang Derkyi and Chibuzo Maduka Nwabue, 'Challenges of Renewable Energy Development and Deployment in Ghana: Perspectives from Developers' (2020) 0123456789 GeoJournal <https://doi.org/10.1007/s10708-019-10132-z>. accessed 12 June 2020

[727] Dennis Asante and others, 'Exploring the Barriers to Renewable Energy Adoption Utilising MULTIMOORA- EDAS Method' (2020) 142 Energy Policy 111479 <https://doi.org/10.1016/j.enpol.2020.111479>.accessed 18 August 2020

[728] Eleni K Stigka, John A Paravantis and Giouli K Mihalakakou, 'Social Acceptance of Renewable Energy Sources: A Review of Contingent Valuation Applications' (2014) 32 Renewable and Sustainable Energy Reviews 100 <http://dx.doi.org/10.1016/j.rser.2013.12.026>.accessed 18 August 2020

[729] YS Mohammed, MW Mustafa, and N Bashir, 'Status of Renewable Energy Consumption and Developmental Challenges in Sub-Sahara Africa' (2013) 27 Renewable and Sustainable Energy Reviews 453 <http://dx.doi.org/10.1016/j.rser.2013.06.044>.accessed 12 November 2020

[730] Gautam Gowrisankaran, Stanley S Reynolds, and Mario Samano, 'Intermittency and the Value of Renewable Energy' (2016) 124 Journal of Political Economy 1187 < https://www.journals.uchicago.edu/doi/pdf/10.1086/686733> accessed 19 June 2020

The intermittency challenge can be overcome by following what Suberu, Mustafa and Bashir have identified, thus energy storage systems (ESSs), they are the best way to harvest the needed energy during the time of the day it is available for later use.[731] They describe ESS as a method of transforming electricity from the electrical power network into a form that can be converted to electricity when needed. Suberu and others underscored that ESS are more economical when used for autonomous power generating units bringing about economic advantage over other alternatives such as grid expansion.[732] Stram has also offered solutions as to the flexibility of the grid in accommodating electricity generated from variable sources and trading with other electricity grids as the way forward.[733] Furthermore, smart grids offer the avenue in addressing the accommodation of variable RE into the grid.[734] Computer hardware and software allow more research to be carried out to overcome these optimisation difficulties using computational resources that apply to the renewable and sustainable energy field.[735] The summary of the key barriers are presented below in table 11

Table: 10 Summary of Key Barriers

Category	Key barrier
Political and legal	**Poor implementation of the Renewable Energy Act, 2011 (Act 832) and other supporting instruments has not promoted non-hydro RE penetration in the electricity generation mix. Bureaucratic licensing and permit regime, unclear policies.**
Technical	**Lack of skilled personnel, lack of R&D facilities, lack of local manufacturing factories for RE systems.**
Economic	**High interest rate, high initial cost, a weak local currency, lack of access to credit.**
Socio-cultural	**Poor dissemination of information about the cost and benefits of RETs.**
Transmission	**Weak grid network leading to transmission and distribution losses.**
Land use	**Solar and wind technologies use large tracts of land, and this interferes with some wildlife habitats and agriculture.**
Intermittency	**Some RETs depend on the season of the year and time of the day. Wind RE depends on the wind speed of a given location and solar RE depends on the time of the day e.g., available in the daytime and not night and less on cloudy days.**

Source: Author's elaboration with ideas from the literature (2022)

[731] Mohammed Yekini Suberu, Mohd Wazir Mustafa and Nouruddeen Bashir, 'Energy Storage Systems for Renewable Energy Power Sector Integration and Mitigation of Intermittency' (2014) 35 Renewable and Sustainable Energy Reviews 499 <http://dx.doi.org/10.1016/j.rser.2014.04.009>.accessed 10 August 2020

[732] ibid

[733] Bruce N Stram, 'Key Challenges to Expanding Renewable Energy' [2016] Energy Policy < https://doi.org/10.1016/j.enpol.2016.05.034> accessed 10 January 2020

[734] ISGAN Synthesis Report, 'The Role of Smart Grids in Integrating Renewable Energy' (May 2015) < https://www.nrel.gov/docs/fy15osti/63919.pdf> accessed 22 November 2020

[735] R Baños and others, 'Optimization Methods Applied to Renewable and Sustainable Energy: A Review' (2011) 15 Renewable and Sustainable Energy Reviews 1753 < https://doi.org/10.1016/j.rser.2010.12.008> accessed 16 September 2020

6.4 Mitigation Actions for Removing Key Barriers to Renewable Energy Technologies in Ghana

RE barriers have been discussed above, it is important to proffer solutions to address them. The table below has identified the main barriers and grouped them under the following headings: political and legal, technical, economic, socio-cultural, transmission, land use and intermittency. The mitigation actions for addressing the barriers are presented below in table 11.

Table: 11 Mitigation Actions

Barrier	Mitigation actions
Political and legal	**Operationalise the RE Fund, implement the Renewable Energy Act fully i.e., remove licensing bureaucracy, and establish the RE Authority.**
Technical	**R&D should be encouraged, and funding provided, more skills training is needed in RE systems so that these systems can be manufactured locally in Ghana.**
Economic	**Tax incentives should be provided, subsidies for solar and wind. Provide credit support for investment in RETs especially non-hydro RE.**
Socio-cultural	**Provide education on the benefits and reliability of RETs through public engagements and seminars.**
Transmission	**The grid needs to be upgraded and be designed to accommodate energy generated from variable RE sources.**
Land use	**Devise modern farming techniques that allow cropping to take place on both solar and wind farms, the designs of hydro dams and turbines should take into consideration wildlife and take action to mitigate the impact on their habitats.**
Intermittency	**Development of energy storage systems that can store the generated energy at the time of availability for later use. Use of smart grids that can provide data that aid in the monitoring of the weather pattern.**

Source: Author's elaboration with ideas from the literature (2022)

6.5 Energy Security

Energy generation and consumption is one of the contributors to GHG emissions, which has brought about climate change.[736] As such, countries have turned their attention to RE not only to stem the effects of climate change but also to improve ES, reduce local air pollution and create employment.[737] Also, article 2 of the Paris Agreement requires countries to implement

[736] International Energy Agency, 'Global Energy & CO_2 Status Report 2019' (IEA, March 2019) <https://www.iea.org/reports/global-energy-co2-status-report-2019> accessed 25 October 2020
[737] Martin Stadelmann and Paula Castro, 'Climate Policy Innovation in the South - Domestic and International Determinants of Renewable Energy Policies in Developing and Emerging Countries'

and meet their nationally determined carbon reductions and over time increase their ambitions which will contribute to keeping the rise in global mean temperature below 2°C.[738] ES planning aims to achieve a low carbon economy which in the long run helps to meet climate change mitigation goals.[739]

Ghana is no exception to this new approach and has turned to RE to bolster its ES, mitigate climate change and fulfil its international obligation. Given the intermittent power shortages over the years, Ghana has put ES at the heart of its energy policy. Ghana's Renewable Energy Act, 2011 (Act 832) has specifically, as part of the aims of adopting RE, stated "to provide for the diversification of supplies to safeguard ES".[740] ES has generated a lot of arguments and current literature lacks consensus on a commonly agreed definition. The topic has become necessary in the discourse because of its ability to shape policies and shape countries' behaviour. Policymakers need to take on board ES when formulating policies as it deserves urgent priority, and they need to ensure that energy consumers' needs are catered for.[741]

Grigoroudis and others have opined that the ES of a country depends on its energy mix, the adequacy of energy stocks and the level of dependence on energy imports.[742] The transition to a more sustainable energy generation depends on a country's ability to alter its energy mix by deploying more environmentally friendly and efficient power technologies. Thus an optimal energy mix should ensure minimum environmental impact and ensure maximum ES.[743] Azzuni and Breyer define ES as the feature (measure, situation, or status) in which a related system functions optimally and sustainably in all its dimensions, freely from any threats.[744] The International Energy Agency (IEA) has defined ES as the uninterrupted availability of energy sources at affordable prices.[745] ES is a concept rather than a policy or a strategy.[746] The enhancement of ES is an essential objective for society and sustainable energy strategies.[747] This is because ES is needed to fulfil basic human needs.[748] ES has many aspects thus short-term and long- term. Short-term ES focuses on the ability of an energy system to respond to sudden changes in the supply-demand balance as promptly as possible. On the other hand, long-term ES involves timely and adequate investments that will supply energy in accordance

(2014) 29 Global Environmental Change 413 <http://dx.doi.org/10.1016/j.gloenvcha.2014.04.011>.accessed 20 September 2019

[738] Joeri Rogelj and others, 'Paris Agreement Climate Proposals Need a Boost to Keep Warming Well below 2 °c' (2016) 534 Nature 631 < https://doi.org/10.1038/nature18307> accessed 10 October 2020

[739] Tareq Abu Hamed and Lindsey Bressler, 'Energy Security in Israel and Jordan: The Role of Renewable Energy Sources' (2019) 135 Renewable Energy 378 <https://doi.org/10.1016/j.renene.2018.12.036>.accessed 10 September 2020

[740] Ghana's Renewable Energy Act, 2011 (Act 832) 1 (2) (C).

[741] Benjamin K Sovacool, 'Energy Security: Challenges and Needs' (2012) 1 Wiley Interdisciplinary Reviews: Energy and Environment 51 < https://doi.org/10.1002/wene.13> accessed 12 August 2020

[742] Evangelos Grigoroudis and others, *Energy Sustainability: A Definition and Assessment Model* (Springer Berlin Heidelberg 2019) <https://doi.org/10.1007/s12351-019-00492-2>.accessed 18 October 2020

[743] ibid

[744] Abdelrahman Azzuni and Christian Breyer, 'Definitions and Dimensions of Energy Security: A Literature Review' (2018) 7 Wiley Interdisciplinary Reviews: Energy and Environment 1 < https://doi.org/10.1002/wene.268> accessed 27 September 2020

[745] International Energy Agency, 'Energy security Reliable, Affordable Access to all Fuels and Energy Sources' (IEA) <https://www.iea.org/topics/energy-security> accessed 10 July 2020

[746] Lynne Chester, 'Conceptualising Energy Security and Making Explicit Its Polysemic Nature' (2010) 38 Energy Policy 887 <http://dx.doi.org/10.1016/j.enpol.2009.10.039>.accessed 12 September 2020

[747] John Andrews and Bahman Shabani, 'The Role of Hydrogen in a Global Sustainable Energy Strategy' (2014) 3 Wiley Interdisciplinary Reviews: Energy and Environment 474 < https://doi.org/10.1002/wene.103> accessed 10 October 2020

[748] Abraham H. Maslow, 'A Dynamic Theory of Human Motivation' in C. L. Stacey & M. DeMartino (Eds), *understanding human motivation* (Howard Allen Publishers 1958) <https://doi.org/10.1037/11305-004> accessed 18 October 2020

with economic development and environmental needs.[749] The Asia Pacific Energy Research Centre (APERC) has extended the original definition of IEA and formulated the so-called four As of ES:[750]

(1) Availability of the supply of energy resources,

(2) Affordability of the price of energy resources so that economic performance is not adversely affected,

(3) Accessibility to all social actors and

(4) Acceptability from a sustainability standpoint.

The first two As thus availability and affordability are denoted as the classical view of ES, which reflects the twentieth century's approach. The last two As, accessibility and acceptability, depict contemporary environmental concerns on issues like climate change, energy poverty, and carbon emissions.

There are many methods used to measure ES and most often depend on the author's interest and the dimension to include.[751] One of the major early works on ES was done by Willrich in 1976, he made a distinction between "security of supply" and "security of demand''.[752] From that point, studies on the subject have focused on the supply side, which encompasses diversification of supply, uninterrupted supply, and affordability of energy. This thesis' approach focuses on the supply side of ES and leaves the demand side for future research. If supply is adequate, as stated above, it would invariably take care of the demand side and would not allow demand to exceed supply. In most of the dimensions, the description of the energy system is done in three parts thus the source (production), the energy service (consumption) and the transfer from production to consumption.[753] In the APERC definition, the most important components include availability, diversity, cost, acceptability, and accessibility. The discussion is going to focus on these aspects of the definition. The world Bank Group refers to the three of the above as the three pillars of ES.[754]

6.5.1 Availability Dimension of Energy Security

Availability is an essential dimension of ES; as argued by Ang, Choong and NG.[755] This is so because it supports economic and welfare growth. Availability has three parameters: availability of energy resources, e.g., oil, gas, hydro, solar, availability of the means to transform these resources into energy services, e.g., energy infrastructure or pipelines and lastly, availability of consumers of energy, e.g., industrial use or public use and all the above

[749] ibid
[750] Asia Pacific Energy Research Centre (APERC). A Quest for Energy Security in the 21st Century: Resources and Constraints. Japan: Asia Pacific Energy Research Centre. 2007 <http://aperc.ieej.or.jp/file/2010/9/26/ APERC_2007_A_Quest_for_Energy_Security.pdf> accessed 10 October 2020
[751] BW Ang, WL Choong and TS Ng, 'Energy Security: Definitions, Dimensions and Indexes' (2015) 42 Renewable and Sustainable Energy Reviews 1077 < https://doi.org/10.1016/j.rser.2014.10.064> accessed 29 July 2020
[752] Mason Willrich, 'International Energy Issues and Options' (1976) (1:743-772) Annual Review of Energy <https://doi.org/10.1146/annurev.eg.01.110176.003523> accessed 10 July 2020
[753] Jeffrey Kucharski and Hironobu Unesaki, 'A Policy-Oriented Approach to Energy Security' (2015) 28 Procedia Environmental Sciences 27 <http://dx.doi.org/10.1016/j.proenv.2015.07.005>.accessed 30 October 2020
[754] World Bank Group,' Energy Security Issues' (WB, 5 December 2005) <http://documents1.worldbank.org/curated/en/464811468175435408/pdf/361100ENGLISH01gy1Security01PUBLIC1.pdf> accessed 20 June 2020
[755] Ang, Choong and Ng (n 751).

three parameters should be in existence because if energy resources do not exist, then there is no notion of an energy system. In that wise, the RES exist and are available, for example, non-hydro RES such as solar, wind, and biomass. In Ghana, daily solar irradiation levels range averagely between 4.0 to 6.5 kWh/m²/day, and annual sunshine duration ranges between 1800 to 3000 hours per annum.[756] Wind has a hub height of 50 m, and the average wind speed is measured as 8.4 to 9.9 m/s which could generate about 7300 GWh electricity if exploited with current technology.[757] Ghana certainly has an abundant endowment of RES. Certainly, it is wise to exploit these resources to boost its ES. Globally, RES such as solar energy, wind power, marine energy, and flow-of-the-river are available and sufficient to meet demand.[758]

It can be concluded that there is plenty of energy resources available in sufficient quantities to meet global demand.[759] As such, there are no ES issues regarding availability on the global level.[760] However, these resources, both conventional and non-conventional, are not evenly distributed and demanded around the globe.[761] Therefore, the existence of energy resources can be a constraint when viewed in the perspective of a specific country and population, but when viewed in relation to RE then some balance can be achieved to a certain degree, and this balances resource existence and demand. In short, the reality is that energy resources may be available on a global scale that can suffice the global demand. However, many countries have to rely on imports from other countries with plenty of supply. In this scenario, Ghana is less endowed with conventional energy resources but is endowed with RES, which satisfies the availability dimension of ES, the focus of this research.

6.5.2 Diversity Dimension of Energy Security

The next dimension is diversity which is important because it enhances ES.[762] The dimension of diversity can be translated into the popular expression of not putting your eggs in one basket. Winston Churchill, the First Lord of the British Admiralty, said ES "lie in variety and variety alone''.[763] In principle, an energy system that has diversity, that is, more than one energy carrier is more secured and, in that case, when one part of the energy system malfunctions, there are others to replace it.[764] An energy mix of oil, gas, hydro, solar, biomass,

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[756] Marriette Sakah and others, 'Towards a Sustainable Electrification in Ghana: A Review of Renewable Energy Deployment Policies' (2017) 79 Renewable and Sustainable Energy Reviews 544. < https://doi.org/10.1016/j.rser.2017.05.090> accessed 24 January 2020

[757] Energy Commission Ghana, 'Sustainable Energy For All Action Plan' (EC, June 2012) <http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf> accessed 20 January 2020

[758]JC Jansen, 'Energy Services Security: Concepts and Metrics' [2009] Expert paper submitted as input to the ongoing IAEA project: Selecting and Defining Integrated Indicators for Nuclear Energy 1 < http://www.ecn.nl/docs/library/report/2009/e09080.pdf> accessed 19 October 2020

[759] Gawdat Bahgat, 'Europe's Energy Security: Challenges and Opportunities' (2006) 82 International Affairs 961 < https://doi.org/10.1111/j.1468-2346.2006.00580.x> accessed 19 July 2020

[760] José Goldemberg and Thomas B. Johansson, 'UNDP World Energy Assessment, Overview 2004 Update <http://pure.iiasa.ac.at/id/eprint/12595/1/World%20Energy%20Assessment%20Overview-2004%20Update.pdf> accessed 18 October 2020

[761] Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, William W. Behrens, The Limits to Growth. Club of Rome (Universe Books New York 1972) <http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf> accessed 16 June 2019

[762] Jonathan Elkind,' Energy Security: Call for a Broader Agenda' in Carlos Pascual and Jonathan Elkind (eds), Energy Security: Economics, Politics, Strategies, and Implications (The Brookins Institution Press Washington DC 2010) 119 <https://assets.thalia.media/images-adb/4d/e1/4de18262-54ef-45f6-9419-5b4a305c9e7f.pdf> accessed 19 September 2020

[763] Daniel Yergin, 'Ensuring Energy Security' (2006) 85 Foreign Affairs 69 < https://www.jstor.org/stable/20031912> accessed 15 June 2020

[764] Mario Tagarinski and Andrius Avizius, 'Energy Security for the Euro-Atlantic Region' in Stec S and Baraj B (eds), *Energy and Environmental Challenges to Security* (Springer; Berlin 2009)

nuclear can be described as diverse as the different types of energy carriers are included and the malfunction of one, the rest can come to the rescue of the energy system to make it secure. It is true because it is highly unlikely that all the parts can fail at the same time. The shock, in the event of the malfunction of one, is shared among the rest of the functioning others.[765]

The main parameters of diversity are presented as follows, diversity of fuels, (energy carriers), diversity of resources, diversity of the means to make the energy available to end-users, e.g., technologies and transportation and diversity of consumers, e.g., markets and sectors. For example, an energy system that depends solely on coal is less secure than a system that depends on coal and gas. Also, an energy system that relies on one source is less secure compared to a system that relies on different sources, e.g., many EU members rely on Russian gas as their source of supply. This dependence on Russian gas brought about a crisis in 2012 in which they had less gas supply to meet their energy needs. If they had other sources of supply, the impact would have been less. In 2022 the EU finds itself in the same situation following the outbreak of war between Russia and Ukraine, in which the EU is unable to impose sanctions on Russia's oil and gas. In a similar vein, Ghana had difficulty getting sufficient gas supply from Nigeria to run its thermal plants through the WAGP. Many factors accounted for this, including vandalism, terrorism and Nigeria diverting the gas meant for WAGP to its power plants.[766] That was the only source Ghana could get gas from, and it led to power shortages from 2012 to 2016. At the peak of the crisis, it adversely affected the country in terms of the economy. Residential consumers were left without power and industry as well. Ghana has built its own independent infrastructure for the start-up of gas from its Sankofa oil field to start receiving gas from the field for thermal power generation and distribution in the country.

Furthermore, an energy system that relies on fossil fuels cannot be described as secure. In Ghana, petroleum products are the main energy products imported into the country. In 2021, this constituted 50% of the total amount of energy products imported; this is an indication that Ghana relies on substantial imported petroleum products which come from fossil fuels.[767] In contrast, an energy system that relies both on conventional and non-conventional can be described as secure, but a more secure energy system is the one which relies solely on RE. Diversity is a dimension that reduces the risks of energy systems with regards to energy sources, infrastructure, and suppliers.[768] Diversity is a means to address the prevention of energy supply disruptions (fuel-price fluctuations) or mitigate their impact should they occur.[769] In light of this, Ghana will need to increase contribution from all available sources over the long term to shore up its ES which may include conventional, renewable resources, energy efficiency. However, more importantly, RE should cover its energy mix in the long term.

<https://doi.org/10.1007/978-1-4020-9453-8_1> accessed 10 September 2020

[765] Jeffrey Kucharski and Hironobu Unesaki, 'A Policy-Oriented Approach to Energy Security' (2015) 28 Procedia Environmental Sciences 27 <http://dx.doi.org/10.1016/j.proenv.2015.07.005>.accessed 30 October 2020

[766] Mike Fulwood, 'Opportunities for Gas in Sub-Saharan Africa' [2019] Oxford Energy Insight <https://www.oxfordenergy.org> accessed 16 October 2019

[767] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022.

[768] André Månsson, Bengt Johansson and Lars J Nilsson, 'Assessing Energy Security: An Overview of Commonly Used Methodologies' (2014) 73 Energy 1 < https://doi.org/10.1016/j.energy.2014.06.073> accessed 14 August 2020

[769] Andy Stirling, 'Multicriteria Diversity Analysis. A Novel Heuristic Framework for Appraising Energy Portfolios' (2010) 38 Energy Policy 1622 <http://dx.doi.org/10.1016/j.enpol.2009.02.023>.accessed 16 June 2020

Ghana over-relied on hydro, which in the last decades could not meet demand and ensure sustainable energy consumption.[770] The government decided to diversify by increasing thermal using natural gas until thermal surpassed hydro in 2016 instead of RE which is sustainable. This trend of depending on natural gas is set to continue into the next decade.[771] To satisfy the diversity requirement, the nation's energy mix comprises hydro, thermal, solar natural gas, biomass, and oil, but the domination of fossil fuels does not completely guarantee ES. This is because these sources are not replenishable and are finite, vulnerable to price fluctuation and sometimes they are located in unstable regions and remote areas, and this makes them unreliable. The development of RE promotes new energy sources utilisation and thereby enhances ES.[772] Grubb, Butler, and Twomey observed that the symptoms of a non-secure energy system include sharp rises in energy prices, reduction in quality (power outages 'dumsor'), sudden supply interruption and long-term disruption of supply.[773] This depicts the Ghanaian energy system which has all the symptoms mentioned above even with its diversity in the electricity generation mix. It cannot be said to have met the requirement of an energy secured system as the diversity is dominated by fossil fuels which are finite and therefore the dimension cannot be said to have been adequately fulfilled.

6.5.3 Affordability Dimension of Energy Security

Cost is a dimension of ES, which is also referred to as affordability. The affordability of energy services is seen in the price to be paid for energy. From the perspective of end-users and the economy, the cheaper the energy prices are, the better for economic growth and industrial production and it encourages more consumption.[774] This scenario looks good and satisfies ES requirements. However, a more critical look reveals many drawbacks as follows: since ES depends heavily on large investments, cheaper energy prices undermine this and future planning.[775] Also, lack of funds for investments impact future prices, thereby affecting ES.[776] Cheap prices give a false impression of instant security which in reality is not the case, especially if there is no guarantee for such cheap prices in the future. When there is no guarantee of low prices in the future, this leaves societies and consumers in a vulnerable situation, especially in the face of any price shocks.[777] In contrast, high energy prices will lead to less demand, and this can compel and encourage the development of alternative sources which can meet the affordable needs of end-users.

Low energy prices do not appeal to energy generators, it means less returns and loss in profits which results in economic loss. In a country like Ghana, such economic losses tend to affect other sectors of the economy. So, in such a situation, do higher prices help achieve ES? To a

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[770] Sylvester Afram Boadi and Kwadwo Owusu, 'Impact of Climate Change and Variability on Hydropower in Ghana' (2019) 38 African Geographical Review 19 <http://doi.org/10.1080/19376812.2017.1284598>.accessed 10 August 2020

[771] Simon Bawakyillenuo, 'The Political Economy of Renewable Energy Investment in Ghana' in Ana Pueyo and Simon Bawakyillenuo (eds), *Green Power for Africa: Overcoming the Main Constraints* (IDS Bulletin Brighton 2017) < https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/13387/IDSB48.5_6_10.190881968-2017.167.pdf?sequence=1> accessed 29 September 2019

[772] Azzuni and Breyer (n 744).

[773] Michael Grubb, Lucy Butler, and Paul Twomey, 'Diversity and Security in UK Electricity Generation: The Influence of Low-Carbon Objectives' (2006) 34 Energy Policy 4050 < https://doi.org/10.1016/j.enpol.2005.09.004> accessed 12 May 2020

[774] Elkind (762).

[775] Andrei Konoplyanik and Thomas Walde, 'Energy Charter Treaty and Its Role in International Energy' (2006) 24 Journal of Energy and Natural Resources Law 523 <https://heinonline.org/HOL/P?h=hein.journals/jenrl24&i=531> accessed 19 September 2020

[776] Gawdat Bahgat, 'Central Asia and Energy Security' (2006) 37 Asian Affairs 1 < https://doi.org/10.1080/03068370500456819> accessed 19 July 2020

[777] Elkind (n 762).

certain extent, yes, because higher prices connote in the short-term big profits and growth in new supplies.[778] This can bring about an increase in capital investment which invariably can be used to establish a sustainable energy system.[779] This leads to the achievement of ES.[780] The Ghanaian energy system can be seen as providing low prices to end-users because it is a system that is dominated by government subsidies. However, this has instead led to energy distribution companies such as ECG, NEDCo and EPC Ltd, raking in more debts in their operations and making losses. It has denied them the needed capital to invest in improving their infrastructure to guarantee ES. They have accumulated huge debts because the power sold is far cheaper than the cost involved in generating it. Also, government subsidies are not paid over a very long period. To address the challenge raised above, PURC has introduced the Automatic Adjustment Formula, which is a mechanism which reviews tariffs periodically to reflect changes in the factors that affect the operations of the utilities (VRA, ECG, GRIDCo, NEDCo, EPC).[781] This would allow tariffs to be charged fairly to all involved thus power generators, distributors, and customers. Comparatively, energy prices in Ghana are somewhat high, as observed by the finance minister, so one would presume that if prices are high, it could either lead to the search for alternatives or it would bring about profits that can bring about investment to expand the energy system.

However, in the Ghanaian situation, it has not increased profits for energy generators, nor has it brought in sustainable alternatives like RE. What is seen is, instead the government is increasing thermal to 80% in the next decade at the expense of RE, which is a source of concern as to which pathway will lead to the RE niche in the Ghanaian electricity generation mix.[782] The energy mix of a country should be founded on a well-diversified portfolio of energy sources especially RE for the maximisation of ES, optimise energy intensity and minimise the negative impact on the environment.[783] The affordability dimension of ES in Ghana depicts an energy system that is dominated by subsidies which artificially keeps prices cheap. However, realistically they are high as transmission and distribution losses are high, and other inefficiencies are charged into customers' energy bills. When this is compared to Ivory Coast, it is expensive, as seen under section 6.7 further below.

6.5.4 Acceptability Dimension of Energy Security

Acceptability reflects the impact of energy generation, and consumption on both the economy and environment; acceptability is hinged on the relation between energy, economy, and environment.[784] Acceptability also refers to an energy system that recognises and respects environmental concerns.[785] With the frequent extreme global weather and air pollution people now pay attention and raise concerns about environmental issues vis-à-vis energy

[778] Bahgat (n 759).
[779] World Energy Council 'World Energy Issues Monitor' (WEC, 2012) <https://www.worldenergy.org/assets/downloads/PUB_world_energy_issues_monitor_2012_WEC.pdf > accessed 14 August 2020
[780] Lenka Kovačovská, 'European Union's Energy (in) Security – Dependency on Russia' < http://www.amo.cz/wp-content/uploads/2015/11/amocz-RP-2007-12.pdf> accessed 10 October 2020
[781] Public Utilities Regulatory Commission Ghana, 'Explanatory Notes to Revised Automatic Adjustment Formula for Setting Electricity and Water Tariffs' (PURC, January 2011) <https://www.purc.com.gh/categ/tariffs/subcategories/automatic-adjustment> accessed 10 November 2020
[782] Bawakyillenuo (n 771).
[783] Grigoroudis and others (n 742).
[784] Debin Fang, Shanshan Shi and Qian Yu, 'Evaluation of Sustainable Energy Security and an Empirical Analysis of China' (2018) 10 Sustainability (Switzerland) 1 < https://doi.org/10.3390/su10051685> accessed 30 December 2020
[785] Larry Hughes, 'A Generic Framework for the Description and Analysis of Energy Security in an Energy System' (2012) 42 Energy Policy 221 <http://dx.doi.org/10.1016/j.enpol.2011.11.079>.accessed 29 January 2020

consumption. Concerted action is now required to shift from a high carbon economy to a low carbon one and change the attitude of energy use from low efficiency to high efficiency. The consumption of non-fossil energy and its development, thereby increasing its share in the total primary energy consumed, will enhance energy supply security, and improve the energy sustainability of the energy system. However, the way energy resources are exploited, the methods used, and the outcome of energy usage have an adverse impact on the environment. These parameters of the dimension on the environment have contributed to the increasing concerns about the environment. Take, for instance, fracking technology which extracts shale gas from shale stones, causes much harm to the environment because of the chemicals used in the process and the destruction of the earth layers all the way to the shale makes it dangerous and impacts the environment.[786] Acceptability naturally refers to the environment and focuses on environmental impact caused by carbon emissions annually and death caused by particulate emissions. In Ghana, opposition to the siting of many of the energy infrastructure is not common thus fulfilling this dimension of ES. The District Assemblies have sensitised the people to see such infrastructure as their due share of development projects in the Country, and such projects are for their own benefit.

6.5.5 Accessibility Dimension of Energy Security

Pachauri explains that energy access is "the right or opportunity to use something", following this explanation, he notes that physical availability is a precondition to access.[787] In the report of the U.N Secretary-General's advisory group on energy and climate change (AGECC) energy access is defined as "access to clean, reliable, and affordable energy services for cooking and heating, lighting, communication, and productive uses".[788]

Energy accessibility, according to Kruyt and others, entails a large spatial discrepancy between consumption and the locations where resources are produced; having access most often carries geopolitical implications.[789] Access to electricity is inextricably linked to economic development as well as human development and has thus become an indispensable dimension of ES in Ghana and has been captured by Sustainable Development Goal 7. Globally about 1.4 billion people are without access to grid electricity. It is estimated that about 550 to 600 million people do not have access to electricity in Africa.[790] Access to energy is important because of the benefits that are accrued from it; in view of this, electricity coverage in Ghana is 87%, the GoG initiated the National Electrification Scheme to extend electricity to the nook and cranny of the Country in the year 2020.[791] This target was not achieved in 2020.

Besides the availability of resources, the ability to access these resources is one of the major challenges in ensuring the security of supply to meet current and future demand. Some of the

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[786] Robert B Jackson and others, 'The Environmental Costs and Benefits of Fracking' (2014) 39 Annual Review of Environment and Resources 327 < https://doi.org/10.1146/annurev-environ-031113-144051> accessed 10 November 2020

[787] Shonali Pachauri, 'Reaching an International Consensus on Defining Modern Energy Access' (2011) 3 Current Opinion in Environmental Sustainability 235 <http://dx.doi.org/10.1016/j.cosust.2011.07.005>.accessed 10 August 2020

[788] The U.N Secretary-general's Advisory Group on Energy and Climate Change (AGECC), 'Energy for a Sustainable Future' (AGECC, 28 April 2010) < https://www.un.org/millenniumgoals/pdf/AGECCsummaryreport[1].pdf > accessed 20 November 2020.

[789] Bert Kruyt and others, 'Indicators for Energy Security' (2009) 37 Energy Policy 2166 < https://doi.org/10.1016/j.enpol.2009.02.006> accessed 19 September 2020

[790] Sustainable Energy for All, 'SEforALL Analysis of SDG7 Progress - 2020' (SEforALL) <https://www.seforall.org/data-stories/seforall-analysis-of-sdg7-progress-2020>.accessed 28 November 2021

[791] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022

main barriers to energy supply accessibility are political, economic, and technology. Under geopolitical factors, global oil resources are unevenly distributed. Most of it is concentrated in the Middle East, a politically unstable region. Energy supply from the region is very unreliable and comes with fluctuations in price. Therefore, it makes wisdom to explore other alternatives, which are RES, which are evenly distributed across the globe.[792] Another geographical challenge is that large reserves of undiscovered energy resources are located in the deep-sea offshore or arctic areas. Many oil companies find it challenging to reach these areas due to the high cost of exploration and environmental restrictions.

RE has several factors that limit its accessibility. One major constraint is the initial capital cost which is relatively high compared to conventional sources. In overcoming this challenge, subsidies and other incentives are given, as seen in the Renewable Energy Act, 2011 (Act 832). The Act approves the establishment of the RE Fund to provide funding for RE policies that would increase the development of RE. In addition, accessibility to RE for electricity generation depends much on the regulatory frameworks that govern the economy and the effectiveness of the policies used in the development of RE. For example, FIT (now repealed) and REPO are mechanisms that can be used to promote the deployment of RE. The use of these policies demonstrates the government's commitment to the promotion of RE which attracts RE investors to invest in the RE subsector. Lack of technological advancements such as solar PVs and wind turbines limit access to RE. Therefore, it is in the global interest that the transfer of technology from developed countries to developing countries is encouraged to facilitate the increase in accessibility to RE. In Ghana, as seen above, the national access rate is 87%, an indication that about 13% of the population, especially those living in rural areas and Island communities, do not have access to electricity, meaning the access dimension is not completely met.

6.5.6 The Concept of Energy Security in Ghana

Ghana has commercial quantities of offshore oil, which it started to exploit in 2010. However, the Country is largely considered as an oil-importing country because Ghana's oil from its offshore oil fields is not used locally; it is exported and sold in the international energy market. As a result, most of the oil Ghana consumes is imported. Petroleum products dominate the final energy consumed in Ghana. Petroleum products include diesel, gasoline, LPG, and jet fuel, and they accounted for 50% (of about 4,630 Ktoe) of final energy consumed in 2021.[793] Ghana, as an energy importing country, its main concern is about security of supply.

In Ghana, the concept of ES is captured as one of the objectives of the Renewable Energy Act, 2011 (Act 832) in 1 (2) (C) diversification of supplies to safeguard ES.[794] Furthermore, the REMP states, "Ghana like many other countries, is focused on the integration of RE into the national energy mix to ensure the security of energy supply, ensure a cleaner environment, and help mitigate climate change".[795] ES is referred in the RE Act to mean, the availability, adequacy, reliability and environmental sustainability of energy supply.[796] The whole concept of ES is based on the notion of the continuous supply of energy which is important to the functioning of the economy. Given the interdependence of economic growth and energy consumption, gaining access to a stable energy supply is very crucial to the country.

In the Ghanaian context, ES suggests the availability, adequacy, reliability, and environmental sustainability of energy supply. It is clear from the current electricity generation mix that non-

[792] Asia Pacific Energy Research Centre (APERC) (n 750).
[793] Energy Commission of Ghana (791).
[794] Ghana's Renewable Energy Act, 2011 (Act 832).
[795] Energy Commission of Ghana, 'Ghana Renewable Energy Master Plan' [EC, February 2019] <https://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf> accessed 10 May 2022
[796] Ghana's Renewable Energy Act, 2011 (Act 832).

hydro RE has a small share of 0.55%, which does not satisfy the dimensions mentioned above. RE contributes to the reduction of energy imports and enhances the diversification of supply options, thereby reducing the economy's vulnerability to price fluctuation, which gives the chance to enhance ES. For example, in the early 1970s, when there was an abundance of electricity generated from the hydro dams, Ghana did not use thermal plants and did not import natural gas and light crude oil to generate electricity. RE adoption can increase the reliability of energy services and extend electricity access to many remote communities of the country. With the increased diversification of RES in the energy mix, it can enhance the ES of the Country, especially with more solar and wind technologies deployed.[797]

However, as seen above, ES is mentioned in the RE Act, but the definition of the concept has not been given. Nevertheless, the interpretation of ES given in the REMP gives the indication that the concept is used in relation to the availability, adequacy, reliability, and environmental sustainability of energy supply. The REMP interpretation leaves out the affordability and accessibility of the concept, especially access to modern energy. The same applies to the environmental aspect; the RE Act does not discuss climate change mitigation in relation to ES except in REMP, which says RE can be used to ensure the security of energy supply to mitigate climate change. Ghana, as an energy importing country, has not developed any specific concept of ES. Being a consumer of energy, it has instead adopted the concept of security of energy supply.

ES remains one of the most important objectives of many countries. The deployment of RETs fulfils this objective of ensuring ES with added benefits. It has been established that ES, represented by energy generation over consumption ratio per capita, energy generation level contributes largely to economic growth.[798] As discussed earlier, diversifying the generation mix by adding RE supports the overall energy generation portfolio. RE contribution to the diverse generation and storage propels the energy system to withstand shocks. A diverse energy system is capable of providing improved reliability, and the integration of the various RES.[799] RE contributes to the increase in reliability of energy services, especially in locations like island communities that often lack sufficient grid access.[800] From the preceding discussion, despite any social acceptability issues and negative environmental impact, RE will help Ghana to be more energy secure and, at the same time, make it independent of the vagaries of the fossil fuel markets.[801]

6.6 Nuclear Energy in Ghana

Nuclear technology has been around for some time now and could help address the concerns of GHG emissions because it is a clean energy source. Mallah has intimated that nuclear energy can be used to provide ES, SD and to address the concerns of GHG emissions

[797] Owusu and Asumadu-Sarkodie (n 705).
[798] Thai Ha Le and Canh Phuc Nguyen, 'Is Energy Security a Driver for Economic Growth? Evidence from a Global Sample' (2019) 129 Energy Policy 436 <https://doi.org/10.1016/j.enpol.2019.02.038>.accessed 16 December 2020
[799] Sadie Cox and others, 'Bridging Climate Change Resilience and Mitigation in the Electricity Sector Through Renewable Energy and Energy Efficiency: Emerging Climate Change and Development Topics for Energy Sector Transformation' [2017] Doe Osti.Gov 1 <http://www.osti.gov/servlets/purl/1411521/%0Ahttps://www.nrel.gov/docs/fy18osti/67040.pdf>.accessed 20 September 2020
[800] Owusu and Asumadu-Sarkodie (n 705).
[801] John A. Paravantis and Nikoletta Kontoulis, Energy Security and Renewable Energy: A Geopolitical Perspective (Intech Open 2020) <http://dx.doi.org/10.5772/intechopen.91848> accessed 15 November 2020

reduction.[802] Many countries use nuclear energy to provide ES and to reduce their dependence on energy imports. It is apposite to point out that in Ghana, nuclear does not feature in the country's energy mix. However, Ghana has expressed interest in nuclear for the purpose of generating power to overcome its electricity deficit. The Country is now working through the Ghana Atomic Energy Commission and other stakeholders to include nuclear in the energy mix. A roadmap has been drawn for the commissioning of the first nuclear power plant in 2029.[803] The funding of the project rests with the government as some nuclear reactor vendors have expressed interest in the programme and it is thus going to be GoG and vendor financing.[804] But many people are apprehensive of the dangers of nuclear, so it remains to be seen if this proposal will be carried through.

What has been discussed above is done to provide an overview of nuclear's role in ES. As seen above, many countries set forth to use it to gain ES and reduce GHG emissions, which may be achievable to a large extent. However, measuring nuclear against World Energy Council's three As thus, availability, accessibility, and acceptability, it does not meet all these criteria. Take, for instance, the availability dimension, nuclear is derived from uranium, and its deposit is not widespread. It is limited to some regions and countries. Moreover, there is no data showing Ghana has nuclear endowment, which means it will have to be imported should the country go nuclear.

Furthermore, the importation of uranium and the building of a nuclear reactor is going to add more expenditure to the energy importation bill, which the government is already struggling with the existing one. Furthermore, the importation of uranium over long distances increases the carbon footprint of Ghana and thereby causes more climate change which the Country pledged to reduce. Aside from the above, the safety concerns associated with it, is troubling and the fact that it is derived from uranium a mineral which is not considered a renewable source complicates matters in its deployment. Also, it is described as clean because it does not emit carbon emissions, but it is not a renewable source, and therefore its use cannot be considered sustainable. Therefore, should Ghana adopt nuclear as it plans? According to World Nuclear Industry Status Report, "nuclear power…meets no technical or operational need that renewable competitors cannot meet better, cheaper, and faster".[805] As a result, nuclear cannot guarantee the ES of a country on its own as compared to RE though it is a clean energy source. As a result, it is not a good idea to introduce nuclear into the energy mix based on the above.

Other alternatives like hydrogen and artificial photosynthesis are clean and could provide solace to energy demand. However, the technologies are at a stage where they are nowhere near scale deployment. As such, the researcher does not want to include them here but to highlight that such technologies exist and have the potential to be deployed in the future on a large scale to meet our energy needs and provide ES to countries which undoubtedly will include Ghana.

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[802] Mallah, Subhash. 'Nuclear energy option for energy security and sustainable development in India' Annals of Nuclear Energy (Oxford); Journal Volume: 38; Journal Issue: 2-3 < https://doi.org/10.1016/j.anucene.2010.10.010> accessed 17 December 2020

[803] Kwame Gyamfi and others, 'The Choice of Nuclear Energy for Ghana as a Result of Development of Its Energy Production' (2020) 2020 Journal of Energy 1 < https://doi.org/10.1155/2020/8823720> accessed 28 December 2020

[804] David Dalton, 'Ghana / Five Vendors Have Responded To Request For Interest, Says Ministry Official' (NUCNET,5 October 2021) <https://www.nucnet.org/news/five-vendors-have-responded-to-request-for-interest-says-ministry-official-10-2-2021> accessed 19 April 2022

[805] World Nuclear Industry Status Report, 'The World Nuclear Industry Status Report 2019' (World Nuclear Industry Status Report, 27 September 2019) <https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2019-HTML.html> accessed 16 March 2020

6.7 Evaluation of the Effectiveness of the Legal Frameworks Deployed in Ghana to Address Energy Security Challenges

In chapter three, there was a discussion on the Renewable Energy Act, 2011 (Act 832) and the RE policies deployed for the development of RE in the Country.[806] This section looks at the RE Act and RE policies deployed for the development of RE in Ghana to ascertain their effectiveness to address ES challenges. The summary in chapter three on the discussion made on the RE Act revealed many shortcomings emanating from it by some scholars.[807] The shortcomings need to be addressed to rectify those pitfalls and put in place proper regulatory frameworks and incentives that can improve ES in Ghana.

The RE Act relies on the private sector to champion the RE revolution in Ghana. Therefore, some pertinent policies need to be in place to attract investment in the RE subsector, so that the cost of generation and distribution is relatively kept low at affordable prices. Also, to allow small size RE investors to be able to connect to the grid with ease and eliminate the 20 MW cap imposed on electricity generated from solar PV to connect to the grid. It is unattractive to large scale investment in solar PV and would discourage many potential investors. The RE Act employs policies like REPO, and net metering (yet to be implemented) to attract investments in RETs to make them cheap and to explore all mechanisms for their widespread use to speed up economic prosperity. The shortcomings in the RE Act as observed, the regulatory aspect of the Act has introduced bureaucratic procedures in the acquisition of licences that make investment in the RE subsector unattractive to investors.[808] The time-wasting licensing procedures need overhauling to accommodate the concerns of prospective RE investors so that the daunting requirements are revised.

As stated earlier in the thesis, in his state of the nation address in 2017, the president of Ghana alluded to these regulations being anti-investor friendly. The president indicated that the RE Act needs reviewing to streamline things to attract investors.[809] Take Spain, for instance, which has considerable wind resources in addition to good government policies, the maturity of the wind technology has aided technological competition, which has resulted in reasonable projections for investors and has led to private investment attraction in the RE sector.[810] Although the RE Act has the potential to address the ES challenges of the Country, in its current state as alluded by the president needs amendments to address the challenges identified. Transitioning to a low carbon economy, this is not going to happen without costs, and the possibility is that it is going to draw away resources in investments from other equally important sectors like health, and education.[811]

However, as seen in the discussion, most of these instruments have not been effective and have, therefore, limited accessibility. Due to the poor implementation of these legal instruments and policies, the contribution of non-hydro RE to the electricity generation mix

[806] Chapter 3, sections 3.7 to 3.9
[807] Like Atuguba and Tuokuu (2020), and Sakah and others (2017).
[808] Raymond A Atuguba and Francis Xavier Dery Tuokuu, 'Ghana's Renewable Energy Agenda: Legislative Drafting in Search of Policy Paralysis' (2020) 64 Energy Research and Social Science 101453 <https://doi.org/10.1016/j.erss.2020.101453>.accessed 10 August 2020
[809] Nana Akuffo Addo, 'State of the Nation Address 2017' (Parliament of Ghana, February 2017) <https://www.parliament.gh/epanel/docs/pub/SONA%20Feb%202017.pdf#viewer.action=download> accessed 19 January 2020
[810] Carmen Navarro, 'Spain: Greening Electricity while Growing the Economy' in William M. Lafferty and Audun Ruud (eds), *Promoting Sustainable Electricity in Europe: Challenging the Path Dependence of Dominant Energy Systems* (Edward Elgar Publishing limited 2008)
[811] Yacob Mulugetta and Frauke Urban, 'Deliberating on Low Carbon Development' (2010) 38 Energy Policy 7546 <http://dx.doi.org/10.1016/j.enpol.2010.05.049>.accessed 19 June 2020

was 0.3% in 2020, falling short of the target of 10%. The main challenge that compelled Ghana to opt for RE has not been addressed thus the accessibility aspect of ES. As indicated earlier, Ghana has 87% electricity coverage. It has the policy to extend access to reliable electricity supply to every part of the Country through the NES to achieve universal access in 2020, which was not met.

Furthermore, a programme called Self Help Electrification Programme specifically addresses access constraints in rural areas. However, these policies have not yielded the needed access as projected. Currently, there is a disparity in power access between the urban centres and rural areas of which access for the former is higher than the latter.[812] In view of this; the NES has not covered the whole country as planned, it is estimated that about 600,000 households remain to be connected to the national grid and therefore access to power nationwide has not been met to fulfil the accessibility dimension of ES in Ghana.[813] Furthermore, Ghana relies on imported crude oil as such the country is vulnerable to price fluctuation in the international market. The hydro dams suffer from a lack of water; as such, the diffusion of non-hydro RE has very little penetration; it can be concluded that the accessibility dimension has not been met.

Cost, which is also referred to as affordability, is an essential dimension of ES, and it relates to the price that is paid for the energy generated and consumed. As seen earlier in the discussion, cheap energy does not allow full cost recovery. It does not promote investment in the expansion of the energy sector's infrastructure. This instead stagnates the development of the sector; the tariff regime also equally undermines the actual cost involved in the power generated as tariffs are set far below the actual cost of generation.[814] The Ghanaian energy sector, which includes the RE subsector, is dominated by subsidies and unrealistic tariffs which stifle competition. Most of the companies operate as state monopolies in the generation, transmission, and distribution of power to end-users. This arrangement has saddled the sector with huge debts and thereby denied the companies the needed capital for investment.[815] If the tariffs are low, the question is can these low tariffs be sustainable into the foreseeable future? Certainly no, they can be described as artificial and cannot be maintained and therefore would undoubtedly impact the ES of the Country. The above has been a general energy price assessment which has established that tariffs have been kept artificially low due to subsidies.

In terms of competitiveness, the power that is generated in Ghana is expensive, especially as transmission and distribution losses are high. However, these losses are calculated into the final energy bills of consumers.[816] When this is compared to some neighbouring West African countries like Ivory Coast, it would be revealed that power is expensive in Ghana. This is mainly due to inefficiencies and the use of fossil fuels, whose prices keep going high in the international market. Also, the gas supplied to the thermal plants comes via the WAGP from Nigeria, which is expensive and unreliable. However, this problem is being solved as Ghana

[812] Ephraim Bonah Agyekum, Vladimir Ivanovich Velkin and Ismail Hossain, 'Sustainable Energy: Is It Nuclear or Solar for African Countries? Case Study on Ghana' (2020) 37 Sustainable Energy Technologies and Assessments 100630 <https://doi.org/10.1016/j.seta.2020.100630>.accessed 12 April 2022

[813] Sulemana Abubakari, 'Achieving Universal Access and Options for Financing' (MOEn, June 2019) <https://atainsights.com/wp-content/uploads/2019/06/4.-Sulemana-Abubakari-Ministry-of-Energy.pdf> accessed 10 December 2020

[814] Maame Esi Eshun and Joe Amoako-Tuffour, 'A Review of the Trends in Ghana's Power Sector' (2016) 6 Energy, Sustainability and Society 1 <http://dx.doi.org/10.1186/s13705-016-0075-y>.accessed !8 June 2019

[815] ibid

[816] Public Utilities Regulatory Commission Ghana, 'Explanatory Notes to Revised Automatic Adjustment Formula for Setting Electricity and Water Tariffs' (PURC, January 2011) <https://www.purc.com.gh/categ/tariffs/subcategories/automatic-adjustment> accessed 10 November 2020

now depends more on domestic gas from its oil fields. The inefficiencies come from high generation, transmission and distribution losses, and the consumer bears this. Hence in Ghana, tariffs are going on averagely 15,5 cents per kilowatt, whilst in Ivory Coast, they are going for 10.5 cents per kilowatt.[817] This has the potential to reduce Ghana's competitiveness as far as power is concerned. Cheap power can attract both domestic capital and foreign investments.

6.8 Conclusion

The discussion has shown that there are many opportunities to be derived from adopting RE. RE emits negligible GHG emissions, ensures ES, mitigates climate change, and provides socio-economic development. Ghana is endowed with plenty of RES and harnessing these resources for power generation is the right thing to do to increase the ES of the Country. Over the years, due to population growth, urbanisation, economic growth and access, there have been power generation and supply deficits. It has awakened the government to explore other sustainable and environmentally friendly alternatives. The major RETs in Ghana include hydro, solar, wind, and biomass. They have enormous potential to be harnessed to improve the electricity supply in the country. Apart from these sources mentioned above, other alternatives were considered and prominent among these is nuclear. Nuclear is considered a clean energy source which does not emit GHG emissions, but it is not a renewable source. In addition, there are concerns over its safety. Nuclear does not feature in the energy mix of Ghana, but there is an indication that the country might explore this in the future.

The government enacted the RE Act to exploit these RES to improve the country's ES. ES has been understood traditionally to mean security of supply; as such, the discussion did not include security of demand. This is so because Ghana is considered as an energy importing country, and many of the energy importing countries are concerned with security of supply. However, there is no consensus on the definition of ES in the literature. Therefore, in this chapter, the definition of APERC is used. APERC formulated the four As, availability, affordability, accessibility, and acceptability. These dimensions were used to measure the energy mix of Ghana to ascertain whether it meets ES requirements.

Following this examination, it has come to light that Ghana's ES is in a precarious state. Ghana's energy mix has met the availability, acceptability, and diversity dimensions of ES but has failed to meet the affordability and accessibility dimensions. This analysis concludes that Ghana has not fully met one of the major objectives of enacting the RE Act, which is ES. The GoG heavily subsidises Ghana's energy sector, and therefore, tariffs do not reflect the actual market prices. If the subsidies are removed, tariffs will be higher and be beyond the affordability level of most final power consumers in Ghana. The discussion further showed that Ghana had not developed the concept of ES except to mention it in the RE Act without giving it the proper attention. The country relies heavily on imported energy sources, and as an energy importing country, one of the main concerns ought to be the security of energy supply. Though the RE Act mentions ES, Ghana has not defined the concept. Therefore, it needs to develop the concept of ES just like other countries have done to clearly spell out its priorities and how it can overcome its ES challenges.

Accessibility denotes the safety and reliability of supply. This dimension is important as it has been captured in the RE Act. Access to electricity is inextricably linked to economic

[817] Theophilus Acheampong and Bridget O. Menyeh, 'Ghana's Electricity Supply Mix Has Improved, but Reliability and Cost is still a Challenge' (Conversation, 9 June 2021) <https://theconversation.com/ghanas-electricity-supply-mix-has-improved-but-reliability-and-cost-is-still-a-challenge-161762> accessed 10 January 2022

development as well as human development and has thus become an indispensable dimension of ES in Ghana. However, the discussion has shown that most of these instruments have not been effective and have, therefore, limited accessibility. Due to the poor implementation of these legal instruments, the main challenge why Ghana opted for non-hydro RE has not been achieved (ES). Ghana has 87% electricity coverage and had the policy to extend access to reliable electricity supply to every part of the country through the NES to achieve universal access in 2020.[818] However, Ghana did not achieve this target in 2020. As a result, universal access has not been achieved. Currently, it is estimated that about 600,000 households remain unconnected to the national grid; therefore, access to electricity nationwide has not been met to fulfil the accessibility dimension of ES in Ghana. Following the above finding, it has been established that an energy system that has RE dominating the energy generation mix will provide it with the desired ES and such security provided will meet the energy sustainability of the country and will ultimately increase access.

It has been demonstrated in the discussion that an energy system that uses RE is more secure than any other. ES and climate change are critical drivers affecting policies, legal frameworks, and investments in the energy sector. It is, however, important to state that ES cannot be considered in isolation when energy policies are being formulated. Following the findings of the discussion that the electricity generation mix of Ghana does not wholly meet ES standards, the study went further to intimate that, to overcome this challenge, the Ghanaian energy system should have RE dominating the generation mix. That will provide it with the desired ES, and such security provided will meet the country's energy sustainability and will eventually contribute to climate change mitigation. Security of supply can also be achieved by harnessing locally available RES, e.g., wind, solar, biomass and adopting energy efficiency practices. The analysis concludes that Ghana has not fully met one of the main objectives of enacting the RE Act, which is ES.

The following discussion is on chapter seven, which examines the legal and policy frameworks on solar energy development and its adoption as a priority in Ghana. Ghana is endowed with plenty of solar energy and is more abundant than any other renewable source, hence the choice.

[818] Energy Commission of Ghana (n 791).

CHAPTER SEVEN

LEGAL AND POLICY FRAMEWORKS ON SOLAR ENERGY DEVELOPMENT AND ITS ADOPTION AS A PRIORITY IN GHANA

7.1 Introduction

As the deployment of solar photovoltaic (PV) systems continues to increase at a fast pace in recent times, the economic viability, module reliability and durability have become important to both investors and prospective system owners, and they want some guarantee that their investments will yield the desired benefits. This chapter explores solar PV technology development and deployment in Ghana and makes a case for its widespread adoption due to the country's abundant solar energy endowment. The discussion would investigate the many benefits to be derived from it. It would probe further to see the challenges facing solar PV deployment and to ascertain how the legal and policy frameworks, and strategies that promote its development have performed.

Solar has been propelled to the forefront of technological options due to its role as a clean energy source in the emission mitigation agenda that has been pursued globally and in Ghana. Solar energy is the most abundant, inexhaustible, and clean among all the RES to the present day.[819] The fast increase in solar PV is driven in part by virtue of some outstanding attributes it possesses, such as low operating cost, scalability, ability to be used for traffic lighting, household lighting, rural vaccine storage, water pumping and many more. In recent times investment in solar PV has been substantial, but much more investment is needed in the coming years to meet climate change targets set by many countries.

The enactment of the Renewable Energy Act, 2011 (Act 832), by the government of Ghana clearly is a recognition of the significant role to be played by RE in general and specifically, solar PV.[820] According to the renewable energy master plan (REMP), Ghana, like many other countries, is focused on integrating RE into the national electricity generation mix.[821] Ghana is turning to RE to ensure security of energy supply, ensure a cleaner environment, and help mitigate climate change.[822] Following international trends, in recent years solar PV has attracted more interest and investment than any other energy technology in Ghana. Ghana's abundant solar potential has been identified as what is needed to bolster and improve the ES, and reliability of power supply. This potential could help overcome supply challenges during periods when thermal and hydro plants generate below capacity. Solar PV is tipped to help overcome supply constraints and eventually dominate the energy generation mix to provide sustainable power supply.

Reliable solar PV system performance over its useful life, typically between twenty-five to thirty years, is important to investors and prospective owners to make a return on investment. Although solar PV systems are known to have characteristically high initial costs, the financial metrics are particularly important as the failure and underperformance of the technology cannot cover the expenditure/investment already incurred. As such, issues of economic viability that depend on a system's reliability and durability are crucial. To assure investors

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[819] Bhubaneswari Parida, S Iniyan and Ranko Goic, 'A Review of Solar Photovoltaic Technologies' (2011) 15 Renewable and Sustainable Energy Reviews 1625 <http://dx.doi.org/10.1016/j.rser.2010.11.032>.accessed 12 December 2020

[820] David A Quansah, Muyiwa S Adaramola and Gabriel Takyi, 'Degradation and Longevity of Solar Photovoltaic Modules—An Analysis of Recent Field Studies in Ghana' (2020) 8 Energy Science and Engineering 2116 < https://doi.org/10.1002/ese3.651> accessed 05 February 2021

[821] Energy Commission of Ghana, 'Ghana Renewable Energy Master Plan' [EC, February 2019] <https://www.energycom.gov.gh/files/Renewable-Energy-Masterplan-February-2019.pdf> accessed 10 May 2022

[822] Ibid

and owners of the quality of their PV systems, manufacturers give warranties which is a promise of 80% or more of nominal power covering the lifespan of twenty-five years of the system. This work probes all these variables and establishes that solar PV satisfies all the relevant issues such as economic viability, durability, and environmental protection. In the 1980s and 1990s, the technology was introduced to different countries in Africa to plug the electricity supply gap.[823] The initiative was to provide electricity to remote areas and provide basic services like health and water supply.[824] However, this initial introduction did not make a significant impact as the capital cost was just too high, and it was a few institutions that could afford the installations, e.g., the Ghana cocoa marketing board.

For over four decades following the introduction of solar PV in Ghana for different purposes and applications, little penetration has been achieved due mainly to the capital costs. However, in recent years, following the decline of the expenses coupled with government policies and the passage of the RE Act, whose objective is to promote the adoption of RE, solar has become a sought-after technology in Ghana now. The LCA of a solar PV system has confirmed the potential benefits to be derived from it.[825] The thesis relied on the data from the first utility-scale solar power plant at Pungu to conduct the analysis. The results confirm that the Pungu solar power plant is economically viable as well as environmentally friendly due to the GHG emissions it saves.

This study seeks to establish that the country is endowed with solar energy as such, it is worth exploiting it using solar PV due to its sterling attributes such as economic viability, carbon emissions reduction, and other benefits it offers to all the actors along the solar value chain in Ghana. Also, to demonstrate the opportunities solar has to offer and highlight the constraints in deploying solar PV and make a case for changes in state policy that would enhance its deployment. Finally, it would give a clear understanding of the challenges around solar PV to enhance its promotion; this can reinvigorate and rejuvenate more interest in it in the country.

The chapter contains fourteen main sections and subsections. It is structured as follows: following the introduction is section 7.2 which makes the case for solar energy to be adopted as a niche technology in Ghana. Section 7.3 gives a brief history of solar electricity development in Ghana. It is followed by section 7.4 which discusses solar energy in Ghana. Section 7.5 shows the solar map of Ghana. Section 7.6 gives the land requirement of a solar PV system. Section 7.7 gives an overview of solar energy technologies. Section 7.8 discusses the global solar PV market. Section 7.9 evaluates the financial viability of a solar PV system, a case study of the Pungu solar power plant. Section 7.10 discusses the legal and policy frameworks supporting solar PV deployment in Ghana. Section 7.11 gives a summary of the benefits and drawbacks of solar technology in Ghana. Section 7.12 highlights the challenges of solar PV technology deployment in Ghana. Section 7.13 explores future pathways for solar PV in Ghana. Section 7.14 draws the summary of the salient issues deliberated upon to conclude the chapter.

7.2 Case for Solar Energy to be Adopted as a Niche Technology in Ghana

Ghana has already exploited its hydro potential by building three large hydro dams with generating capacity of 1,584 MW. The changing weather pattern has rendered the dams less

[823] Gideon Gope, Farhad Aghdasi and MD Dlamini, 'A Review of the Photovoltaic Industry and Its Development in Africa' (1997) 59 Solar Energy 217 <https://doi.org/10.1016/S0038-092X(96)00152-1> accessed 12 January 2021

[824] ibid

[825] Masakazu Ito, 'Life Cycle Assessment of PV systems' in Sukumar Basu (eds), Crystalline Silicon - Properties and Uses, IntechOpen <https://doi.org/10.5772/23134> accessed 10 January 2021

dependable over the years. Therefore, the RE Act has concentrated on other renewables like solar, wind, biomass and mini hydro and has excluded the big dams. As such the remaining RES; solar, wind and biomass are left however, since the coming into force of the Act in 2011, the share of these resources in the electricity generation mix is less than 1%.[826] According Aboagye and others of the three resources per their potential, wind is moderate and mainly high around the coastal regions of Ghana.[827] The unsustainable consumption of traditional biomass is not encouraged because it has contributed to the depletion of the country's forest reserves. From the foregoing the onus falls on solar as it is ubiquitous and widespread around the country and due to Ghana's position within the equatorial belt where solar irradiation is high makes it a good candidate to harness it.

The daily solar irradiation levels range between 4.0 to 6.5 kWh/m²/day, and sunshine duration ranges between 1800 to 3000 hours per annum.[828] As such solar energy potential in the country is enormous than other renewables Ghana is endowed with which makes sense when the country adopts it as a niche technology. This potential is high and certainly is not going to be affected by the adverse weather changes like hydro. As stated above hydro has become less reliable over the years and therefore solar which is abundant can be relied upon to increase the generation capacity of the country. The potential of having RES in sufficient quantities and in good quality influences governments to exploit them as discussed in chapter three under subsection 3.4.4 Ghana is sufficiently endowed with many of these RES especially solar. The sun hits the earth with plenty of energy more than humans can consume and in the case of Ghana, it is well distributed around the country as discussed in section 7.4 Harnessing solar energy and making it a dominant resource in the energy mix brings a lot of benefits as evidenced from the discussion in subsection 7.9.1 on the first grid solar power plant at Navrongo.

A solar PV system's lifespan ranges between 25 to 30 years, in the past these systems were considered to be capital intensive but due to rapid technological advancement, in recent times there have been a decline in their cost making their procurement less costly and due to their lifespan, they can continue to generate green energy for a long time for any system's owner to make a return on investment. The discounted payback period and the simple payback period was estimated as 14.95 years and 8.34 years respectively with the case study of Pungu solar power plant in section 7.9.1 In considering the economic viability of a utility-scale grid solar PV system, a payback period between 8 and 18 years is recommended. These statistics further demonstrate that a solar PV can convert solar energy into affordable electricity during its lifespan which goes a long way to ensure ES for the country. Furthermore, solar equipment like solar lanterns, utility scale systems, solar home systems, water supply systems, traffic signals, rural vaccine storage, street lighting can be deployed to remote areas especially Island and lakeside communities to cater for their power needs which the grid could not have reached and in cases where it could reach it would not be competitive as the above-mentioned solar systems.[829]

Concerns relating to land use for energy instead of food cultivation can be addressed by adopting the measures discussed in section 7.6 further below. Another solution is using "degraded lands", "abandoned lands", "'idle lands" and "marginal lands". Furthermore, another concern raised is intermittency thus it is not available in the night and on cloudy days

[826] Energy Commission of Ghana, '2022 National Energy Statistics' (EC, April 2022) <http://www.energycom.gov.gh/files/2022%20Energy%20Statistics.pdf> accessed 03 June 2022.
[827] Bernard Aboagye and others, 'Status of Renewable Energy Resources for Electricity Supply in Ghana' (2021) 11 Scientific African e00660 <https://doi.org/10.1016/j.sciaf.2020.e00660>.accessed 30 January 2021
[828] Marriette Sakah and others, 'Towards a Sustainable Electrification in Ghana: A Review of Renewable Energy Deployment Policies' (2017) 79 Renewable and Sustainable Energy Reviews 544. <https://doi.org/10.1016/j.rser.2017.05.090> accessed 24 January 2020
[829] Energy Commission of Ghana, Ghana Renewable Energy Master Plan (n 821).

less energy is harnessed, the solution is to use what Suberu, Mustafa and Bashir have identified, thus energy storage systems.[830] Aside these concerns raised which can be addressed as stated above, Ghana going solar can forestall the intermittent power outages the country has been experiencing due to a shortfall in generation. This stems from the fact that since 1965 to 2016, Ghana relied solely on hydro for its electricity supply and the surplus was exported to neighbouring countries like Togo. Unlike hydro which has declined due to changing weather pattern, solar is derived from the sun which is a permanent phenomenon that occurs daily delivering enormous energy in hours more than humans can consume.

A diverse electricity generation mix is good as it makes the energy system secure as seen in chapter six under subsection 6.5.2 which confirms that a more secure energy system is the one dominated by RE such as hydro and the addition of solar as a niche technology. As noted in the thesis the electricity generation mix is dominated by thermal with a share of 65.3% followed by hydro 34.1% and solar and the others with 0.55% share. From the above the domination of thermal does not auger well for ES. A legislation is therefore needed for solar due to its sterling quality as was done for hydro by the enactment of the Volta River Development Act, 1961 (Act 46). The RE Act is formulated as a general Act not for a specific non-hydro RE source. If a new legislation is enacted, it will lead to its (solar) wide-spread use and eliminate the 20 MW cap imposed on solar energy generators to connect to the grid which will encourage more investors who can generate more solar electricity to come to the RE subsector. Solar would then dominate the electricity generation mix and provide the country with the needed ES.

7.3 Brief History and the Development of Solar Electricity in Ghana

The discovery of solar PV can be traced back to the nineteenth century, Fritts made the first deliberate functional PV device in 1883.[831] However, modern-day PVs began in 1954 when researchers at Bell Labs in the USA accidentally discovered that PN junction diodes generated a voltage when lights in a room were on.[832] Within a year's time, they had produced a 6% efficient SI PN junction solar cell.[833] 1973 became an important year for PV as significant improvement in performance was made with violet cell improvement, which led to a 30% increase in efficiency. Since then, various technological improvements have kept increasing to the present day.

Solar electricity development in Ghana can be traced to 1983, following the establishment of the National Energy Board (NEB).[834] Policies on solar were developed by NEB, the first solar PV electrification projects were first initiated in the early 1990s, and in 1991 there were about 335 solar PVs installed in Ghana with an estimated generating capacity of about 160 kW.[835]

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[830] Mohammed Yekini Suberu, Mohd Wazir Mustafa and Nouruddeen Bashir, 'Energy Storage Systems for Renewable Energy Power Sector Integration and Mitigation of Intermittency' (2014) 35 Renewable and Sustainable Energy Reviews 499 <http://dx.doi.org/10.1016/j.rser.2014.04.009>.accessed 10 August 2020

[831] Antonio Luque and Steven Hegedus, *Handbook of Photovoltaic Science and Engineering* (Wiley and Sons Ltd 2003) 11

[832] Adolf Goetzberger and Volker U. Hoffmann, *Photovoltaic Solar Energy Generation* (Springer 2005) 2

[833] ibid

[834] Simon Bawakyillenuo, 'The Political Economy of Renewable Energy Investment in Ghana' in Ana Pueyo and Simon Bawakyillenuo (eds), *Green Power for Africa: Overcoming the Main Constraints* (IDS Bulletin Brighton 2017) < https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/13387/IDSB48.5_6_10.190881968-2017.167.pdf?sequence=1> accessed 29 September 2019

[835] Institute of Economic Affairs. Stand Alone PV Systems. Institute of Economic

Solar PV was seen as an alternative to grid electricity to provide electricity to remote areas of the country that were not covered by the grid. The National Electrification Scheme was launched in the late 1980s, and the government policy was to electrify the whole country in 2020. Solar PV lighting systems in rural communities became prevalent and fell under the NES initiative.[836] As a result, more solar PVs were installed, and in1992 PV installed capacity rose to 350 kW.

The GoG supported research and the fabrication of some components of PV systems was made by Kwame Nkrumah University of Science and Technology.[837] Also, it worked in conjunction with the Spanish government to establish a local facility for the manufacture of solar PV components. The use of solar PV for rural electrification as part of NES allowed solar PV systems imported into the country not to attract import duties or taxes. In Ghana the challenge at the time was that there were no known lenders or financial institutions that could provide credit for solar PV projects. This was because of the high initial cost of solar PV systems in addition, they were seen as risky.[838]

Following the passage of the RE Act, a bold initiative was embarked upon by the state-owned VRA.[839] VRA installed a 2.5 MW grid-connected solar power plant at Pungu in the Upper East Region, and another 700-kW grid-connected solar system at the University of Ghana and Noguchi Memorial Research Institute.[840]

In recent times the GoG announced the solar rooftop programme in 2015. The programme's objective is to provide 200 MW peak relief on the national grid using solar PV technology by installing 200,000 solar PV systems on rooftops in the country in the medium term. It targets residential, commercial, public, and industrial properties. Each beneficiary's maximum generation capacity from solar panels with the programme is 500 watts. The programme has been dubbed "Government Goes Solar". The implementation of the programme commenced in February 2016.[841]

7.4 Solar Energy in Ghana

"The sun is hugely powerful-it delivers more energy in an hour than humankind uses in a year, and unlike fossil fuels, it will never run out".[842] Solar energy has emerged from the shadows of a gloomy picture of Africa's geological environment and has become a significant power

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Affairs (IEA) PVPS Task III, Ghana. 1999 < https://assets.publishing.service.gov.uk/media/57a08d99ed915d622c001ab5/R6243_ANNEX.PDF> accessed 18 January 2021

[836] ibid

[837] Institute of Economic Affairs. Stand Alone PV Systems. Institute of Economic Affairs (IEA) PVPS Task III, Ghana. 1999 < https://assets.publishing.service.gov.uk/media/57a08d99ed915d622c001ab5/R6243_ANNEX.PDF> accessed 18 January 2021

[838] bid

[839] Volta River Authority, '2.5 Navrongo Solar Power Plant' (VRA, Ghana) < https://vra.com/our_mandate/solar_energy.php > accessed 30 May 2022

[840] George Yaw and Evers Hans-Dieter, 'Solar PV Rural Electrification and Energy Poverty: A review and conceptual framework with reference to Ghana' (2009) ZEF Working Paper Series, No. 36, University of Bonn, Centre for Development Research (ZEF), Bonn <http://hdl.handle.net/10419/88294> accessed 16 January 2021

[841] Ghana government goes solar programme will be discussed further later in the chapter.

[842] Joseph Amankwah-Amoah, 'Solar Energy in Sub-Saharan Africa: The Challenges and Opportunities of Technological Leapfrogging' (2015) Thunderbird International Business Review, 57: 15-31 < https://doi.org/10.1002/tie.21677> accessed 12 January 2021

source, it provides a platform on which new businesses and opportunities thrive.[843] Globally, about 1.4 billion people are without access to grid electricity but ironically have sunlight most days of the year. Harnessing solar power is crucial to poverty alleviation as well as for economic development. Solar PV offers the opportunity to people who do not have access to power grids to have light in their homes and for their businesses which hitherto would have been impossible. It is particularly so given that about 600 million people in Africa still do not have access to electricity and rely on expensive and unreliable sources of energy to meet their lighting and heating needs.[844] In Ghana, there are about 600,000 households (3.5 million people) without access to electricity and most of these people live in remote rural communities.[845] As almost half of the population of Africa lack access to electricity, there is a disparity in electrification levels between the rural areas and urban areas whilst the former has 51% the latter has 90%.

As the high energy demand keeps on rising, as a result of population and economic growth, one of the challenges of our time is how to meet this increased demand.[846] This demand is happening at the same time where carbon emissions have wreaked havoc on the global environment by causing climate change. The challenge can be solved with RES as they are being touted as the panacea for climate change and have been widely exploited in recent years. Humankind is confronted with the challenge of ditching fossil fuels whilst keeping abreast with the insatiable global thirst for energy. The solution to this challenge is to adopt more sustainable energy sources which are abundant and readily available. The sun is one of such sources, which is clean and cheap and has been used by nature to sustain almost every life form on earth. Analysis suggests that sunlight could be the primary and even the exclusive source of heat, electricity, and synthetic fuels for the whole world continuously and sustainably on a scale of more than 100 TW.[847]

Consequently, harnessing energy from the sun with solar PV technology offers the hope of addressing this energy challenge.[848] Capturing solar energy through solar PV panels in order to generate electricity is one important promising technology in the RE industry. Solar PV can be explained simply as a technology that can generate electricity directly from the conversion of solar energy. The recent fall in the cost of solar PV gives the opportunity for it to be used to provide fast and cost-effective utility-scale electricity, for modern energy services to the estimated 600 million Africans who lack access to electricity.[849] Increased renewed interest in

[843] Nataliya Kulichenko and Jens Wirth, 'Regulatory and Financial Incentives for Scaling Up Concentrating Solar Power in Developing Countries' (2011) Energy Study <https://doi.org/10.1596/27314> accessed 10 December 2020

[844] Stephen Karekezi and Waeni Kithyoma, 'Renewable Energy Strategies for Rural Africa: Is a PV-Led Renewable Energy Strategy the Right Approach for Providing Modern Energy to the Rural Poor to Sub-Saharan Africa?' (2002) 30 Energy Policy 1071 < https://doi.org/10.1016/S0301-4215(02)00059-9> accessed 12 January 2021

[845] Sulemana Abubakari, 'Achieving Universal Access and Options for Financing' (MOEn, June 2019) <https://atainsights.com/wp-content/uploads/2019/06/4.-Sulemana-Abubakari-Ministry-of-Energy.pdf> accessed 10 December 2020

[846] Jon D Erickson and Duane Chapman, 'Photovoltaic Technology: Markets, Economics, and Rural Development' (1995) 23 World Development 1129. <https://doi.org/10.1016/S0301-4215(02)00059-9> accessed 19 November 2020

[847] Jerome Martin Weingart, 'The Helios Strategy: An Heretical View of the Potential Role of Solar Energy in the Future of a Small Planet' (1978) 12 Technological Forecasting and Social Change 273. <https://doi.org/10.1016/0040-1625(78)90037-9> accessed 17 January 2021

[848] I Chambouleyron, 'Photovoltaics in the Developing World' (1996) 21 Energy 385 < https://doi.org/10.1016/0360-5442(95)00118-2> accessed 17 December 2020

[849] International Renewable Energy Agency, 'Solar PV in Africa: Costs and Markets' (IRENA, September 2016) <https://www.irena.org/publications/2016/Sep/Solar-PV-in-Africa-Costs-and-Markets> accessed 19 January 2021

solar PV systems in Ghana can be attributed to the falling price of PV technologies, low maintenance costs and the ability to generate electricity without fuel.

Ghana lies within the equatorial belt, in which the humidity is high, as well as the radiation. The geographical position of Ghana within the belt means there is a relatively high solar radiation distributed around the country and throughout the year. It makes it prudent to harness and utilise solar energy and give its adoption a priority. The high solar irradiation data have been recorded by a number of institutions like the Ghana Meteorological Agency and UNDP. This monitoring has come to confirm the daily solar irradiation levels and sunshine duration, as noted above. The dependence on hydropower and fossil-based fuels for electricity generation has long since become less reliable and erratic, it is, therefore, time to harness the solar energy resources of the country on a larger scale.[850]

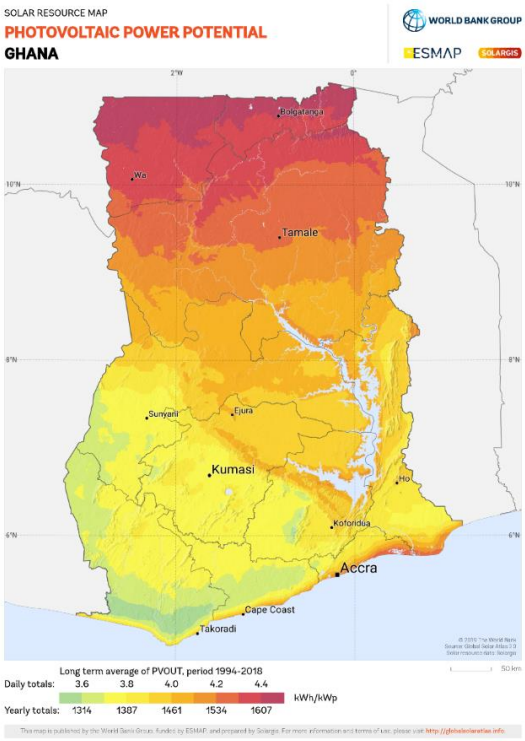
7.5 Solar Map of Ghana

The Ghana Meteorological Agency has divided the country into four agro-ecological zones, namely: savannah, transition, forest and coastal.[851] The solar map of Ghana below shows the country is divided into two major zones that is north and south. Generally, the whole country has high solar insolation potential. However, the northern parts have higher solar insolation potential than the southern parts and is therefore, an excellent place to deploy a grid-connected solar PV system or off-grid solar PV system. Due to this potential, the first utility-scale solar PV plant has been installed in this part of the country. Find below in figure 2 the solar energy potential map of Ghana.

[850] K Godfrey Adanu, 'Promoting Photovoltaic Electricity Usage in Developing Countries - Experience from Ghana' (1994) 34 Solar Energy Materials and Solar Cells 67 <https://doi.org/10.1016/0927-0248(94)90025-6> accessed 14 January 2021

[851] Leonard K Amekudzi and others, 'Variabilities in Rainfall Onset, Cessation and Length of Rainy Season for the Various Agro-Ecological Zones of Ghana' (2015) 3 Climate 416 < https://doi.org/10.3390/cli3020416> accessed 17 January 2021

Figure: 2 Solar Resource Map of Ghana



Source: Agyekum (2020)

7.6 Land Requirement for a Solar Photovoltaic System

A utility-scale solar plant requires a large expanse of land for the installation of the equipment. The requirement is 2.5 acres (1 hectare) per MW.[852] A 5 MW grid-connected solar PV system requires an investment of US$17,752,179 and land of 25,313 m² for the installation.[853] The land requirement is huge, as this may compete with other land use options. Ghana is already grappling with a huge housing deficit. As such it makes this requirement to raise a lot of concerns. Furthermore, when large hectares of land are used for solar systems like the Pungu Solar Power Plant (SPP), it leaves the local community, which hitherto used the land to cultivate crops, stranded. It, therefore, threatens the food security of the community, a development that goes against energy justice; especially when the evaluation of the recognition dimension has not been made as discussed in chapter one- under subsections 1.6.2.4 and 1.6.2.5 Under this circumstance, no remediation measures are put in place to mitigate the injustice. This injustice can be mitigated by promoting the mixed-use of land for solar farms and agricultural cropping. The EC of Ghana, in October 2014, issued some guidelines relating to utility-scale grid-connected solar plants. The notice stipulates that land with valuable economic trees like cocoa and oil palm could be used for solar PV farms. However, the design must be such that it can accommodate the cultivation of food and cash crops alongside the solar PV plant, and evidence of the design is submitted to EC before a construction permit is granted for the project.

[852] Energy Commission of Ghana, Renewable Energy Master Plan (n 821).
[853] Samuel Asumadu-Sarkodie and Phebe Asantewaa Owusu, 'The Potential and Economic Viability of Wind Farms in Ghana' (2016) 38 Energy Sources, Part A: Recovery, Utilization and Environmental Effects 695 < https://doi.org/10.1080/15567036.2015.1122682> accessed 12 February 2021

7.7 Overview of Solar Energy Technologies

Solar energy is the conversion of sunlight to other usable energy forms, thus solar PV, solar thermal electricity and solar heating and cooling are all matured solar technologies.[854] There are two main solar energy technologies- solar PV and concentrated Solar-thermal Power (CSP). In Ghana, diffuse radiation constitutes over 30% of the total solar radiation, and this is not favourable for concentrating collectors that are used in solar thermal power plants; PV modules are not affected by the diffuse radiation and may be used effectively anywhere in the country hence this study is focused on solar PV.[855] Photovoltaic conversion is when direct sunlight is converted into electricity without the use of any heat engine in the process. PV panels are simple devices that are designed in a way that they are able to capture the power of the sun. Solar PV panels require little maintenance and are built as stand-alone systems capable of generating electricity from microwatts to megawatts. In chapter three under subsections 3.5.1 to 3.5.1.3 a discussion was made on solar energy and PV and are considered to be potentially part of this section.

7.8 The Global Solar Photovoltaic Market

The global solar PV market is influenced by technology which is divided into two major groups: a photovoltaics segment and a concentrated solar thermal segment. The solar PV market is now dominated by China.[856] Asia Pacific became the leading PV market globally by value in 2019, and this can be attributed to key players such as Jinko Solar (China), Trina (China), JA Solar (China) and LONGI (China). China, India, Japan have increased their adoption of solar PV modules with a cumulative installed capacity of 300 GW as of 2019.[857] The APAC region is the largest producer and consumer of solar PV modules and balance of the system (BOS) components.[858] The global PV market was estimated to be US$ 76.6 billion in 2020 and projected to reach US$113.1 billion in 2025 at a compound annual growth rate CAGR of 8.1%.[859] Global electricity generation from solar PV increased to 156 TW/h making a 23% growth in 2020.[860] Recent market trends show that by 2019 more than 580 GW of solar PV systems were installed globally, representing 14-fold growth for the technology since 2010.

7.8.1 Current Market Trends of Solar Photovoltaic in Africa

It is crucial to perform an economic analysis of a solar PV system in relation to capacity factor, operation, and maintenance (O&M), cost and levelised cost of electricity (LCOE) for decision-making by public and private sectors' investments. In 2019 about 98 GW of newly installed

[854] International Energy Agency, 'Solar' (IEA, 15 December 2022 <https://www.iea.org/fuels-and-technologies/solar> accessed 30 December 2022

[855] Samuel Asumadu-Sarkodie and Phebe Asantewaa Owusu, 'A Review of Ghana's Solar Energy Potential' (2016) 4 AIMS Energy 675 < http://www.doi: 10.3934/energy.2016.5.675> accessed 19 January 2021

[856] ibid

[857] Market Research, 'Photovoltaic Market' (Markets and Markets, October 2020) <https://www.marketsandmarkets.com/Market-Reports/building-integrated-photovoltaic-market-428.html?gclid=Cj0KCQiA7NKBBhDBARIsAHbXCB7ShuhDiZuqM5_TGJowNTxkAA6g3Sk08xlrS6WHBnhaV64LSo_guSEaAocdEALw_wcB> accessed 24 February 2021

[858] ibid

[859] Market Research, 'Photovoltaic Market' (Markets and Markets, October 2020) <https://www.marketsandmarkets.com/Market-Reports/building-integrated-photovoltaic-market-428.html?gclid=Cj0KCQiA7NKBBhDBARIsAHbXCB7ShuhDiZuqM5_TGJowNTxkAA6g3Sk08xlrS6WHBnhaV64LSo_guSEaAocdEALw_wcB> accessed 24 February 2021

[860] International Energy Agency, 'Solar PV' (IEA, September 2022) <https://www.iea.org/reports/solar-pv> accessed 29 December 2022

solar PV systems were commissioned, making it the highest among the rest of RETs for the year. In 2019 growth was driven by new additions from Asia, thus the region contributing about 60% of new installed capacity.

In Africa, installed costs for power generated by utility-scale solar PV projects have declined as much as 61% since 2012 to as low as US$ 1.30/W compared to the global average of 1.80/W; mini-grids using solar PV and off-grid solar home systems serve quality energy services at equally lower costs, stand-alone solar PV mini-grids installed costs in Africa is as low as US$ 1.90 per watt.[861] The average cost of a utility-scale solar PV system is in a lower bound of US$1,500 per kilowatt derived from a 20 MW PV system built by Chinese developers.[862] The lower cost of projects may be due to the continuous decline in solar PV installed costs, and this trend could make newer projects less costly than older ones, and this falls within the trend at the international level.[863]

In Ghana, following the enactment of the RE Act, it broadly adopts economic and technical strategies to guide the development of the RE market. The fiscal incentives such as the FIT scheme and the RE Fund are geared towards creating a conducive investment environment and market for the private sector's participation in RE generation. Furthermore, the RE master plan presents a new focus for scaling up RE by showing the investment opportunities available in the RE market in Ghana.

7.9 Economic Viability of Solar Photovoltaic: A Case Study of Pungu Solar Power Plant

To assess the economic viability of a solar PV power system in Ghana, it has become necessary to conduct a case study of the first grid-connected solar PV system, the Pungu Solar Power Plant. The study's outcome will provide vital information to the country on the adoption of solar PV. Some important words going to be used in the study are explained briefly. Capacity factor is the ratio of the energy generated by a power plant or fleet of generators over a period usually a year which is divided by the installed capacity. Simply it measures a power plant's actual generation when compared to the maximum amount of energy it could generate over a given period without any interruption.[864] Operation and maintenance costs are the set of actions focused on the preservation of a solar PV system in good operating conditions avoiding its degradation, it increases availability especially at peak times, reliability and improves its efficiency.[865] The levelised cost of electricity (LCOE) in electrical energy generation can be defined as the present value of the price of the generated electrical energy

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[861] International Renewable Energy Agency, 'Solar PV in Africa: Costs and Markets' (IRENA, September 2016) <https://www.irena.org/publications/2016/Sep/Solar-PV-in-Africa-Costs-and-Markets> accessed 19 January 2021

[862] Ana Pueyo, Simon Bawakyillenuo and Helen Osiolo, 'Cost and Returns on Renewable Energy in Sub-Saharan Africa: A Comparison of Kenya and Ghana' [2016] Evidence report Pro-Poor Electricity Provision1 <https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/11297/ER190_CostandReturnsofRenewableEnergyinSubSaharanAfricaAComparisonofKenyaandGhana.pdf> accessed 19 June 2020

[863] International Renewable Energy Agency, 'Renewable Power Generation Costs in 2018' (IRENA, 2019) <https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf?la=en&hash=99683CDDBC40A729A5F51C20DA7B6C297F794C5D> accessed 17 February 2021

[864] Jorge Morales Pedraza, 'Chapter 4 - Current Status and Perspective in the Use of Coal for Electricity Generation in the North America Region' (2019) Conventional Energy in North America, 211 <https://doi.org/10.1016/B978-0-12-814889-1.00004-8> accessed 22 February 2021

[865] Ana P. Talayero and others, 'Operation and Maintenance in Solar Plants: Eight Study Cases' (2018) 1 Renewable Energy and Power Quality Journal 499 <https: doi.org/10.24084/repqj16.363> accessed 14 January 2021

(usually expressed in units of cents per kilowatt hour).[866] It considers the economic life of the plant and the costs incurred in the construction, operation and maintenance and the fuel costs.[867] Simple payback period is the time in which the initial capital investment into a project is expected to be recouped from the cash inflows that is generated by the project.[868] Discounted payback period is the length of time it takes the discounted net cash revenues or cost savings of a project to payback the initial investment.[869]

7.9.1 Pungu Solar Power Plant (SPP)

This research has selected the 2.5 MW solar power plant located at Pungu in Navrongo in the Upper East region of Ghana for the economic viability analysis because it is the first utility-scale solar power plant to be built in Ghana and sited at a location where the solar insolation is high. Simulations can be used to assess the performance of a solar PV system but relying on studies carried out on an existing solar PV system under real-life conditions is the best approach to examine the actual performance of this kind of system at a particular site. Hence the choice of the work of these authors: Mensah, Yamoah and Adaramola (Performance evaluation of a utility-scale grid-tied solar photovoltaic (PV) installation in Ghana).[870] The Pungu solar PV power plant (SPP) is made of 8640 SUNTECH and STP 295-24/Vd modules with an installed capacity of 2.5 MW.

The global solar irradiation on the horizontal surface in Pungu varies from 4.61kWh/m²/day in August to 6.11 kWh/m²/day in March and an annual average of 5.54 kWh/m²/day according to Mensah, Yamoah and Adaramola[871]. The maximum highest ambient temperature at this site is 43°C recorded in March/April; the high radiation at Pungu makes it ideal for the siting of the solar PV system. The facility was installed by the state-owed generation company called VRA in 2013 at the cost of US$8,082,025 million (GH¢16,089,200 million); the amount included the costs of the modules, balance of system (BOS) and installation costs.[872] The solar PV system has a lifespan of twenty-five years and sited on a 4.77 hectare of land or 12-acre land and has an expected annual generation of 3.7 GWh.[873] The performance ratio is found to be 70.4%. LCOE is estimated to be US$0.2411/kWh.

Applying the exchange rate when the project was commissioned and ten years guaranteed FIT tariff, they then applied these data and the results are as follows; the discounted payback period for the Pungu SPP was estimated as 14.95 years, whilst the simple payback period

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[866] Magdi Ragheb, Wind Energy Engineering: A Handbook for Onshore and Offshore Wind Turbines (Academic Press Elsevier 2017) <https://doi.org/10.1016/B978-0-12-809451-8.00025-4> accessed 16 January 2021

[867] ibid

[868] Frank Lefley, 'The Payback Method of Investment Appraisal: A Review and Synthesis' (1996) 44 International Journal of Production Economics 207 <https://doi.org/10.1016/0925-5273(96)00022-9> accessed 15 March 2021

[869] Edwards Bailey Chartered Accountants, 'Discounted Payback Period Definition' (Accounting Tools, 15 September 2022) <https://www.accountingtools.com/articles/discounted-payback-period.html> accessed 28 December 2022

[870] Lena D Mensah, John O Yamoah, and Muyiwa S Adaramola, 'Performance Evaluation of a Utility-Scale Grid-Tied Solar Photovoltaic (PV) Installation in Ghana' (2019) 48 Energy for Sustainable Development 82 <https://doi.org/10.1016/j.esd.2018.11.003> accessed 12 October 2020

[871] ibid

[872] Walter Banuenumah, Francois Sekyere and Emmanuel Donkor, 'Impact of Solar Photovoltaic as an Alternative Source of Power for Rural Electrication in Ghana. (A Case Study in Pungu – Navrongo Upper East Region)' (2016) 7 687 <https://www.ijser.org/researchpaper/Impact-of-Solar-Photovoltaic-as-an-Alternative-Source-of-Power-for-Rural-Electrication-in-Ghana-A-Case-Study-in-Pungu-Navrongo-Upper-East-Region.pdf> accessed 12 November 2020

[873] EB Agyekum, VI Velkin and I Hossain, 'Comparative Evaluation of Renewable Energy Scenario in Ghana' (2019) 643 IOP Conference Series: Materials Science and Engineering 3 < https://doi.org/10.1088/1757-899X/643/1/012157> accessed 29 December 2020

was estimated as 8.34 years. In considering the economic viability of a utility-scale grid solar PV system, a payback period between 8 and 18 years is recommended.[874] This range suggests that Pungu SPP is within the economic viability bracket. From the above, it can be assumed that it will take about 15 or 8 years when using discounted payback and simple payback periods, respectively, for the project to "pay for itself". It will still have about ten years (discounted Payback period) or 17 years (simple payback period) of its lifespan to generate more electricity. The plant has saved over 3852 metric tonnes of CO_2 emissions annually since its installation due to the clean energy it generates. This saving is going to be made throughout the lifespan of the plant. Therefore, the Pungu SPP is thus economically viable and offers a lot of environmental benefits, thus the reduction of CO_2 emissions.

7.10 Legal and Policy Frameworks Supporting Solar Photovoltaic Deployment in Ghana

Before the enactment of the RE Act, the EC of Ghana had taken the initiative to explore ways the RES of the country could be exploited to augment the less reliable hydro dams and thermal plants. As a result, many plans have been initiated detailing the government's policy on RE. these include:

(1) The Strategic National Energy Plan (SNEP) for the period covering 2006 to 2020, which has now been extended to 2030,

(2) The National Energy Policy (NEP) 2010,

(3) The Energy Sector Strategy and Development Plan (2010),

(4) The Renewable Energy Act, 2011 (Act 832),

(5) Fiscal Incentives for the Promotion of RE,

(6) Ghana Shared Growth and Development,

(7) The Economic Community of West African States (ECOWAS) Energy Policy (2015),

(8) National Rooftop Solar Programme Policy (2015) and

(9) The recent updated SNEP (2020 to 2030). These policies are deployed for the development of RE in Ghana.

7.10.1 Strategic National Energy Plan (SNEP) 2006 to 2020 and National Energy Policy (NEP) 2010

SNEP 2006 to 2020 and NEP 2010, have already been discussed in chapter three and would therefore not be repeated but would be considered to be potentially part of this subsection.[875]

[874] International Finance Corporation (IFC), Utility-Scale Solar Photovoltaic Power Plants: A Project Developer's Guide (2015) Washington D.C. USA: World Bank Group < https://www.ifc.org/wps/wcm/connect/a1b3dbd3-983e-4ee3-a67b-cdc29ef900cb/IFC+Solar+Report_Web+_08+05.pdf?MOD=AJPERES&CVID=kZePDPG> accessed 20 January 2021

[875] Chapter 3, subsections 3.6.1 and 3.6.2

7.10.2 Energy Sector Strategy and Development Plan (ESSDP) 2010

The energy sector's vision is stated in the plan as "to guarantee the availability of an adequate energy supply to meet the country's internal demands and ensure universal access to modern energy in 2020 and provide surplus energy for export".[876] In the plan, the GoG shall focus on:[877]

(1) Promoting the exploitation and use of mini hydro, solar, and wind energy resources,

(2) Providing tax incentives for all equipment imported for the development of RE projects and

(3) Support the use of decentralised off-grid alternative technologies such as solar PV and wind where they are competitive.

The vision of ESSDP 2010 has not been realised as the internal demand level fluctuates, and there was no universal access to modern energy in 2020. As a result, there has not been any surplus left for export as envisaged.

7.10.3 The Renewable Energy Act, 2011 (Act 832)

Following the lackluster implementation of SNEP 2006 to 2020, NEP 2010, and ESSDP 2010, it became clear that the RE subsector needed a legal regime to oversee its activities. Therefore, the RE Act was enacted in 2011 to harmonise government policies and strategies for the RE subsector. The RE Act was discussed in-depth in chapter three- under section 3.7 (Analysis of the Renewable Energy Act, 2011 (Act 832)) and subsections 3.7.1 to 3.7.3 and potentially forms part of this subsection and would not be repeated. The RE Act represents the legal framework governing the RE subsector. The RE Act's overarching objective is to provide for the development, management, and utilisation of renewable energy sources for the production of heat and power in an efficient and environmentally sustainable manner.[878] The RE Act re-echoed one of the most important policies that was formulated in SNEP thus to increase the share of non-hydro RE to 10% in the electricity generation mix in 2020.

7.10.4 Fiscal Incentives for Solar Photovoltaic as Provided by the Renewable Energy Act of Ghana

The country has huge potential in solar energy and other renewables. For this to happen, legal frameworks are needed to bring this to fruition and notable among these is the promulgation of the Renewable Energy Act, 2011 (Act 832). The RE Act has been enacted to promote private sector participation in the RE subsector for the development and utilisation of RES for electricity generation. The Act provides the legal framework for the government's support for the RE subsector. It creates the enabling environment to attract participation by private sector investors in the generation of RE. The Act aims to encourage the use of RETs to increase the share of non-hydro RE in the energy mix, which includes solar.

RE adoption is therefore expected to increase the diversification of the different RES into the energy mix, which would bring about ES and improve access to electricity to the different categories of consumers. It is also expected that, it would lead to the building of indigenous capacity in technology for large scale generation, and that will likely increase RE (solar) market

[876] Ministry of Energy Ghana, 'Energy Sector Strategy and Development Plan' (MOEn, February 2010) < https://ouroilmoney.s3.amazonaws.com/media/documents/2016/06/09/energy_strategy.pdf> accessed 29 December 2019
[877] ibid
[878] Ghana's Renewable Energy Act, 2011 (Act 832).

share in the future.[879] The RE Act has made provisions to incentivise the RE subsector to promote the deployment and development of RETs. These include the proposed establishment of the RE Fund, RE Authority, REPO, and net metering. The RE Fund, as provided in the Act, will give financial support such as capital subsidies, financial incentives, and production-based subsidies to RE developers to promote the development of RE.[880] Furthermore, through the rooftop solar PV programme, participants are given a subsidy of GH¢1,900.00 to promote the adoption of solar PV for the generation of electricity. The policy direction aims to bring about improvement in the cost-effectiveness of RETs, create a favourable regulatory and fiscal environment.[881] Furthermore, support for R&D using local content will bring the cost of RETs further down and provide support that would bring improvement for off-grid technologies such as solar PVs.

It was envisaged that the contents of the RE Act would be fully implemented to entice the private sector (IPP) to participate in the RE subsector for the generation of electricity in the country, but this did not quite happen as expected. Further discussion on why solar has made a small contribution to the energy mix following the implementation of the legal framework and policies is provided in section 7.12 and subsections 7.12.1 to 7.12.4

7.10.5 Ghana Shared Growth and Development Agenda (GSGDA)

The medium-term national policy framework (GSGDA ll) for 2014 to 2017 was formulated based on the lessons learnt from the performance of the first GSGDA, which was from 2010 to 2013. GSGDA ll identified power as one of the main constraints to the speedy growth and development of the economy. GSGDA ll states that: "in the medium-term, the government policy will focus on increasing the proportion of renewables and other sources of energy in the supply mix particularly solar, wind, mini hydro, and waste-to-energy".[882] The strategies to be adopted included:[883]

(1) Accelerating the implementation of the provisions of the RE Act,

(2) Providing access to waste-to-energy technologies and

(3) Facilitating access to the grid for stand-alone RE power plants.

These strategies are ongoing in aid of the deployment of RE in the country.

7.10.6 Strategic National Energy Plan Volume One (SNEP 2030)

SNEP (2006 to 2020) was published in 2006; however, after its publication, Ghana's energy-economy landscape underwent a lot of changes, such as the discovery of crude oil in

[879] Fausto Cavallaro, 'A Comparative Assessment of Thin-Film Photovoltaic Production Processes Using the ELECTRE III Method' (2010) 38 Energy Policy 463 <http://dx.doi.org/10.1016/j.enpol.2009.09.037>. accessed 19 December 2020

[880] UNDP, 'China-Ghana South-South Cooperation on Renewable Energy Technology Transfer' (UNDP, May 2014) < https://info.undp.org/docs/pdc/Documents/CHN/ProDoc%20-%2091276.pdf> accessed 12 November 2019

[881] Energy Commission of Ghana, Renewable Energy Master plan (n 821).

[882] Ghana National Development Planning Commission, 'Ghana Shared Growth and Development Agenda (GSGDA) II, 2014-2017 - Vol I: Policy Framework' (Government of Ghana, December 2014) < https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/GHANA%29%20Ghana%20Shared%20Growth%20and%20Development%20Agenda%20%28GSGDA%29%20II%202014-2017%20Vol%20I.pdf> accessed 11 August 2019

[883] Energy Commission of Ghana, 'Renewable Energy Policy Review, Identification of Gaps and Solutions in Ghana' (EC, 2015) < http://energycom.gov.gh/files/Renewable%20Energy%20Policy%20and%20Regulatory%20Gap%20%20%20%20%20Analysis%20Final(2015).pdf> accessed 10 August 2019

commercial quantities in 2007 and the rebasing of the country's economy in 2006 and 2013. These changes have necessitated the review and update of SNEP (2006 to 2020). SNEP (2020 to 2030) is thus the second SNEP published by EC as part of its mandate. The goal of SNEP (2020 to 2030) is "to contribute to the development of a sound energy market that would provide sufficient, viable and efficient energy services for Ghana's economic development".[884] SNEP (2020 to 2030) has been divided into two volumes; volume one covers the demand sectors of the economy, and volume two covers the supply-side of the energy sector, which includes electricity, oil and gas and renewables.

There are seven specific objectives of SNEP (2020 to 2030). The three relevant to this thesis are as follows:[885]

(1) Identify possible energy demand profiles for the country from 2020 to 2030,

(2) Assess energy supply options or strategies (oil and gas, coal, hydropower, nuclear, wind, biomass and solar) and their strengths and weaknesses (costs, environmental impact, and technical constraints) to determine sustainable ES and

(3) Identify key policy issues and promising policy options for transition to the long-term sustainable development of the country's energy sector and the economy.

Looking through the plan, the10% target has not been included. The reason for the exclusion of the target could be that the energy managers of the country have realised that there is still more work left to be done before the target can be met. It may be in recognition of the current slow pace at which the law and policies on RE are being implemented.

The update does not give much focus to RE as it deals with other energy forms, which include fossil fuels and nuclear. Instead, the focus is on the energy market that is envisaged to provide efficient energy services for the development of the Ghanaian economy. The thesis has sought to establish through the discussions, that the GoG is rather relying on fossil fuels to the neglect of RE. This is because the document is still considering fossil fuels to be part of the electricity generation mix in 2030 despite the coming into force of the RE Act for well over eleven years now. This development clearly demonstrates the partial and lip service the GoG gives to renewables. The pathway is adding more fossil fuels to the energy mix by the government for a quick fix to the country's energy challenges. The lack of political will to continue to pursue the RE agenda aggressively since it was launched in 2011, has contributed to the paltry diffusion of non-hydro RE in the electricity generation mix in 2020.

As noted above, this SNEP 2020 to 2030 is volume one and focuses on the demand sectors of the economy; volume two considers the supply-side of the energy sector, which includes renewables. When volume two is published, then further in-depth discussion can be made on it.

7.10.7 National Rooftop Solar Programme

GoG's bid to expand the country's solar capacity is taking place across a number of fronts. The MOEn, in collaboration with the EC, is implementing the rooftop solar PV programme in the country, as part of the government's quest to harness the country's solar potential to increase capacity. The programme is in fulfilment of the president's rooftop solar PV initiative,

[884] Energy Commission of Ghana, 'Strategic National Energy Plan (SNEP 2030)' (EC, July 2019) < https://energycom.gov.gh/files/SNEP%20Demand%20Oct2019_SNEP2030_Final.pdf> accessed 15 August 2020
[885] ibid

which was announced in 2015.[886] The overarching objective is to provide an intervention of 200 MW peak load relief on the national grid by using solar PV in the medium term. It is in recognition of the role solar can play in the country's electricity generation mix. It is an attestation of the government's determination to tap its RES. The scheme involves the mounting of solar arrays on the roofs of homes across the country, especially in those areas without access to reliable electricity services. Some changes have been made to the scheme since its first inception. In March 2017, the Minister of Energy announced the expansion of the scheme to cover non-residential facilities to include ministries, agencies, and departments; the objective of this change is borne out of the need to reduce the utility costs raked in by government agencies.

With the residential side of the initiative, the EC has been tasked with the responsibility to facilitate the implementation of the installation of 20,000 rooftop solar PV systems in private homes under a capital subsidy scheme commencing in 2016.

7.10.8 Administration of the Capital Subsidy Scheme

The scheme operates in two forms in which the beneficiaries will be given either:[887]

(i) Cash payments for the cost of the components of the solar panels of the solar PV system or

(ii) Actual solar panels are supplied after the beneficiary has bought and installed the right BOS parts of the solar PV system, including an inverter, charge controls, batteries, mounting frame.

Each beneficiary will be granted a maximum of solar panels with a generation capacity of up to 500 watts. In addition, many banks have expressed interest in providing loans to beneficiaries of the scheme to procure their own BOS. e.g., Energy Bank, Ghana Commercial Bank, Societe Generale Ghana.

7.10.9 Qualifying Criteria for Prospective Beneficiaries

The criteria include:[888]

(1) Change all lamps in their facility to LED lamps,

(2) Be willing to buy BOS parts,

(3) Agree that the installation of the BOS will be done before the supply installation of the solar PV panels from the scheme,

(4) Install only deep cycle batteries designed for solar PV systems,

(5) Ensure the BOS meet the minimum standards set by Ghana Standards Authority and

(6) Employ the services of installers who are qualified and licensed by EC for all the installation works.

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[886] Energy Commission, 'Application Form for Rooftop Solar Programme Residential' (EC) <http://www.energycom.gov.gh/about/18-announcement/27-132-application-form-for-rooftop-solar-programme-residential> accessed 22 April 2021

[887] ibid

[888] ibid

After meeting the above criteria, the beneficiary needs to complete an application form and go through the process for approval. When the rooftop system is in place, it allows the beneficiaries to sell their surplus electricity generated to the local grid through the net-metering scheme. In evaluating the impact or effectiveness of the programme so far, the programme is still ongoing and has made some significant gains since its implementation in 2016 as follows: The programme has brought social, environmental, and economic benefits to the households as follows:[889] In terms of the social impact, an estimated 40,000 households in Ghana are going to get access to clean and affordable energy. The environmental benefits come from the avoided GHG emissions and air pollutants from grid-connected thermal-based power plants. The avoided electricity bill for the 40,000 households over a 15-year period is a huge saving for them. Also, it creates direct and indirect jobs as it will likely generate about 280 installation and maintenance jobs during the implementation period.[890]

However, the 200 MW target set under the programme is rather over-ambitious. There is uncertainty regarding its uptake rate, especially as it has not been piloted to ascertain how it works. More so, how the surplus power can be sold to GRIDCo through the net metering scheme has not been mentioned. Key details of the scheme are not known, such as power limits restrictions for net-metering eligibility and the surplus power sold, how the beneficiary can redeem payments and how it is calculated; these uncertainties need clarification for the smooth operation of the policy.[891]

7.10.10 Results of the Legal Interventions

Following the major legal and policy intervention noted above in the RE subsector, the contribution of RE (solar) to the electricity generation mix has been abysmal. As a result, the 10% target has been missed and has now been extended to 2030.[892] The share of solar is less than 1% in the electricity generation mix, indicating that the 10% target has been missed.[893] The abysmal performance and missing of the 10% target can be attributed to many factors. The relevant ones relating to solar are being discussed below:

The government's action is tantamount to a double standard, which has undermined the effective implementation of the RE Act. According to Bawakyillenuo, the development trajectory pursued by the government is unsustainable because it envisions increasing thermal generation to over 80% in the next decade.[894] This raises the question as to which pathways would lead to the RE development niche in the current energy regime. It is in sharp contrast to the objective of the RE Act and the goal of NEP (2010) seen above. Moreover, it demonstrates that the government's approach to RE is lackluster and sends the wrong signals to the private sector that is being attracted to come and invest in the RE subsector.

The RE Act has mandated EC and PURC to be the regulators for the RE subsector. As such, in 2014, PURC carried out its responsibility by publishing the tariff rates for the various RES

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[889] Initiative for Climate Action Transparency, 'Sustainable Development Impacts Assessment of Ghana's Rooftop Solar Programme' (ICAT, December 2019) < https://climateactiontransparency.org/wp-content/uploads/2021/07/Sustainable-development-impacts-assessment-of-Ghanas-rooftop-solar-programme.pdf>. accessed 10 April 2021

[890] ibid

[891] Oxford Business Group, 'Solar power grows in Ghana with state support and foreign investment' (Oxford Business Group) <https://oxfordbusinessgroup.com/analysis/rise-solar-lamps-and-panels-become-more-widespread-thanks-mix-government-initiatives-and-foreign> accessed 14 April 2021.

[892] Aboagye and others (n 823).

[893] Ministry of Energy, 'Overview of the Ghana Power Sector' (MOEn) <https://www.energymin.gov.gh/sector-overview> accessed 30 March 2021

[894] GhanaWeb, 'Government Projects 80% of Power Plants to be Thermal' (Business News, 13 April 2016) <www.ghanaweb.com/GhanaHomePage/NewsArchive/Gov-tprojects-80-of-power-plants-to-be-thermal-430382> accessed 25 February 2021

to guide the utilities. The FIT guaranteed the sale of electricity generated from RES for ten years, and thereafter, subject to a two-year review, this part of the policy has now been repealed in 2020. by an amendment to the Act. The other two components are still being maintained, REPO and connecting to the transmission and distribution systems.

When FIT was in operation until its repeal in 2020, RE generators saw the ten years as rather too short. A disincentive, especially for solar PV, whose lifespan ranges between twenty-five to thirty years to make a return on investment. It, therefore, could have discouraged many potential investors, as confirmed in the work of Bawakyillenuo.[895] Before FIT was repealed, it was already struggling and performing poorly as many RE investors were dissatisfied with the ten years' guarantee as small.

As part of its regulatory responsibilities, EC published codes that will be used to connect to the grid to protect it. A generator of RE electricity bears the cost of connecting to the metering point of the grid. This requirement will affect generators with insufficient cash flows to absorb this additional cost. It is likely to make operators like GRIDCo take advantage of the weak financial position of small generators by deliberately putting impediments in their way by requiring upfront payments. This approach has solved one problem of connecting to the grid to protect it and has created restrictions on the quantum of electricity that can be supplied to the grid. This restriction particularly affects solar energy generators, Ghana's grid is obsolete and weak, and it is reported that the distribution losses were high as 29.7%.[896] These losses are way above the Sub-Saharan average of 12%. It ultimately affects the quantum of RE electricity that can be connected to the grid at a given time. This inefficiency of the grid is a setback for large generators of RE (solar) electricity as they are restricted and given a limited quantity of electricity they generate to be evacuated through the grid. Renschhausen intimates that if the challenges of transmission and distribution losses are not addressed, it would be difficult for the generation of large quantum of electricity from renewables to be transmitted through the current weak infrastructure.[897]

Furthermore, The EC issues licences to power generators; it suspended the issuance of licences and permits to wholesale electricity supply with respect to utility-scale grid-connected solar PV systems. It was followed up with a capacity restriction of 20 MWp per plant, and 150 MWp aggregate was imposed on solar PV plants without storage systems. The restriction is meant to prevent the overloading of the weak grid network with fluctuating electricity generated from solar. Further, a wholesale electricity supply licence (WESL) is required to trade in electricity supply. Per the requirement, WESL is only issued to a person who intends to supply electricity to a distributor or a bulk customer. Most solar PV installation companies do not qualify. They cannot also enter into a power purchasing agreement with a distribution utility due to the suspension of the issuance of new WESLs. In 2015 the much-awaited net metering was introduced through the net metering code for connecting RE generating systems to the distribution networks. However, the subcode did not work as it failed to credit the system's owner. As a result, the system's owner was charged for all electricity purchases made instead of being credited. All these issues could have contributed to dampening the interest of potential RE developers from investing in solar PV systems in the Ghanaian RE subsector.

Kankam and Boon examined the benefit of solar PV system deployment in rural communities in the Northern Region of Ghana; The results of their study found that solar PV systems offered

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[895] Simon Bawakyillenuo, 'The Political Economy of Renewable Energy Investment in Ghana' (2017) 48 (5-6) IDS Bulletin Transforming Development Knowledge <https://doi.org/10.19088/1968-2017.167> accessed 17 September 2020

[896] Energy Commission of Ghana (n 826).

[897] M. Meyer-Renschhausen, 'Evaluation of feed-in tariff-schemes in African countries' (2013) 24(1) Journal of Energy in Southern Africa <http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-447X2013000100008&lng=en&nrm=iso> accessed 30 March 2021

significant benefits, thus lighting services for their homes in non-gridded communities.[898] However, the study disclosed that residents preferred electricity supplied from the national grid to solar PV.[899] The main reason for this is that tariffs from the central grid are far cheaper, and this is due to the subsidies applied to the fuels used in generating the electricity. In contrast RE, for that matter, solar, does not receive such incentives.

7.11 Benefits and Drawbacks of Solar Technology in Ghana

Reference is made to the discussion on the drawbacks of solar as a RET in chapter six- under subsection 6.3.6 (Land Intermittency and Landscape Barriers) and section 6.4 (Mitigation Actions for Removing Key Barriers to RETs in Ghana). As such, the researcher's attention is going to be focused on the benefits that a solar PV system can offer. A summary of the benefits of a solar PV system is going to be provided as follows:

(1) Solar PV offers the opportunity for off-grid remote communities to be able to get electricity through mini grids or as stand-alone facilities,

(2) No fuel, no operation, and maintenance costs,

(3) It has a capacity factor of 22%, specifically Pungu SPP,

(4) Pungu SPP saves about 3852 metric tonnes of carbon emissions annually,

(5) Estimated GHG emissions payback period for a solar PV is between 2.5 and 3.3 years as it has a positive impact on the environment and mitigates climate change,

(6) Decommissioning cost is minimal as many parts are salvaged to be used again, such as aluminum frames and

(7) Using discounted or simple payback periods, it is possible to determine the economic viability of a solar PV plant. The discounted payback period is 14.95 years and 8.34 years for the simple payback period for the Pungu SPP. In both cases, the breakeven will be reached with many more years left for the Pungu SPP to generate profits and benefits such as carbon savings.

7.12 Challenges of Solar Photovoltaic Technology Deployment in Ghana

Energy is one of the drivers of the global economy and drives the economies of many countries, including Ghana.[900] It is widely accepted that access to clean, affordable energy services is crucial to the sustainability of energy generation and consumption, which ensures the ES of the country. To assess the economic viability of solar PV systems to many others, both centralised and decentralised systems, for grid and off-grid electrification, an LCA must be conducted to understand their economic competitiveness. However, it is worth noting that the results depend on the local costs of components and would therefore vary from country to

[898] Stephen Kankam and Emmanuel K Boon, 'Energy Delivery and Utilisation for Rural Development: Lessons from Northern Ghana' (2009) 13 Energy for Sustainable Development 212 <http://dx.doi.org/10.1016/j.esd.2009.08.002>.accessed 30 September 2019

[899] ibid

[900] S Ghasemian and others, 'An Overview of Global Energy Scenarios by 2040: Identifying the Driving Forces Using Cross-Impact Analysis Method' [2020] International Journal of Environmental Science and Technology <https://doi.org/10.1007/s13762-020-02738-5>.accessed 10 June 2021

country and from one region to the other, making it hard to make any generalisation. The most common challenges experienced in Ghana in relation to the application of solar PV systems border on the development of the right legal instruments for energy incentives, and how to integrate the rural electrification policy with the deployment of solar PV systems. Some of the challenges are discussed as follows:

7.12.1 Absence of Coordination Between Donor Support and Government Interventions

Donor support for solar PV projects has brought about a lot of benefits to the beneficiaries as well as enhancing the transfer of technology and capacity for the duration of the projects' lifetime, however, after their departure, the projects are left in a state of disarray.[901] To establish a sustainable energy programme involves a well-thought-out coordinated approach that has a clear vision that goes beyond the commitment periods of donors. Also, lack of government clear policy and support coupled with the usage of unreliable components, poor installation and maintenance are the main contributors to the failure of solar PV systems diffusion.[902] Maintenance of PV systems by users is not common as well as the inability to collect charges to be used for their maintenance contributes to the failure in penetration of solar PV systems.[903]

7.12.2 Lack of Qualified Personnel and Credit

The lack of well trained, qualified technicians who have experience and technical know-how in the promotion and installation of solar PV systems has been a constraint on the development of solar PV technology in Ghana. Luthra and others have noted that there is the need for local people who are technically well trained with practical skills, who can install RE systems to be hired to reduce the cost of hiring expatriates at a high cost which increases the cost of investment in RE.[904] The cost involved in acquiring solar PV systems is very high thus the marketing, delivery, and maintenance and this inhibits their wide-spread diffusion in the country. Banks in Ghana are now aware of the environmental benefits of RE projects, but the sector is still viewed as risky, and this perception continues to limit the lending of loans for such projects.[905]

Credit facilities are not readily available for the purchase of solar PV systems, and this is a concern to both dealers and customers as such the sale of these systems is cash and carry. The high cost puts some risk on the systems which the dealers fear and cannot sell them without collecting cash up front; also, the high cost is far way above the affordability of many prospective customers, and this is a barrier in the adoption of solar PV technology.[906] Many people lack the awareness of how solar PV systems work. The market is not large to provide many outlets to facilitate the easy procurement of these systems, lack of variety of models to choose from to satisfy the varying needs of a diverse customer base, the high prices of solar

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[901] Yacob Mulugetta, Tinashe Nhete and Tim Jackson, 'Photovoltaics in Zimbabwe: Lessons from the GEF Solar Project' (2000) 28 Energy Policy 1069 < https://doi.org/10.1016/S0301-4215(00)00093-8> accessed 18 November 2020

[902] M Jafar, 'Renewable Energy in the South Pacific - Options and Constraints' (2000) 19 Renewable Energy 305 <https://doi.org/10.1016/S0960-1481(99)00045-2> accessed 14 November 2020

[903] ibid

[904] Sunil Luthra and others, 'Barriers to Renewable/Sustainable Energy Technologies Adoption: Indian Perspective' (2015) 41 Renewable and Sustainable Energy Reviews 762 <http://dx.doi.org/10.1016/j.rser.2014.08.077>.accessed 18 June 2020

[905] James Haselip, Denis Desgain and Gordon Mackenzie, 'Financing Energy SMEs in Ghana and Senegal: Outcomes, Barriers and Prospects' (2014) 65 Energy Policy 369 <http://dx.doi.org/10.1016/j.enpol.2013.10.013>.accessed 28 February 2021

[906] JP Painuly, 'Barriers to Renewable Energy Penetration: A Framework for Analysis' (2001) 24 Renewable Energy 73 < https://doi.org/10.1016/S0960-1481(00)00186-5> accessed 12 March 2021.

PV systems with limited hours of usage are the challenges in the adoption of these systems.[907] Lack of financial support, investment, subsidies for conventional fuels, high transaction costs and lack of awareness about the benefits of solar PV systems at all levels are some of the market barriers found in the least developed countries.[908] Meetings that provide information on solar PV systems and technical support information, social networking have a positive effect in the promotion of solar PV, but this is lacking in Ghana since solar PV technology was introduced into the country. The lack of government policies that support the expansion of solar PV application and inadequate management and maintenance are responsible for the little success of some of the initiatives.[909]

7.12.3 Poor Market Development

Solar PV markets are poorly developed in developing countries, and this reflects the situation in Ghana. Lack of capacity building, financial infrastructure and community empowerment pose hurdles in providing electricity through solar PV technology. The design and development of a free local market look more successful than a market design based on donors' perspectives. The development of a solar PV market based on the quality features of the product is more helpful in its penetration than using subsidies which are artificial and not sustainable in the long run, as seen in the donors' model.[910] The availability of credit, long-term loans, business advisory services and grid extension are seen as enhancing the development of the growth of the solar PV market.[911] There are also stumbling blocks in the solar PV market in Ghana, in spite of the regulatory infrastructure in place for the generation of solar PV power, a WESL is mandatory to trade in electricity, and the licence is only issued to a person who intends to supply electricity to either a bulk customer or a distribution utility. As such, most PV installation companies do not meet the WESL requirement and cannot also enter into any power purchase agreement with any distribution utility.

Furthermore, the decision to freeze the issuance of new power generation licences are some of the barriers to entering the Ghanaian solar PV market.[912] This ban is detrimental and limits the deployment of solar PV systems in the country. The suspension of issuance of WESL was due to capacity restrictions imposed on solar PV plants to protect the grid's stability. The challenge can be overcome by fixing the National Interconnected Transmission System, which needs to be upgraded to be robust to be able to transmit any quantum of power generated from solar PV plants.

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[907] MA Muntasser and others, 'Photovoltaic Marketing in Developing Countries' (2000) 65 Applied Energy 67. <https://doi.org/10.1016/S0306-2619(99)00094-X> accessed 19 December 2020

[908] Tania Urmee and David Harries, 'A Survey of Solar PV Program Implementers in Asia and the Pacific Regions' (2009) 13 Energy for Sustainable Development 24 <http://dx.doi.org/10.1016/j.esd.2009.01.002>.accessed 14 January 20 21

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7.12.4 Poor Access to the Grid

Ramli and Twaha have stated that poor access to the grid limits the generation of substantial renewable electricity.[913] According to the EC of Ghana, the transmission and distribution networks across the country are in a poor state and, therefore, not efficient, and this leads to huge transmission and distribution losses. In Ghana, there is an access policy in force to limit the impact of RE integration on the weak grid infrastructure.[914] This access policy is a setback as generators of electricity from solar cannot exceed 20 MWh to connect to the grid. Another discouraging policy is that the costs of grid connection and enhancement to the metering point of the grid are borne by the RE power developers, and the amount of RE power supplied to the grid is supposed to conform to the interests of the grid company. This requirement would definitely limit the large deployment of RE (solar) in the country.[915]

7.13 Pathways into the Future for Solar Photovoltaic

The future looks bright for solar PV in Ghana, but the challenges and barriers need to be overcome to speed up the deployment and development of the technology. It calls for well-thought-out formulated policies, a legal framework, and a strong commitment from the government to put solar PV on top of its agenda. Some possible pathways for adoption are as follows:

7.13.1 Policy Shift Towards Solar Photovoltaic

Large-scale solar PV deployment is possible, but the current economic, market, legal framework and policies prevailing are not conducive to its development and impede the RE subsector's policy attainment. From the discussion, it is seen that solar PV has come a long way, but there are no significant gains made. For solar PV to succeed, there is the need for fundamental changes that would bring about policy shifts that will be focused on solar specifically than RE in general, to make it a niche technology for large scale adoption. The policy regime where individual solar system components are taxed needs reviewing and subsequently removed. It would thereby reduce the cost of maintenance of solar PV systems, which would invariably enhance their longevity.[916] The policy of adding a 10% share of non-hydro RE to the electricity generation mix by 2030 may not be achievable because the first target that was set for 2020 was not met due to little penetration of solar in the electricity generation mix. Since the missing of the first target, there has been no radical uptake of solar PV that would lead to the achievement of the second target, whose target year is 2030. This policy needs to be set at a realistic percentage that can be achieved when the challenges identified above are addressed.

The local market needs improvement, so the GoG can put in place schemes that can guarantee users and providers of solar electricity the needed financial support. It would help in the acquisition of solar equipment at fairly affordable prices-hence the need for the

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[913] Makbul AM Ramli and Ssennoga Twaha, 'Analysis of Renewable Energy Feed-in Tariffs in Selected Regions of the Globe: Lessons for Saudi Arabia' (2015) 45 Renewable and Sustainable Energy Reviews 649 <http://dx.doi.org/10.1016/j.rser.2015.02.035>.accessed 11 February 2021

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[915] Sakah and others (n 828).

[916] Divine Atsu, Emmanuel Okoh Agyemang and Stephen AK Tsike, 'Solar Electricity Development and Policy Support in Ghana' (2016) 53 Renewable and Sustainable Energy Reviews 792 <http://dx.doi.org/10.1016/j.rser.2015.09.031>.accessed 23 September 2020

establishment of the long-awaited RE Fund.[917] The current regulation on WESL acquisition does not promote the solar PV industry as many PV companies are not able to meet it. WESL is issued to either a distribution utility or bulk customer. These entities should have at least a demand of 500 kilovolt-ampere (KVA) which is at the same time consistent for three consecutive months, or a minimum annual consumption of 1,000000 kWh.[918] The revision of this requirement can increase the participation of many more companies which include solar PV companies too. Furthermore, this was introduced due to the technical challenges fluctuating power generation from solar PV plants poses to the grid. The solution to the challenge is more investment in upgrading the grid network, which has begun; it is hoped that the freeze on the licence issuance will be eased after the upgrading.

7.13.2 Application of Technology to Curb Transmission Losses

Power Electronics Technology (PET) is one of the contemporary technologies developed for the distribution of energy which includes energy generated from RES, and this can aid the power generated to be easily integrated into the national grid network.[919] This new approach is extensively applied globally as a more efficient way of integrating energy generated from RES to the grid network, and it ensures reliability and avoids fluctuation and intermittence. Using PET requires semiconductor changes that have the capacity to control higher voltages and can adapt by switching fast without delay. Power output in large solar PV plants continues to fluctuate during the day; as such, it raises security concerns because fluctuating power can cause instability in the grid.[920] To resolve the instability fluctuating power can cause to the grid; solar PV developers will have to install storage systems that can mitigate the risk. However, this leads to additional operational costs system owners would have to incur.[921] The use of technology, as noted above, would mitigate the challenge of transmission losses.

7.13.3 Guaranteed Financial Support

The grid needs upgrading in line with modern grid systems. Investment is therefore needed in this direction to make the grid robust to accommodate any quantum of electricity generated from RES., Especially solar, which has a grid limit restriction of 20 MWh currently imposed on investors to safeguard the integrity of the grid. The government should provide the necessary financial institutional framework that would guarantee finance for consumers and generators of solar electricity. It can be an intervention that can support those in the RE subsector, which can help the government to meet basic social amenities like adult education, health improvement (vaccine storage) and stimulate economic activities for the people.

Financial availability can help in rural electrification where solar PV systems can be used in remote areas instead of extending the grid, which is expensive compared to a solar PV

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[917] ibid

[918] Energy Commission, 'Licence Manual for Service Providers in the Renewable Energy Industry (Wholesale Electricity Supply Licence)' (EC, September 2012) <http://energycom.gov.gh/files/Wholesale%20Electricity%20Supply%20Licence.pdf> accessed 18 May 2020

[919] JM Maza-Ortega and others, 'Overview of Power Electronics Technology and Applications in Power Generation Transmission and Distribution' (2017) 5 Journal of Modern Power Systems and Clean Energy 499. <https://doi.org/10.1007/s40565-017-0308-x> accessed 15 January 2021

[920] K Akom, MK Joseph and T Shongwe, 'Renewable Energy Sources and Grid Integration in Ghana: Issues, Challenges and Solutions' [2019] 2018 International Conference on Intelligent and Innovative Computing Applications, ICONIC 2018 0. <https://doi.org/10.1109/ICONIC.2018.8601219> accessed 16 February 2021

[921] Walid A Omran, M Kazerani and MMA Salama, 'Investigation of Methods for Reduction of Power Fluctuations Generated from Large Grid-Connected Photovoltaic Systems' (2011) 26 IEEE Transactions on Energy Conversion 318 < https://doi.org/10.1109/TEC.2010.2062515.> accessed 12 November 2020

system. Furthermore, the RE Act has envisaged the establishment of the RE Fund. This fund will be responsible for the provision of incentives and subsidies. However, unfortunately, the RE Fund has not yet been established as the GoG has said there is no money. During the interviews, an official from the MOEn indicated that a credit facility was being arranged to provide financial support to IPPs in the interim.[922] The green credit scheme will be administered by the EC of Ghana and a German NGO. Financial support to educate people and market players about the benefits of solar electricity would help reduce the negative perceptions that solar PV is a costly technology suitable for only piloting purposes and that the high cost associated with it far outweighs its benefits.[923]

7.13.4 Guaranteeing of Energy Security

The country's energy generation mix is dominated by fossil fuel-based generating thermal plants. Relying on natural gas and light crude oil to generate electricity is expensive as the gas source is not reliable. Furthermore, the price of these sources fluctuates in the international market, and their reserves have depleted over time; as such, their dominance in the energy mix is a source of concern. Therefore, turning to solar and other RES guarantee ES as they are renewable sources. In Ghana, the national electrification coverage is about 87%. The non-covered areas are in inaccessible remote communities. Therefore, off-grid stand-alone solar PV systems can be deployed to cater for their electricity needs as better alternatives to petrol-powered generators.

7.14 Conclusion

Solar PV systems have seen a drastic cost reduction, and installed capacities have increased unprecedentedly, making it one of the fast-growing renewable energy technologies. It is mainly due to improvements in technology and increased investment interests. Following international trends in recent years, solar PV has attracted more interest and investment than any other energy technology in Ghana. The discussion has provided an understanding of the economic viability and other benefits solar PV has to offer using data from the Pungu SPP. The evaluation of the data has confirmed that the SPP at Pungu is economically viable and environmentally beneficial. In addition, the Pungu SPP has a simple payback period of 8.34 years and a discounted payback period of 14.95 years, thus confirming its economic viability. However, some regulatory constraints have hampered solar PV deployment in relation to the suspension of the issuance of WESL, which has been highlighted in the discussion.

The discussion has shown that in terms of endowment, Ghana's daily solar irradiation levels range averagely between 4.0 to 6.5 kWh/m²/day, and sunshine duration ranges between 1800 to 3000 hours per annum. Therefore, this endowment is abundant and can be harnessed by using solar PV to address ES and climate change challenges.

The RE Act and other supporting legal instruments have promoted the adoption of RE, especially solar and wind. However, wind potential is moderate in Ghana, therefore, the onus falls on solar. Aboagye and others have affirmed this and gone further to intimate the high solar potential in the country with approximately thirty-five sites that have been identified. If this potential is harnessed, can meet the energy supply a hundred times the current energy demand of the country. However, the implementation of these legal instruments has been met with some challenges. Some of them have been identified as follows: EC related regulatory challenges; these challenges hinder solar PV deployment; this is in respect of the suspension of the issuance of WESL. It is followed by a capacity restriction of 20 MWp per solar plant to

[922] Participant 1 interview held via zoon 26 October 2021
[923] Atsu, Agyemang and Tsike (n 911).

connect to the grid, the false start of net metering subcode for connecting RE generating systems to the distribution networks, and the absence of any roadmap to implement net metering policy. Transmission and distribution losses are a big challenge as the grid is obsolete and weak. These deficiencies are a clog in the wheels of solar PV deployment in Ghana.

Despite the drawbacks of solar, which have been discussed, it has been propelled to the forefront of today's technological options due to the unique attributes it possesses that makes it prudent to harness it. These qualities are as follows:

(1) Capacity factor is 22% and is very high, especially in the northern parts Ghana (Pungu),

(2) Solar radiation is generally also high in the country,

3) Operation and maintenance costs are low, and

(4) LCA analysis shows that solar PV has minimal GHG emissions and no fuel cost.

The energy required in the manufacture of solar PV modules/panels can be paid back in time, making it economically viable. The research has confirmed that solar power plants of varying capacities researchers have studied, have all proven to be economically viable and environmentally friendly. From the discussion, the northern parts of Ghana have the highest solar insolation and therefore is the most suitable place for solar PV installation.

A new technology known as PET is a viable solution to the problem of transmission and distribution losses. It is used to overcome grid connection challenges relating to transmission and distribution losses due to the grid instability, If GRIDCo is not already using it, it can begin to procure these devices to shore up the integrity of the grid. Also, proper storage facilities can reduce fluctuations and intermittence of solar PV systems, which will bring a harmonious integration of solar electricity to the grid. Solar energy is the most viable, abundant, and suitable RE in the country that can be exploited for the benefit of the people. It can provide energy access, ES, and climate change mitigation. The country is endowed with plenty of solar energy, and therefore it can be harnessed to augment the country's energy generation mix. As seen throughout the thesis, Ghana has got only one law on RE and some supporting policies. As seen in the discussion, all the provisions are couched for all RES in general as such; no specific policy is targeted at any RE type.

It indicates that there is no priority given to any RES that Ghana is endowed with thus solar, wind, biomass, waste-to-energy, and mini hydro. However, many countries exploit RES that they are endowed with both in quantity and quality to overcome their energy supply challenges, and therefore Ghana can do the same. Of the many RES that Ghana is endowed with, solar is abundant with high insolation country-wide. Furthermore, its adoption on a large scale should be a priority to the GoG. The GoG could introduce specific legal and policy frameworks that would exclusively target solar PV to scale up its adoption to address ES and climate change challenges in the country. This chapter concludes that solar energy is economically viable, environmentally friendly, and can help in climate change mitigation and can provide ES.

The following discussion is on chapter eight, and it provides the summary and conclusion of the thesis.

CHAPTER EIGHT

CONCLUSION

8.1 Summary

This research was carried out to review RE deployment and development in Ghana and to determine whether the evolving legal and policy frameworks are effective enough to surmount the RE subsector's challenges. The research has further attempted to ascertain whether RE can play a role in addressing ES challenges as discussed in chapter six-under section 6.5 and subsections 6.5.1 to 6.5.5 The results showed that Ghana's energy mix has failed to meet the affordability and accessibility dimensions of ES. The research has focused on ES leaving out other challenges such as climate change, sustainability, and competitiveness. However, some less detail discussion has been provided on climate change in the body of the thesis.

The research has attempted to establish that energy consumption in relation to conventional energy sources is detrimental to the ES of the country as well as the environment. The call for humankind to transition from the current energy system, dominated by fossil fuels, to RE finds expression in the transition theory, which lays the foundation for this study. The theory provides the avenue for a socio-technological transition which aptly addresses the energy problem that the development of any new technology must be done to reflect societal needs and aspirations. The socio-technological transition uses the multi-level perspective framework to explain further the transition process involving the niche, regime, and landscape. It gives a clear understanding of the stages of the transition from fossil energy to RE. Furthermore, energy justice is centred around the notion that all humans should have access to energy which is affordable, sustainable, safe and be able to maintain a decent lifestyle and to mitigate the occurrence of any injustice in energy use. In close examination of the transition that occurred in Ghana's electricity generation mix, it can hardly be said to be a transition to RE, as fossil fuels dominate it. Indeed, from 2000 to 2015, the electricity generation mix was dominated by hydro which is RE. However, thermal generation that uses natural gas which comes from fossil fuels surpassed hydro in 2016 and now has a high share of 65.3% in the electricity generation mix in 2021.

A comparative analysis conducted on the RE policies of Australia, Cape Verde and Ghana has given insightful knowledge about the best policies that are implemented in other jurisdictions worth emulating by Ghana. Especially the Cape Verdean policy of acquiring land and designating it as RE development zones and Australia's solar rooftop initiative are policies worth considering and possibly emulating. However, these policies should be implemented to suit Ghana's peculiar situation. When this is done, it could possibly avoid the three failing transfers observed by Williams and Dzhekova, especially 'inappropriate transfer', which happens when the transferred policy is incompatible with the political, social, economic, and cultural contexts that exist between the source country and destination country.

Adoption of RES is the panacea to overcoming the challenges the RE subsector is facing as they offer many benefits that defeat the externalities posed by fossil fuels. One quality feature of RE is that they do not deplete and decline in supply, so when they come on full stream, relying on them is going to be sustainable. They would replenish as and when consumed, thereby bringing about continuous development. As seen in the discussion, it is important to tout RE credentials. However, for now, the reality is that conventional sources still dominate the energy supply system in Ghana and the world at large. RETs can bring about many benefits, as already alluded to, including economic development. Therefore, a seamless transition from an economy powered by fossil fuels to an economy powered by renewables is the way forward. In any way, the growing cost of fossil fuels is not sustainable, as such, there is the recognition that for renewables to take over, much investment is needed for them to be

widespread. However, these investments may be difficult to come by without good legal instruments being enacted to safeguard them (investments) and attract investors.

The environmental benefits of RETs were discussed, and it was revealed that though RE may have some environmental challenges however, they are not comparable to the environmental challenges associated with non-RES. Planning laws ensure that environmental issues are considered at the beginning of every project against environmental laws that focus on environmental issues at the latter stages of every project, thus the processing and consumption stages. The life cycle analysis tool assesses the impact an energy project would have on the environment from the early stages to the latter stages. In chapter seven, the discussion has shown that in terms of endowment, Ghana's daily solar irradiation levels range averagely between 4.0 to 6.5 kWh/m²/day, and sunshine duration ranges between 1800 to 3000 hours per annum. Therefore, the country's solar energy potential is huge, which can be harnessed to bolster the ES of the country and stem climate change in fulfilment of the objective of the RE Act of Ghana. As seen in section 7.10 and subsections 7.10.1,7.10.2, 7.10.3, 7.10.4, 7.10.5 and 7.10.7 these are the policies deployed to develop the solar energy potential of the country.

The chapter has five sections. The first section provides a summary of the salient issues that have been discussed in the thesis. Section 8.2 recaps the research questions. Section 8.3 explains the main research findings. Section 8.4 discusses recommendations. Section 8.5 refers issues that could not be discussed in detail for further research.

8.2 Research Questions

The overarching aim of the thesis was to critically examine the existing legislation and policies on RE to ascertain their effectiveness in the development of RE in Ghana. In order to establish the parameters within which to conduct this research, five initial questions were posed to help evaluate the effectiveness of the legal instruments.

The main question of the thesis was, to what extent do the existing legislation and policies on renewable energy in Ghana effectively address energy security challenges? This question was analysed in six chapters of this thesis. First, the thesis tested the main question in chapter three, and the results revealed that the RE Act and supporting instruments have been less effective in addressing ES challenges due to many constraints. The question was further used to test in chapter six whether Ghana’s energy mix met all the dimensions of ES. The results showed that Ghana's electricity generation mix has met energy security’s availability, acceptability, and diversity dimensions but has failed to meet the affordability and accessibility dimensions.

In the sub-question on, what are the constraints that impeded the successful implementation of the RE Act and policies since coming into force in 2011? It was concluded throughout the thesis especially some parts of chapter three that the constraints are many, including the poor implementation of the RE Act and policies, a dauting process in licence acquisition, defects in policy design, lack of funding to the RE subsector.

In chapter seven, the sub-question on whether the existing legislation and policies have provided the enabling environment for solar energy development to address ES challenges in Ghana was tested. It was revealed that the instruments provided an enabling environment for all RES in general and did not focus on solar alone. and it was also confirmed that the legal instruments had performed poorly and the share of non-hydro RE mainly solar in the electricity generation mix was less than 1% in the year 2020.

The sub question, how likely will Ghana be able to achieve the 10% target set in the Renewable Energy Master Plan by 2030? This question was tested in chapter three, and it was revealed that, the first cycle (2019 to 2020) target of 198.3 MWp was the expected generation capacity to be added at the end of 2020 but just 42.5 MWp was achieved. This means Ghana has entered the second cycle (2021 to 2025) with a deficit. If at the end of the second cycle the same pattern is repeated and replicated in the third cycle (26 to 2030) then the target could be missed.

Finally, the sub question, do the Renewable Energy Act and policies currently in operation in Ghana need review? This question has been tested throughout in the thesis especially in chapter three and it was revealed that some provisions (licensing procedures, connecting to the grid) need review to address the challenges identified.

8.3 Main Research Findings

Some of the literature has identified some of these challenges including those identified by the researcher which have led Ghana to miss the target in 2020, so proceeding from that the researcher has put all these findings together as follows:

(1) The RE Act and policies on RE development in Ghana have generally been poorly implemented.

(2) The RE Authority, which is necessary for the formation of partnerships with private investors and the general running of the day-to-day business of the RE subsector, has not been established,

(3) The RE Fund is yet to be established; because the GoG lacks the necessary monetary resources to finance its creation. That is why the Ghanaian RE agenda relies on the private sector's financing whilst incentives are provided by the government as the attraction.

(4) Bureaucratic processes and red tape in project licence acquisition, it takes sixty-five days including the fulfilment of the required submissions (Exhibit WS 1-36) and other certifications, permits which are many, before the EC would communicate its decision to a prospective RE investor,

(5) There are restrictions put on connecting variable RE electricity to the grid due to its weakness, and therefore RE subcodes have been developed to protect the grid, e.g., with solar, it is 20 MW,

(6) Weak grid network leads to colossal transmission and distribution losses, GRIDCo transmission losses are 5%, and distribution losses for ECG, NEDCo and EPC are pegged at 29.7% in 2021.

(7) Financial insolvency of the utilities is a hindrance for them to undertake investment to upgrade their system's network and provide good service to their customers. It is so because tariffs are charged low, some customers default in paying their energy bills, including state institutions and power theft; all these have accounted for the insolvency.

(8) Lack of credit or loans for small and medium-size private RE investors because financial institutions in Ghana are reluctant to grant credit facilities to RE projects tagging them as risky. In cases where credit is granted, exorbitant interest rates are charged.

(9) The local currency known as Cedi fluctuates massively against other major international currencies like the US dollar. Therefore, it has a toll on doing business in Ghana in the local currency which affects RE power generation.

(10) Cultural constraints as many community dwellers still have negative perceptions that solar PV is a costly technology suitable for only piloting purposes and the high cost associated with it far outweighs its benefits, as discussed in chapter seven- under subsection 7.13.3

(11) R&D in RE are lacking in the country. However, R&D are crucial as the RE subsector is still evolving, and to be able to generate energy using RETs in an efficient way, research is needed to bring about cutting-edge technology that will bring massive improvement to RETs.

8.4 Recommendations

Some of the recommendations of the research are derived from ideas from the literature including those of the researcher and put together to make a case for legal reform to accelerate the development of RE in Ghana.

The RE Act needs review in some areas e.g., licence acquisition and grid connection. With licence acquisition the sixty-five days including the required submissions that include Exhibit WS 1-36 are so many which could be reduced whilst standards are still maintained. It would address the challenges in the development of RE in Ghana and help in the achievement of the objectives of the RE Act.

The RE Fund needs to be established and be resourced adequately to deliver on its mandate so that the incentives that can attract the private sector will be provided.

The RE Authority is a key institution envisaged by the RE Act to be established to run the affairs of the RE subsector. Therefore, it needs to be established to run the day-to-day administration of the RE subsector. It would be independent of government interference and can deliver on its mandate. The Authority would independently see to the effective implementation of the policies and regulate the RE subsector to overcome the challenges detected, which could boost investors' confidence.

The government could partner with foreign RE manufacturers to establish assembling plants in the country so that the cost of RE can decrease in the medium-term whilst focusing on R&D to drive down the cost of RETs further so that local manufacturers would become self-reliant in the long run.

The upgrading of the grid network should take into consideration the infrastructure that can at the same time accommodate variable RE transmission and distribution. Grid connection and related transmission and distribution losses due to grid instability, can be solved by using smart grids and the technology known as Power Electronic Technology, as a workable solution to the intermittent challenges.

The Ghanaian government should begin to hold regulators accountable for failures in the implementation process. For example, the percentage under REPO to be set by PURC if not set; in such a scenario, sanctions can be applied for non-performance, and where performance has been done or exceeded, rewards can be given.

Ghana needs to develop the concept of ES and spell out its priorities and how it can overcome its ES challenges. Regarding the diversity dimension of ES, though the electricity generation mix includes hydro, thermal, solar, this mix is dominated by fossil fuels that do not guarantee

ES. In terms of the affordability dimension of ES, subsidies in Ghana keep prices artificially low. However, realistically they are high given that transmission and distribution losses are high, and other inefficiencies are charged into customers' energy bills. When this is compared to Ivory Coast, it is seen that tariffs are high in Ghana, making it expensive for end users. Furthermore, in terms of the access dimension of ES, the national access rate is 87%, an indication that about 13% of the population, especially those living in rural areas and Island communities, do not have access to electricity. Therefore, Ghana needs to focus on improving the diversity, affordability, and access dimensions of ES to overcome the challenges.

All institutions tasked with developing RE in the country should coordinate their activities share information and avoid duplication of functions.

The Environmental Protection Agency of Ghana (EPA) should include LCA in its environmental impact assessment (EIA) to make the assessment robust. It will take care of environmental issues from the beginning of the project to the end. EPA's policy on EIA can be expanded to ensure that all environmental concerns can be addressed at all stages of all RE projects in the country.

Ghana has a huge solar energy endowment; it is prudent for the government to concentrate on solar PV systems as the prices of solar panels have fallen in the international market and expand the rooftop installation programme vigorously to spread to many parts of the country. Furthermore, the GoG should focus on the formulation of legal and policy frameworks that would exclusively promote the adoption of solar PV on a large scale as the country is endowed with plenty of solar energy.

As seen in Cape Verde, Ghana should acquire land, prepare the necessary documentation get approvals and designate such land as 'RE development areas'. If this is done, it can facilitate the speedy development of RE projects as potential RE developers would be saved from the hustle of going through this time-consuming licensing, permit, land acquisition and certification process.

RE laws, plans, policies, actions, and strategies of previous and current governments should be consolidated and harmonised to become a master plan guide that can be used for RE development in the country.

Public support is crucial for adopting RE in terms of policy formulation and implementation. As noted above, the old approach (top-down) in policy formulation and implementation should give way to a new approach that focuses on citizens' perspectives that considers their input in the formulation of policies. In recognition of this, governments in Africa should factor the views of their citizens in policy formulation to speed up the adoption of RETs. For this to happen, stakeholder consultations, seminars, and workshops can be organised to disseminate vital information about the benefits of RE. Furthermore, when people are involved in the decision-making processes leading to the siting of an RE project, as seen in the energy justice discussion in chapter one- under subsection 1.6.2.5 the more citizens are involved, it minimises opposition to RE projects. The above recommendations will go a long way to improve ES and protect the environment in Ghana.

As noted in this final chapter, many outstanding issues cannot be addressed in this thesis, and such issues will be referred to for further investigation below.

8.5 Further Research

The research has several limitations that lend themselves as potential topics for future investigations. The areas below need further investigation:

Chapter seven of the thesis focused on solar energy, whereas other RES like wind, mini hydro, and biomass were not covered in detail; further research is needed on the effectiveness of the existing legal and policy frameworks on these other forms to ascertain their economic and environmental viability and the contribution these forms can make to the development of RE in Ghana.

The implementation of RE policies requires a certain degree of societal acceptance. It primarily relates to the distributional impact in terms of how they affect the balance between green sunrise and brown sunset industries and how the policies further impact the different interest groups. Further research is therefore needed to look at the social acceptance of solar PV among rural communities in the country as more land is needed for a utility-scale solar PV system.

With the empirical research, the number of experts who participated was ten. To increase the robustness of the results, it is possible that more experts could have participated in the interviews, which would present more data for analysis and could reduce the possibility of biased results emanating from subjectivity by some participants.

As the research focused on ES, other issues such as climate change, sustainability and competitiveness can be explored to see how the RE Act and policies currently in operation can effectively address these challenges. In addition, the demand side of ES has not been covered in the thesis; therefore, further research is needed to explore it in detail.

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