A study on the factors and mechanisms facilitating renewable energy development and access in Togo.

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A STUDY ON THE FACTORS AND MECHANISMS FACILITATING RENEWABLE ENERGY DEVELOPMENT AND ACCESS IN TOGO

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PhD **2024**

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A thesis submitted in partial fulfilment of the requirements of Robert Gordon University for the degree of Doctor of Philosophy

April 2024

DECLARATION

I hereby declare that the research reported in this thesis is original and has been completed independently by myself (Nanimpo Kansongue) under the supervision of Professor James Njuguna and Professor Stephen Vertigans. This PhD thesis has not been submitted for the award of any other degree or professional qualification elsewhere.

Where other sources are used, full references are given.

Nanimpo Kansongue

April 2024

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ABSTRACT

Energy demand is continually increasing due to population growth, improved standard of living, as well as the widespread emergence of industries. This high demand for energy must be met by production with a reasonable reserve margin for sufficiency.

Literature reviews and field visits show that Togo has a significant amount of natural resources, such as wind, solar, biomass, and hydro, required to implement a nationwide sustainable energy system. However, to date, Togo has relied on biomass energy and energy import from Ghana, Côte d'Ivoire, and Nigeria. Although the use of renewable energy is continually increasing, and the technologies are becoming far more affordable, this source of energy still struggles for development in many countries, including Togo. In Togo, research to understand the current energy situation and possible ways to resolve the energy issues are limited. With the continuous increase in Togo's population and living standards and the emergence of industries, the need to develop renewable sources of energy has become a necessity.

This research uses a mixture of methodologies that combines qualitative and quantitative methods (and the use of strategic frameworks such as Delphi, PESTEL, and SWOT for analysis) to investigate the potential of renewable energy, its impacts, and factors that will help its development. The Delphi method is used to analyse the possibilities, barriers, and solutions for energy growth and discuss the views of respondents regarding renewable energy development in Togo.

The study results show a desire to develop renewable energy technologies with the most preferred energy sources being solar photovoltaics (PV) and small-scale hydropower energy to increase energy access. However, key barriers exist, including the complexity of existing policies and regulations; a lack of clarity and transparency; a lack of readily available information for renewable energy, causing high risk for investors; a lack of public-private sector partnership; the non-inclusion of private companies in decision making; and the monopoly of the electricity company. In addition, coordination between entities in the energy sector is weak, dedicated institutions are lacking, responsibilities are unclear, and coordination among agencies is poor. Finally, there is a lack of awareness, high cost of tariffs, and a lack of standardised power purchase agreements and power purchase tariffs amongst others.

The study recommends the review of existing policies and regulations for clarity, transparency, and simplicity, the introduction of incentive measures in taxation, and standardization of power purchase agreements and power purchase tariffs in a way that is fair and beneficial to all. Development of financial models in the form of grants to seek help from funding bodies, working with banks to provide loans to small/medium businesses to initiate new ventures and a micro financing model with payment in the form of crops are recommended.

Moreover, the production of materials that are accessible, efficient, and adapted to Togo would be critical, as well as liberalizing the energy sector, strengthening management, prioritizing renewable energy, and promoting diversification for system optimization. Furthermore, real mapping of technology resources is recommended to provide readily available data for investors. An increase in stakeholders' participation in all stages of the project is encouraged and gender and age inequalities should be avoided in energy policy, planning, and implementation. Finally, the study recommends raising awareness and educating everyone, including illiterate people, about renewable energy and partnering with relevant countries that could help train experts.

Keywords: renewable energy, sustainable development, Delphi method, PESTEL, socio-economic development, solar power, hydropower, rural communities, energy policy, Togo.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

CEB: Communauté Electrique du Bénin

CEET: Compagnie Energie Electrique du Togo

ARSE: Autorite de Reglementation du Secteur de L'Électricité

DGE: Direction Générale de l'Energie

NIOTO: Nouvelle Industrie des Oléagineux du Togo SA

SABER: La Société Africaine des Biocarburants et des Energies Renouvelables

ABREC: African Biofuel and Renewable Energy Company

CGT: ContourGlobal Togo

GWEC: Global Wind Energy Council

ECOWAS: Economic Community of West African States

EERA: Energy, Ecodevelopment and Resilience in Africa

EIA: U.S. Energy Information Administration

GDP: Gross Domestic Product

IEA: International Energy Agency

IRENA: International Renewable Energy Agency

KWh: Kilowatt-Hour

GWh: Gigawatt-Hour

MWH: Megawatt-Hour

PJ: Petajoule

PPIAF: Public–Private Infrastructure Advisory Facility

PPP: Public–Private Partnerships

REEEP: Renewable Energy and Energy Efficiency Partnership

REN21: Renewable Energy Policy Network for the 21st Century

ECREEE: ECOWAS Centre for Renewable Energy and Energy Efficiency

EU: European Union

GCCA: Global Climate Change Alliance

ICER**:** International Confederation of Energy Regulators

IMF: International Monetary Fund

KAS: Konrad-Adenauer-Stiftung

NASA: National Aeronautics and Space Administration

NGO: Non-Governmental Organisations

Solar PV: Solar Photovoltaic

Solar CSP: Concentrated Solar Power

UEMOA: West African Economic and Monetary Union

WAPP: West African Power Pool

WNA: World Nuclear Association

WAEMU: The West African Economic and Monetary Union

JVE: Jeunes Volontaires pour l'Environnement

REA: Rural Electrification Authority

ESMAP: Energy Sector Management Assistance Program

TIPEE: Processing Information for Energy Policy and Ecodevelopment

MDG: Millennium Development Goal

SDG: Sustainable Development Goal

SEP: Smart Energy Path

SHS: Solar Home Systems

SWH: Solar Water Heaters

SME: Small and Medium Enterprises

EERA: Energy, Eco-Development, and Resilience in Africa

STEPS: Stated Policies Scenario

NZE: Net Zero Emissions

WTE: Waste-to-Energy

1 CHAPTER 1 – INTRODUCTION

1.1 Background

The need for energy access remains crucial for sustainable development. Energy access has a direct impact on people's quality of life and well-being. With today's growing economy, many countries are still lagging the rest of the world, with three billion people lacking access to clean energy and suffering from dangerous levels of pollution (Borgen Magazine 2019). Energy demand continues to rise with the increase in population around the world and expanding development.

Currently, global statistics show that approximately 1 billion people lack access to electricity, with a high percentage of the most affected people coming from developing nations such as Asia and sub-Saharan Africa, as shown in Figure 1-1 below (Borgen Magazine 2019; Statista 2021). About 592 million people lacked access to electricity in Africa in 2020. In sub-Saharan Africa, while the electricity access rate increased from 33% in 2010 to 46% in 2019, 592 million people are still without access to electricity (IRENA 2022).

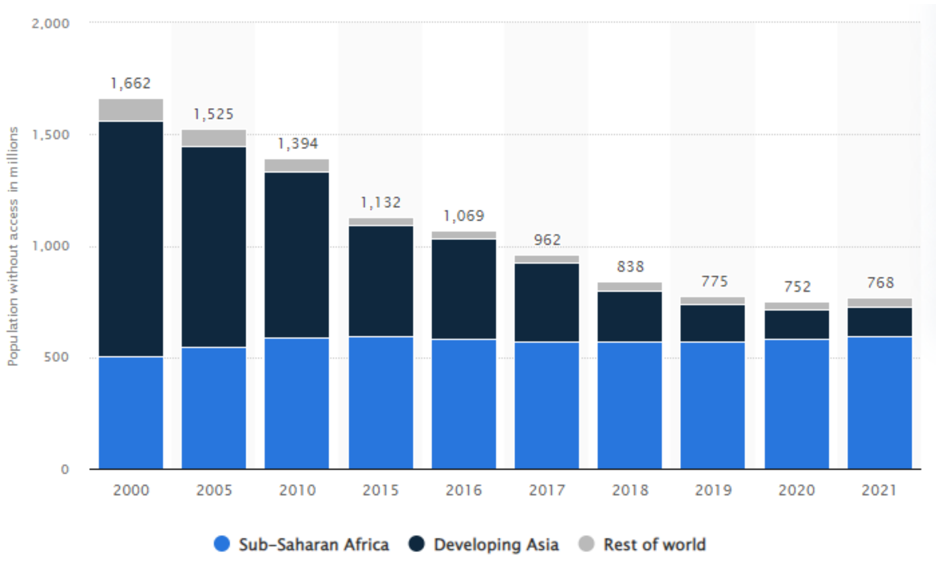

Figure 1-1: Population Without Electricity from 2000 to 2021 by Region (Source: Statista 2021)

Togo is one of the sub-Saharan African countries, with an estimated population of 8,848,700 (World Bank Group 2023). Togo is also one of the poorest countries in the world and one of Africa's least developed countries with a per capita gross domestic product (GDP) of 644.07 US dollars (Trading Economics 2022; World Bank 2021). Over 56% of the Togolese population in 2021 lived in rural areas, where the poverty level was twice as high (58.8%) as in urban areas (26.5%), and lacked access to basic services such as health, education, drinking water, and electricity (World Bank 2023; World Bank 2022; World Bank 2021). Approximately 43% of its inhabitants lack access to energy, one of the key resources for development in today's world (CEET 2021). Togo's energy consumption comes from three sources: biomass, petroleum products, and electricity (Energypedia 2020). The production of electrical energy is mainly provided by hydraulic and thermal properties of the Communauté Electrique du Bénin (CEB) in Togo and the Electric Power Company of Togo (CEET). Togo has no proven oil or natural gas reserves and is forced to import all of its petroleum from Ghana, Côte d'Ivoire, and Nigeria through an interconnection network. This deficit in power slows down economic activities and hinders the economic development of the country.

Like most developing countries, Togo relies on biomass as a source of energy. According to the 2017 report of the Togo Energy Information System (SIE), the share of biomass energy reached 76% of the national final consumption versus 20% for petroleum products and only 4% of energy is used in the form of electricity (SIE 2017; Energypedia 2020). In Togo, nearly 82% of rural households have only a traditional 'Three Stones' stove for cooking with wood. The share of the population using improved stoves (a cooking device that is built to use wood energy or charcoal like the traditional stove but uses far less wood energy and produces less pollution) was 6.55% in 2010 and estimated at 27% in 2020 (PANER 2015; Energypedia 2022). The consumption per capita is exceptionally low, approximately 149 kWh compared to thousands of kWh in Western countries (World Data 2019; Ayenagbo, Kimatu and Rongcheng 2011). Despite this lack of energy, literature and empirical observation reveal that Togo has significant potentials for renewable energy and is one of the countries that still struggle to have a sustainable energy strategy (SunMaster Lighting 2019; Ayenagbo, Kimatu and Rongcheng 2011). Thus, there is a need to develop the use of Togo's potential renewable energy to increase energy access as well as reduce greenhouse gas emissions.

To date, 76% of greenhouse gas emissions in the world are due to energy consumption caused by humans, including transportation, electricity and heat, building, manufacturing and construction, fugitive emissions, and other forms of fuel combustion (Tsai 2021; Ge 2021), which brings about climate change and global warming. Most countries still rely on energy generated from fossil fuels, which generate almost 33 billion tonnes (Gt) of carbon dioxide annually, about 44% of it coming from coal, 34% from oil, and 21% from gas (World Nuclear Association 2021). Moreover, one-third of the world population or 2.6 billion people lack access to clean fuels and cook on polluting open fires or simple stoves fuelled by kerosene, biomass, and coal. According to IRENA (2022), only 16% of the population has access to clean cooking, with an estimated 4% access rate for people living in rural areas. Asians and sub-Saharan Africans (including Togo) are the most affected, as shown in Figure 1-2, exposing them to indoor air pollution and causing approximately 3.8 million deaths globally annually according to the World Health Organization (World Economic Forum 2021).

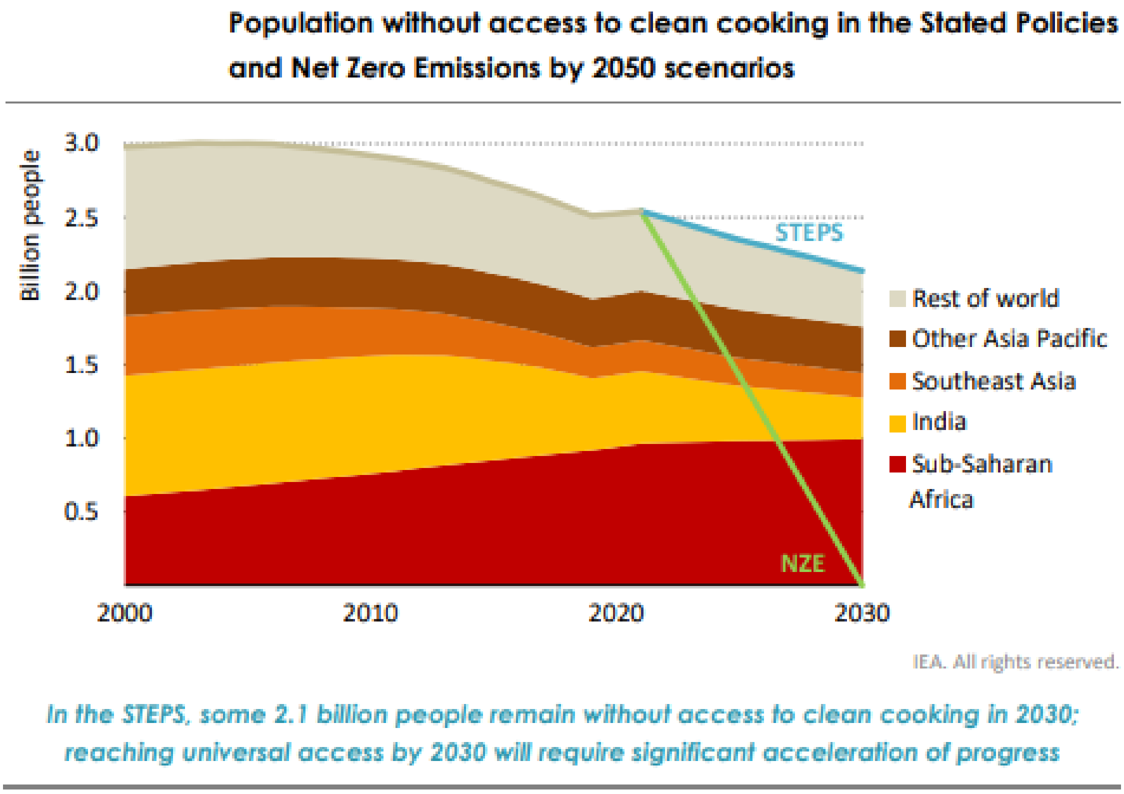

Figure 1-2: Population Without Access to Clean Cooking in the Stated Policies and Net Zero Emissions by 2050 Scenarios. Source: IEA estimates based on historical

data (up to 2019) from the World Health Organization household air pollution database (WHO 2021).

STEPS[1]: Stated Policies Scenario

NZE: Net Zero Emissions

These adverse consequences caused by the lack of access to clean fuels are a global concern, and work is being done by many nations to address them by developing other sources of energy to meet demands.

According to the Public–Private Infrastructure Advisory Facility (PPIAF[2]), Togo faced a serious crisis in 2006 due to a decline in hydrology and a significant increase in energy demand. This affected the country negatively and made the government realise that developing the energy sector would boost economic development. To address this, the government reconstructed the electricity company, reorganised its internal operations, and strengthened its capacity through private sector involvement (PPIAF 2011). As a result, ContourGlobal (an international power company) was selected to design, construct, and operate a 100 MW "tri-fuel" power plant, which became fully functional in 2010 and generates an estimated 780 gigawatt-hours (GWh) of electricity per year (PPIAF 2011; CEET 2020). Since then, the government has entered a 25-year concession

[1] STEPS reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place as well as those that have been announced by governments around the world.

[2] The Public–Private Infrastructure Advisory Facility (PPIAF) administered by the World Bank helps developing-country governments strengthen policies, regulations, and institutions that enable sustainable infrastructure with private-sector participation. As part of these efforts, PPIAF promotes knowledge transfer by capturing lessons while funding research and tools, builds capacity to scale infrastructure delivery, and assists sub-national entities in accessing financing without sovereign guarantees. Donor-supported and administered by the World Bank, its work helps generate hundreds of millions in infrastructure investment. While many initiatives focus on structuring and financing infrastructure projects with private participation, PPIAF sets the stage to make this possible (PPIAF/WBG, 2021).

and purchase agreement with Contour Global, which allows them to sell its electricity generated to CEET.

Despite the positive impact of this action plan, the lack of adequate energy infrastructure and the high electricity demand continue to hinder economic activities in Togo.

1.2 Research Location

Togo is a sub-Saharan West African country that shares a border with Benin to the East, Burkina Faso to the North, and Ghana to the West. With an estimated population of 8,848,700 (World Bank Group 2023), Togo has a density of 159.43 people per square kilometre (Macrotrends, 2023). Most of the Togolese population work in agriculture, and many still live below the poverty line (58.8% in rural areas compared to 26.5% in urban areas according to the World Bank (2023)).

Togo has been selected for this research to understand why it is struggling with energy access, depending on external sources to meet its energy demand, despite available resources, and how this could be changed to make better use of its resources and improve energy access for the community. To better understand the needs of the people, five rural communities have been selected within Togo across different regions for a comprehensive overview. Mango and Mandouri communities have been selected in the northern part of Togo because the majority of the population in those areas does not have access to the electrical grid, and energy access is lower compared to other regions. The research also focuses on Kamboli, located in central region as a mid-point within Togo, to understand its practices and needs and how these differ from other areas. The Notse community in the Plateaux region has also been selected for two reasons: first, there have been installations of solar street lighting within that community in the past few years, and the research sought to understand how these installations have been beneficial to the community; second, a large group of agricultural communities reside in Notse, and understanding their needs and practices as well was deemed necessary for comparison since this community is in the south, where there is a higher rate of access to energy. Finally, the Agome Glozou community in the Maritime region (closer to the capital city of Lomé) was selected, as it previously benefited from the European Union’s financial help with the installation of irrigation pumps. The research sought to understand how these pumps worked and their benefit to the population as well as the needs and practices of its community as a vicinity community of Lomé. The focus on these areas will help provide a better understanding of the energy situation within the country. Specifically, the north is the least developed, accounting for a higher number of people who do not have access to energy, the south is the most developed with greater access to energy, and the central region is at the midpoint of the country. Figure 1-3 below shows the workshop locations.

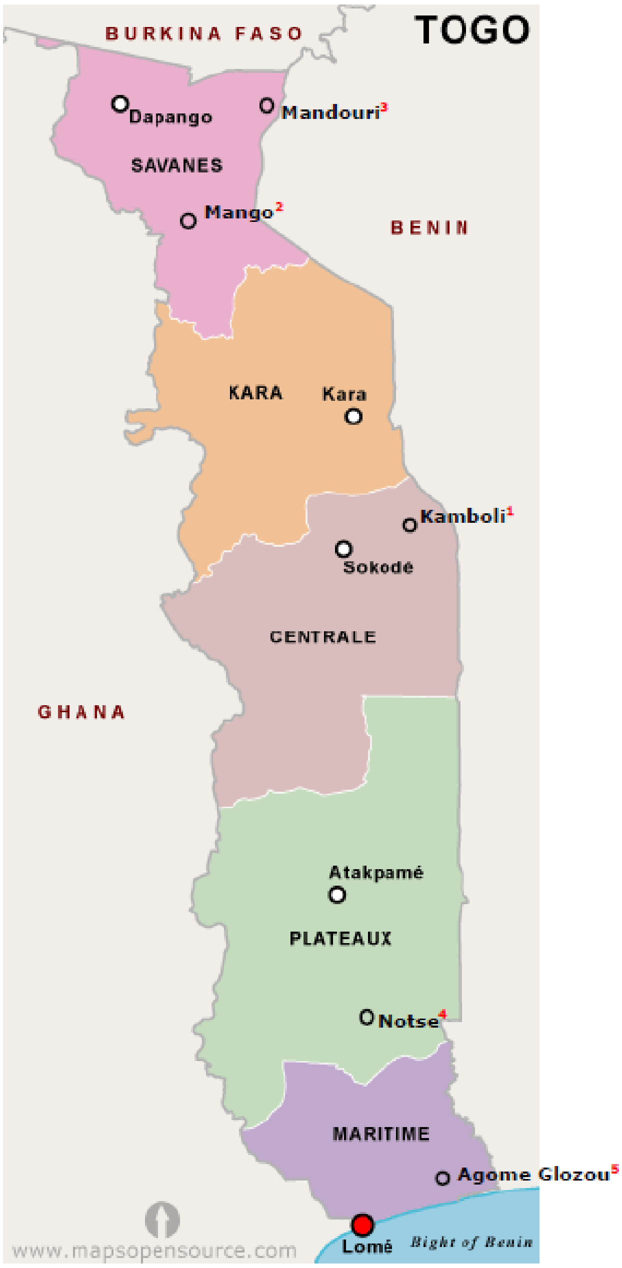

Figure 1-3: Togo Map Showing Workshop Locations. Adopted and modified from: [http://www.mapsopensource.com/togo-regions-map.html]

1.3 Rationale for the Study

In today's world, energy plays a crucial role in the sustainable development of every nation. Taking into consideration the issues highlighted in section 1.1 above, there is a strong belief that the current issues facing the energy sector can be improved, and the introduction of renewable energy with a focus on rural areas can make a significant positive impact on Togo's energy problems and enable sustainable development of the country.

There is therefore a need to undertake a critical investigation and evaluation of the role that renewable energy usage can play in the environment and socio-economic development of Togo. To achieve this, the present research reviews the current energy situation, existing energy policies, and strategies to identify gaps facing the energy sector as well as the current state of renewable energy and its potential use and impact on the development of the country.

To address the energy issue, previous research looked at the introduction of energy-efficient light bulbs and tried to promote the use of renewable energy (mainly solar cookers and photovoltaic solar lanterns with LED lamps), but these remained at an early stage (GCCA 2012; ICER 2010; JVE 2010; Oseni 2015). Non-governmental organisations (NGOs), such as Réseau Climat & Développement, worked on the dissemination of improved cooking stoves and the promotion of renewable energies to promote sustainable energy access for all. Furthermore, HELIO International developed a tool called TIPEE (Processing Information for Energy Policy and Ecodevelopment) to allow policymakers to check how well national energy policies contribute to ecodevelopment under fluctuating conditions (HELIO International, EERA and Togo Workshop team, 2014). TIPEE's methodology measures 24 indicators shown in Table 1-1 below. These cover the central elements that should be looked at when developing an energy policy in line with ecodevelopment (sustainable and equitable development) according to HELIO International (2011).

The indicators below assess a country's success in relation to its energy footprint reduction and gradually reflect their real progress towards a national energy system that promotes improved health and well-being under changing climatic conditions (HELIO International 2011). TIPEE defines a set of sustainability targets which serves as a series of reference points to see how well a country is progressing or regressing.

Table 1-1: Table showing the 24 TIPEE (Processing Information for Energy Policy and Ecodevelopment) Indicators. Source: HELIO International 2011.

Environment	**Indicators**	**Parameters**
Indicator 1	Greenhouse gas emissions (CO_2)	Greenhouse gas emission (CO_2) from the energy sector
Indicator 2	Major local energy pollutant	Concentration or emission level of a significant energy-related local pollutant (CO, NO_x, SO_x, particulates) per capita
Indicator 3	Deforestation	Number of hectares of deforestation or loss of forest vegetation (biodiversity) used for energy purposes
Social		
Indicator 4	Electricity access	Number of households that are electrified
Indicator 5	Household energy burden	Proportion of household income spent on energy services
Economy		
Indicator 6	Non-renewable energy imports	External energy dependence
Indicator 7	Non-renewable energy reserves	Number of days of stock of non-renewable energy supplies
Technology		
Indicator 8	Renewable energy	Deployment of modern, local renewable energy
Indicator 9	Energy efficiency	Energy intensity of industry; or GHG emissions per unit of production; or energy intensity of the economy
Indicator 10	Quality of electricity supply	Length and recurrence of power cuts and frequency changes
Governance		
Indicator 11	Income control	Reduction in the share of revenues from energy that escapes taxes
Indicator 12	Informed consultation	Public hearings and consultations on the impact assessment of proposed energy projects
Indicator 13	Citizen participation	Active participation of civil society, particularly women, in the energy sector
Indicator 14	Balanced governance	Balanced representation of energy demand and supply stakeholders as well as transparency in the decision-making process
Vulnerability		
Indicator 15	Vulnerability of thermal power supply	Vulnerability of power plants (and refineries if applicable) to flooding
Indicator 16	Vulnerability of renewable power systems	Vulnerability of renewable energy systems to climatic variations
Indicator 17	Vulnerability of transmission lines	Length of transmission/distribution networks threatened by extreme weather events
Resilience		
Indicator 18	Investment assets	Rate of domestic savings / GDP
Indicator 19	Mobilisation of renewable energy potential	Proportion of national investment earmarked for renewable energies and energy efficiency
Indicator 20	Local technical capacity	Annual number of sciences and engineering graduates per total population
Indicator 21	Scientific information	Availability of risk maps (flooding, desertification, contamination)
Indicator 22	Siting guidelines	Climate-proof guidelines for power plants siting and building
Indicator 23	Crisis management	Emergency plans for power plants
Indicator 24	Insurance	Availability of domestic insurance policies that account for climate change related damages

TIPPEE used a graphing representation of the indicators, shown in Figure 1-4 below, to give a visual representation of a country's current energy footprint. The expected result is to get a desired value of 0, which indicates a very low footprint, whether it be from an environmental, resources use, or vulnerability perspective (HELIO International 2011). This approach was field tested in 10 African countries, including Togo and Cameroon (HELIO International 2015).

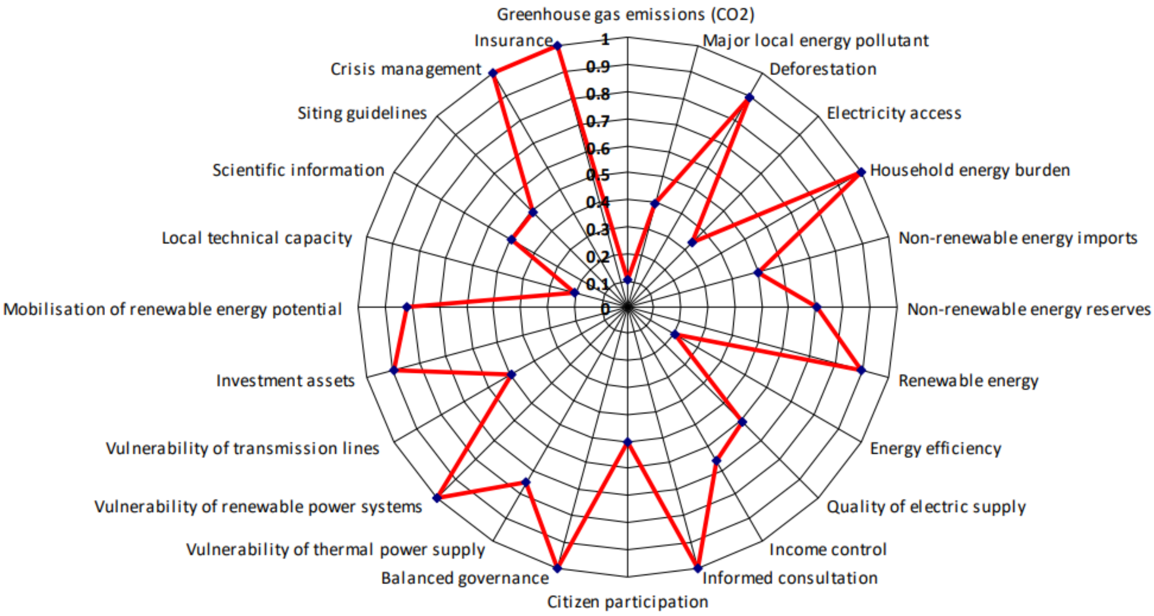

Figure 1-4: Graphing TIPEE Indicators. Source: HELIO International (2011).

In Togo, HELIO International used indicators 1 to 14 represented in Figure 1-5 below for their assessment. They held workshops to train stakeholders, which included the government, energy experts, academia, and civil society, on how to use the indicators and interpret results to assess their national energy situation. The application of the TIPEE approach in Togo and Cameroon revealed that (HELIO International 2015):

- Climate change is creating vulnerability for power plants, refineries, and hydro in Cameroon; in Togo, electricity grids are also at risk.
- There is a lack of knowledge on the traditional biomass use and renewable penetration (projects implemented by NGOs in remote areas).
- The volatility of fossil prices has a high impact on household welfare.
- Electricity cuts/shortages have strong social and economic impacts.
- Energy efficiency and renewable energy create a window of opportunity to improve the country’s resilience.
- Existing mechanisms need to be enhanced to support broader involvement of civil society in energy decisions.

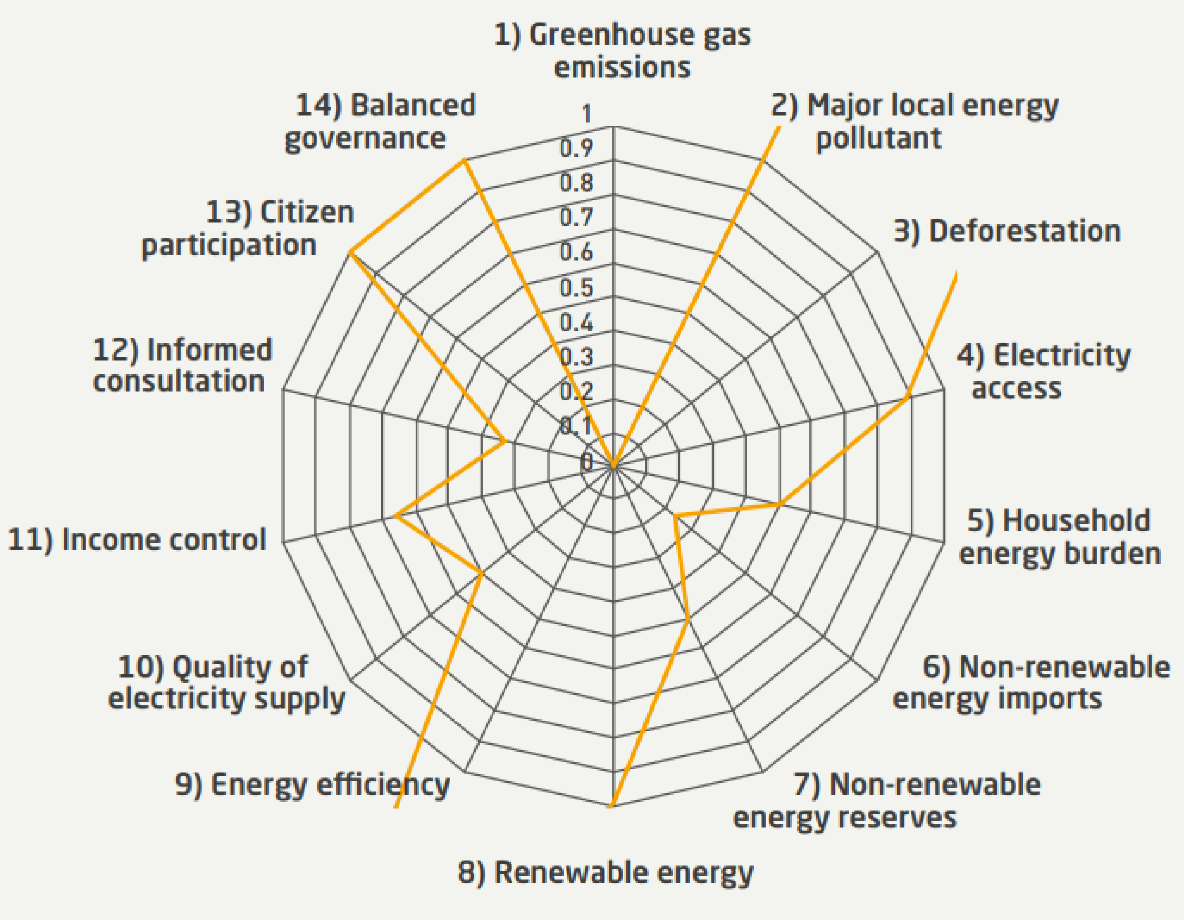

Figure 1-5: TIPEE—Togo Indicators. Source: HELIO International (2015).

The energy policy assessment work using the TIPEE methodology included a theoretical local case study from 11 villages located in the Maritime region of Togo (HELIO International 2014). Their analysis at a national level showed how interventions in social and community infrastructure can allow all Togolese access to modern energy services that could significantly offer improvement in all Millennium Development Goals (MDGs). Recommendations from their analysis underlined the following points (HELIO International 2014):

- It is important to increase the level of awareness and encourage decision-makers in all sectors of the economy to evaluate the energy dimension explicit in sectoral policies and projects.
- The law relating to decentralisation and legislation should be more explicit in terms of energy to give a greater role to mayors and prefectural councillors.

- The creation of a rural electrification energy control agency is an important step.
- The establishment of a framework that promotes decentralised energy production and allows that energy to be sold in the centralised grid is needed on the regulatory front.
- The Benin–Togo electricity code would need to be reviewed and modified based on this new regulatory framework.
- The identification and involvement of all stakeholders, including participants beyond traditional energy stakeholders, must be improved.
- Increasing the population's awareness of the harmful effects of open cookstoves while at the same time providing them with information on the solutions available is crucial.

HELIO International's study was done using villages located in the Maritime region (south of Togo), which might not necessarily reflect other regions' issues. Furthermore, they used a set of sustainability targets which serve as a series of reference points to see how well Togo is progressing and provided recommendations on improving social and community infrastructure to allow all Togolese access to modern energy. Their study did not explore issues relating to other regions; additionally, they did not involve local communities to understand the need and problems facing the communities. Moreover, their study did not explore sources of energy that could be developed to supplement the energy mix. The focus was more on finding out information relating to village proximities, infrastructure, and decision-making mechanisms. Thus, since energy access remains an issue, reflecting on what needs to be done to improve the energy situation in Togo (HELIO International, EERA & Togo Workshop team, 2014) is crucial. This has been confirmed by the field studies and workshops held by the researcher (2014, 2015, 2018, and 2020). Therefore, there is a need to carry out an in-depth investigation of the energy situation to identify ways to resolve the energy crisis by looking into more regions across Togo for better results. This research work is an in-depth study in relation to renewable energy development in Togo and how this could be used to supplement the energy supply. The study investigates the potential and viability of each renewable energy source, its availability and capacity, as well as the potential impacts to socio-economic development. In addition, the study investigates ways of addressing the sustainability challenges facing Togo and identifies the internal/external strengths as well as weaknesses facing Togo. The use of a bottom-up approach, which considers integration from the community to policymakers, is utilised for better results.

1.4 Aim and Objectives

The aim of this research is to undertake a critical investigation of the factors that facilitate renewable energy growth and mechanisms to improve energy security in Togo and its impact on the environment and socio-economic development.

To achieve this aim, this research is deconstructed into five different objectives as follows:

1. To critically review the energy situation in Togo to examine factors resulting in high dependency on the international market.
2. To conduct a field study to evaluate the need and issues relating to energy access in remote rural areas.
3. To evaluate the decision-makers' engagement in relevance to factors that could facilitate renewable energy growth as a mechanism to improve energy access within the country.
4. To analyse the potential impact of renewable energy.
5. To make policy recommendations on ways to improve energy access via renewable energy growth and its impact on sustainable development.

1.5 Methodology Overview

The research adopts a pragmatic approach, which is based on dealing with issues in a way that is practical and realistic instead of relying on only theoretical considerations. It builds up on the existing theories while taking into consideration all available approaches to understand and address a problem rather than focusing on a particular methodology. To best answer the aim and objective of the research, the research participants included those with occupations in the communities, such as indigenous farmers, fishermen, and artisans, as well as key stakeholders in energy, policymakers, private organisations, and financial institutions, amongst others. A mixed method approach is adopted in this research, which allows room to incorporate different worldviews, assumptions, methods, and types of data collection and analysis. An overview of the methodology is shown in Figure 3-1. Chapter 3 provides a detailed explanation of the methodology used in this study.

Data collection for this research was based on primary, secondary, and tertiary data. The primary sources of data included interview notes, field notes, and illustrations. These were collected through a mixture of methods, including interviews, questionnaires, field notes, and observations. Secondary data collection was based on the use of journal publications, conference proceedings, national and international standards, as well as governmental and non-governmental reports. These were collected through a combination of desktop study, literature review, workshops, and conferences. Finally, tertiary data collection made use of database resources from archival review. Appendix A5 summarises the method used to collect data.

To analyse the content of the data collected, the research used both qualitative and quantitative methods. Thematic coding was used to analyse the data collected through interviews. Thematic coding involved marking key points with a series of codes using a data-led grounded theory approach as shown in Appendix A6. This method of analysing data involved extracting data from the text and grouping them into similar concepts to make the data more workable.

1.6 Thesis Structure

The first chapter introduces the study, provides a brief background of the research, and gives reasons for the study. It also presents the current research question, objectives, expected deliverables, and an overview of the proposed method adopted in this study. Chapter 2 summarises relevant development and impact on renewable energy around the world and provides insights into the current energy situation in Togo. A critical comparison of the review is then made in relation to Togo to highlight its relevance and the identified gaps in literature that need to be addressed. Chapter 3 presents the research methods and methodology adopted in this research. Further, it provides details on the field work conducted during this research, the data collection process, schedule, analysis, and the ethical considerations needed for the study. Moreover, Appendix A1 gives details on the action plan and ways to address the objectives; Appendix A2 provides a breakdown of how the research questions were generated; Appendix A3 illustrates the need for renewable energy and Appendix A4 shows how the research sub-questions were generated.

Chapter 4 covers the field study on Togo's renewable energy in rural and remote areas of Togo and presents the results based on data collected during this research. Chapter 5 presents the stakeholders' engagement in relation to renewable energy in Togo and discusses the prospects, opportunities, possibilities, barriers, and solutions from different renewable energy sources. Chapter 6 discusses the potential impact of renewable energy development in Togo using a PESTEL and SWOT approach for analysis in a bid to provide the basis for its potential exploitation in Togo. Chapter 7 summarises the key findings arising from the research and discusses the findings in relation to the literature review. Finally, Chapter 8 provides the conclusion to the report and gives recommendations based on the study and suggestions for future work.

2 CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

First, this chapter provides a brief review of the energy situation in Togo and explores the current energy policies and strategies in place, reviewing the different strategic approaches that have been adopted in other countries to show how the gaps, issues, and barriers facing Togo could be mitigated for better development in alignment with Sustainable Development Goals (SDGs). Appendix B1 provides a critical review of the energy situation describing the potential of different renewable energy sources. In Appendix B2 a clear picture of the energy supply and demand in Togo is discussed and Appendix B3 provides information on the investment taking place within the country.

Second, this chapter examines factors that are influencing renewable energy penetration in Togo, with particular emphasis on rural/remote areas leading the country to high dependency on the international market. It also looks at the global trends in renewable energy development in conjunction with key definitions pertaining to the concept of this study and their impact within the global context.

Finally, this chapter reviews the challenges and opportunities for renewable energy development using a PESTEL and SWOT strategic framework as a rationale that will be used for analysis in Chapter 6 and provides conclusions.

2.2 Renewable Energy in Togo

The development of renewable energy is fast advancing, and the commitment of many countries is confirmed by the number of investments and effort in extra work done to achieve the set targets. The energy systems in many countries, including Togo, are characterized by a balance between centralized and distributed energy systems, which improves energy reliability and independence, thus providing a more stable electricity supply (Kursun et al. 2015; Liu et al. 2019; CEET 2020; Sahoo, Routray and Rout 2020). Togo relies on biomass energy (firewood, charcoal, vegetable waste etc.) for 76% of its energy supply, petroleum products for 20%, and electricity for 4%, with a total energy consumption of 22,943 GWh (Energypedia 2020). The wood biomass used in Togo is usually unclean and highly pollutant when burnt and can slow down economic growth.

Productivity can be lowered when unclean and inefficient sources are used, as illustrated by Maji, Sulaiman and Abdul-Rahim (2019). Moreover, excessive consumption of biomass fuels may sometimes lead to massive environmental pollution, which takes a negative toll on the economy, as illustrated by Qudrat-Ullah and Nevo (2021). Meanwhile, Togo has a lot of renewable energy available, such as solar (example in Figure 2-1 below), hydropower, wind, and biomass. Based on Figure 2-1, the solar irradiation increases from south to north and reaches a maximum value of 2,045 kWh/m^2 per year in the north of the country (Global Solar Atlas 2019). Togo’s total renewable energy production in the energy mix accounts for 9.74% of the total production, while the thermal sources of production are estimated at 38.63% between CEB, ContourGlobal, Kekeli Efficient Power, and CEET (ARSE 2021). Togo is still dependent, with imports accounting for 54.86% of the electrical energy need in 2021 (ARSE 2021).

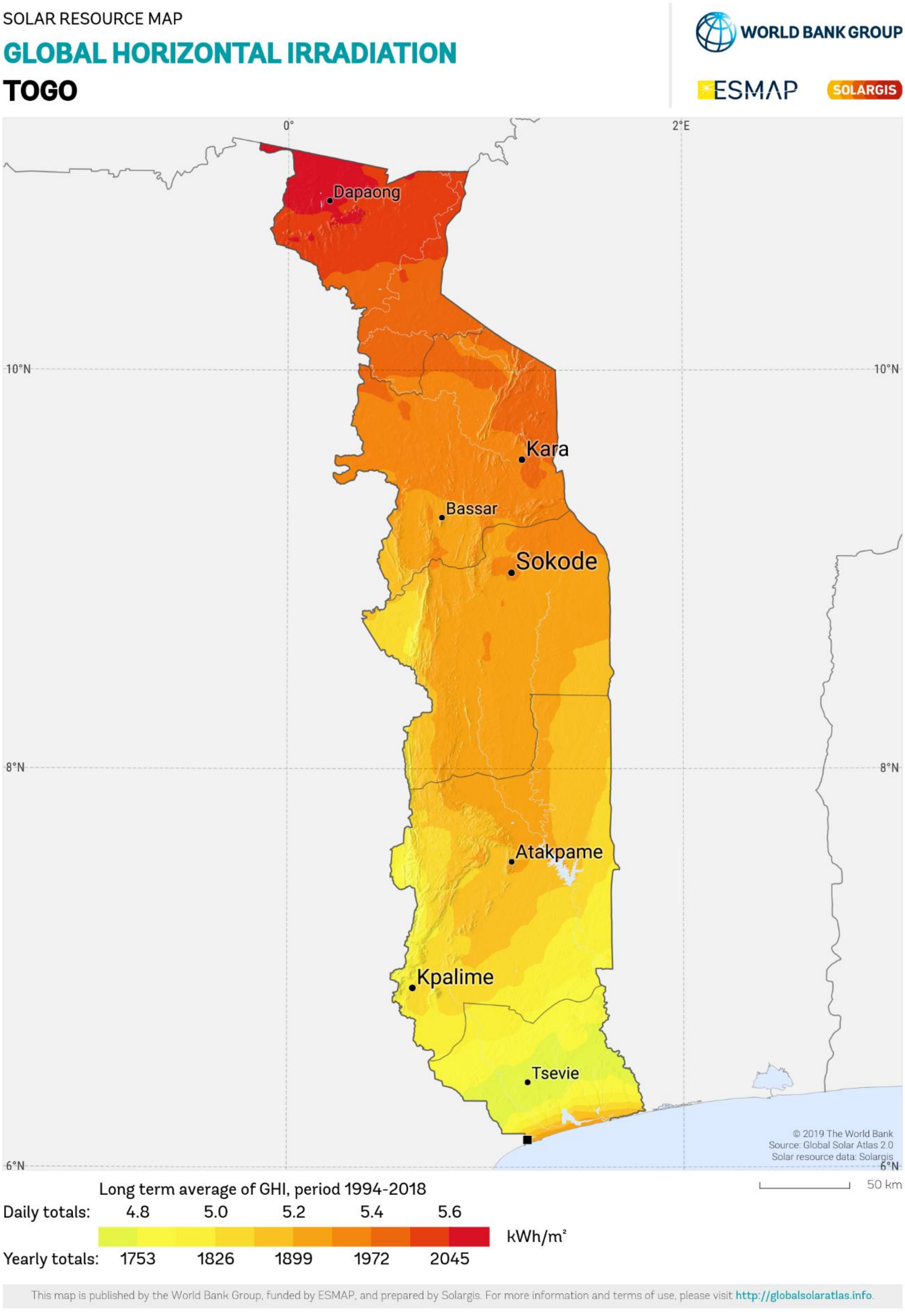

Figure 2-1: Solar Irradiation in Togo. Source: Global Solar Atlas (2019).

2.2.1 Rationale for Renewable Energy Development and Investments

Today, renewable energy is recognized as part and parcel of the energy supply. For the past two decades, its consumption has been encouraged in all countries, particularly in the heavy consumption countries such as the US and those in the EU and Asia, to promote a sustainable environment (Brodny and Tutak 2020; Nguyen and Kakinaka 2019). Africa is not exempt because, according to Armeanu, Vintilă and Gherghina (2017), its long use of conventional exhaustible energy resources has raised serious environmental concerns that hinder sustainable economic growth. The development of renewable energy can help minimize environmental impacts, avoid dependency on fossil fuel, and contribute to economic growth and job creation (Yushchenko et al. 2018; Lee 2019). In their research, Maji, Sulaiman and Abdul-Rahim (2019) stated that, for sub-Saharan Africa and West Africa in particular to achieve sustainable economic growth and social development goals in the near future, cleaner energy sources such as wind, solar, biofuel, and hydropower need to be in place. In addition, Kolb et al.'s (2020) study showed that renewable energy sources considerably reduced electricity prices by between 2.89 ct/kWh in 2014 and 8.89 ct/kWh in 2017, leading to German end consumers' cost savings of a total of €40 billion from 2014 to 2018. Additionally, wind and PV contributed significantly to security of supply, as demand could not have been met by domestic conventional and nuclear generation capacities during up to 424 hours in 2018. Like many sub-Saharan African countries that do not produce oil, Togo depends mostly on imports for its electricity supply. This dependence could be extremely reduced if the share of renewable energy were increased, as observed in many other studies. For example, according to Jenniches and Worrell (2019), the gross output electricity generation in the German state of Thuringia increased from 2.2 GWh with a renewable energy share of 4% in 1991 to 8.4 GWh in 2014 with renewables share of 55%.

Thiam's (2011) research also showed how renewable energy helped improve the standard of living in remote rural areas of Senegal (a Sahelian developing country) through environmental, health, equity, education, and social impacts. Some of these improvements included the reduction of respiratory diseases, saved time for women due to a reduction in time spent collecting wood for energy use, the creation of social ties through means such as nighttime socialising, and a decrease in biomass energy consumption. Based on these examples, developing renewable energy in Togo is not only a necessity to reduce imports for its electricity supply but could also substantially help the country in many areas, including socio-economic development.

Based on the literature, the Togolese national development plan, and discussions with key energy sectors, the government now conscious of the situation, is developing initiatives to increase electricity access in Togo, and plans to achieve universal access by 2030 (Togo PND 2018; AT2ER 2019). These sources indicate that the Togolese government will need about 995 billion West African CFA francs (franc de la Communauté Financière Africaine, FCFA) in investment or will have to mobilize an average of approximately 83 billion FCFA per year over 12 years to achieve universal access by 2030. This is approximately $142 million per year, which will be four times more than the average government investment in electrification development per year (AT2ER 2018). Togo's ambition is to deploy more than 300 mini-grids by 2030. To achieve this ambition, Togo needs approximately 147 billion FCFA or over $251 million in total.

To reach the set target of a 100% electrification rate by 2030, the government of Togo needs to (AT2ER 2018):

- Install 555,000 solar kits
- Install at least 315 mini solar grids
- Connect 960 new localities to the network
- Provide electrification to 400,000 households currently living in the network that are not electrified
- Install at least 108 MW of additional generation in the network

To accomplish these goals, the Togolese government is aiming to utilise a combination of network expansion and off-grid technologies (mini-grids and solar kits). To reach its target, Togo is focusing on mobilizing private sector investments mainly through public–private partnerships (PPP) in combination with targeted support mechanisms allowing, for example, the people who are most vulnerable to access electricity. Working towards this goal, a few developments have been put in place to increase the electrification rate, enabling an increase from 23% in 2010 to 53% in 2020 nationally (as shown in Figure 2-2), thanks to the extension of the network (Togo Local Electrification Program 2018, CEET 2020) and 57.82% according to CEET (2021). More details on these developments, such as few solar installations and the extension of the power grid to some areas, are discussed in Appendix B1. However, it is worth noting that the rate of rural electrification in Togo is still exceptionally low and only increased from 3% in 2008 to 8% in 2020 (PND 2018; Energypedia 2020).

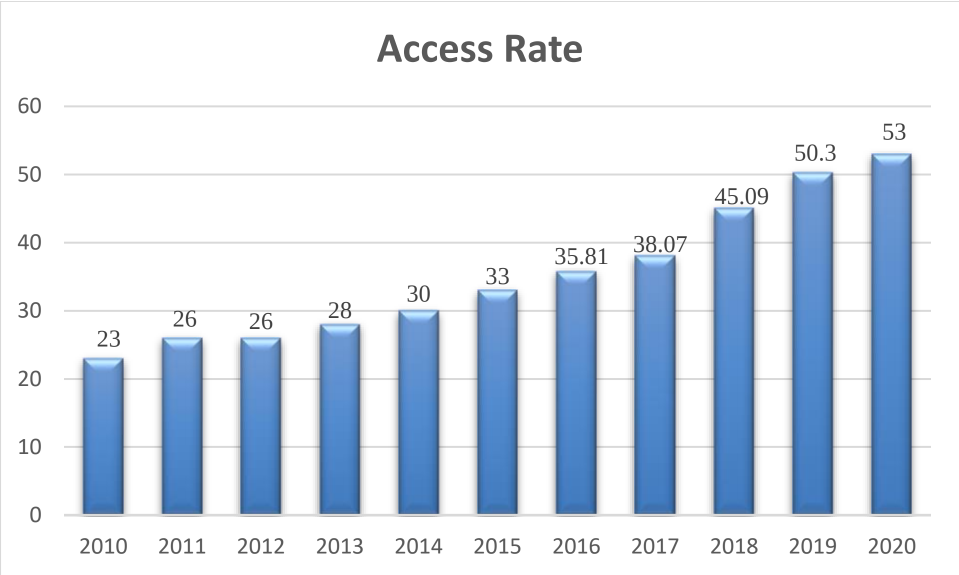

Figure 2-2: Togo Electrification Rate from 2010 to 2020 in Percentage (adopted and modified from CEET 2020; Togo Local Electrification Program 2018).

According to Hako (2022), the West African Development Bank approved a $40 million loan for the construction of a 42 MWp solar plant at Awandjelo, located in the Kara region (northern Togo). This will contribute to the diversification of the energy mix by 2024 and lower the cost of energy generation. It will also improve the living conditions of the populations in those areas. This will increase the share of renewable energy in the energy mix, and the electrification rate is expected to increase to 75% in 2025 (LSE 2022; Hako 2022).

A list of previous investments detailing sponsors, total terms, number of investments, various projects financed, status, and impact is provided in Appendix B3 (AT2ER 2018).

The government is working towards a strategic roadmap for 2021 to 2025, such as the construction of a 44 MW solar and hydro generation project, with the provision of 120,000 connections through extension and 150,000 connections through intensification. The aim for 2026 to 2030 is to accelerate the growth of renewable energy generation as well as the extension of the grid and complete the densification with the following results (AT2ER 2018):

- 45 MW solar and hydro generation
- 110,000 connections through extension
- 170,000 connections through intensification

All these projects and plans require a lot of technical assistance as well as financing.

2.2.2 Alignment With Sustainable Development Goals

The commitment of Togo in alignment with the SDGs has been shown since the adoption of its 2015–2018 and 2018–2022 national development plans, which incorporate SDGs. The plans are looking at the current conditions of sectors such as infrastructure (transportation, communication, energy), productive systems (agriculture, artisan, tourism and cultural, commercial, financial, improvement of the business climate), human development and social inclusion, and increases in environmental management (e.g., natural resource management, sustainable forest management, the fight against climate change). As part of these plans, the government ambition is to make Togo an economically middle-income country socially and democratically solid and stable, united, and open to the world. Its vision to become an emerging country by 2030 incorporates five long-term objectives (PND 2018; PND 2015; Togo Embassy 2022):

- Reduce poverty
- Become a middle-income country
- Reach the stage of a newly industrialized country
- Strengthen national unity and consolidate the democratic process
- Ensure sustainable management of the environment, fight against climate change, sustainably manage disasters, and promote land use planning

To achieve these goals, the Togolese government is working on improving many sectors, including the energy sector, with different planned projects as discussed in Section 2.2.1, with the ambitious goal to achieve universal access to electricity by 2030. So far, there has been some progress towards the achievement of these goals, such as the construction of a 50 MW solar power plant in the Central region as well as the extension of the power grid to some areas (IRENA 2021; Togo Local Electrification Program 2018, CEET 2020). The impact of this is discussed in Appendix B3.

2.3 Factors Influencing Renewable Energy Penetration into Rural and Remote Areas

2.3.1 Drivers and Inhibitors

Compared with other countries, Togo, despite its huge potential of renewable energy resources, is very low on the ladder in terms of the future deployments of renewable energy technologies. This can be seen in Figures 2-3 and 2-4, where Togo's percentage of installed solar and wind generation capacity is considered minimal and listed within "rest of Africa". Figure 2-3 shows that within West Africa, Senegal has made greater progress.

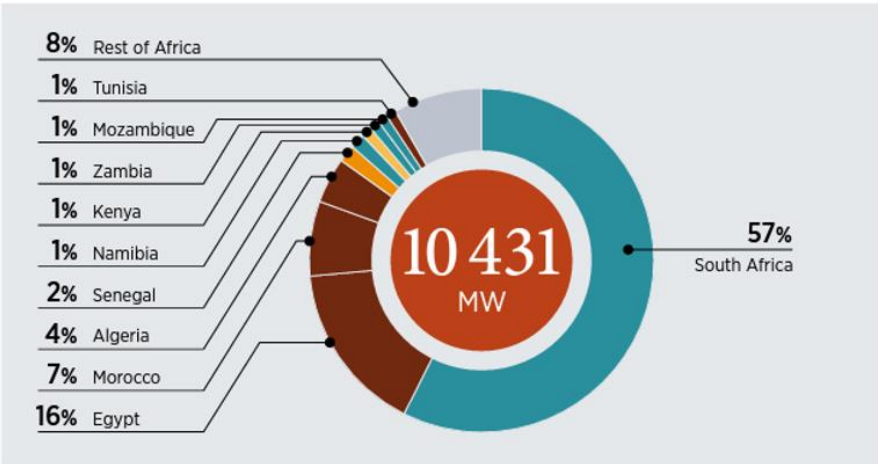

Figure 2-3: Installed Solar Generation Capacity, Africa 2020 (IRENA 2021a; IRENA 2022)

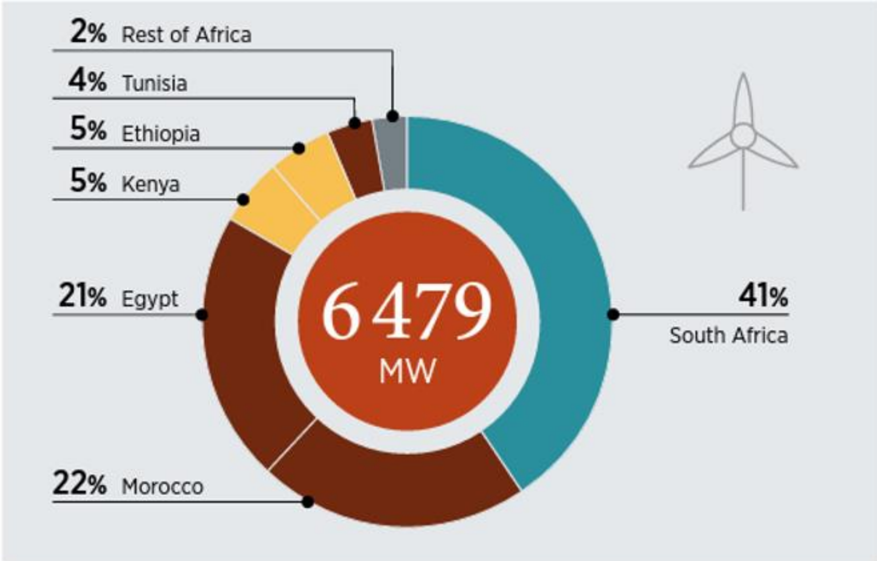

Figure 2-4: Installed Wind Generation Capacity, Africa 2020 (IRENA 2021a; IRENA 2022)

As shown above, South Africa is by far the leader in terms of installed solar and wind and third when it comes to hydropower generation (IRENA 2021a). However, Togo does have some hydropower installed and ranks 31st among African countries in installed hydropower generation capacity, as shown in Figure 2-5 below, while neighbouring Ghana ranks 11th.

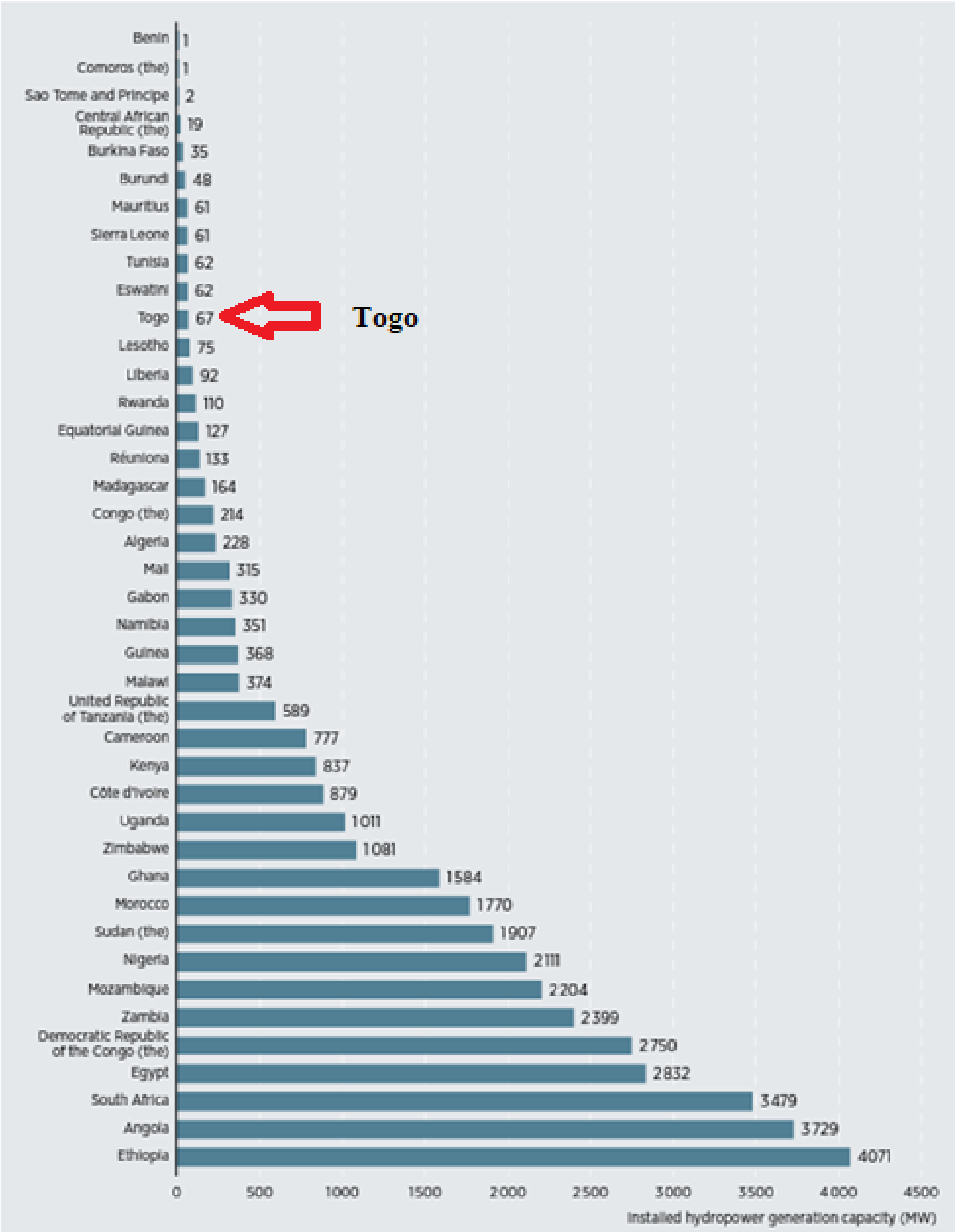

Figure 2-5: Installed Hydropower Generation Capacity, Africa 2020 Source: IRENA (2021a); IRENA (2022). Note: Hydropower includes pumped storage.

This is because there are very few adopted rules and regulations within the energy sector that help or favour the population, few standardized power purchase agreements (PPAs) and power purchase tariffs, and very few incentive measures in taxation and the energy sector is not liberalized to enable and attract investment.

An important factor to note is that development can only be made possible if necessary efforts are made by policymakers to develop enabling frameworks to spur investment and facilitate market development through sound policies and regional cooperation. In addition, Shah and Solangi's (2019) study revealed that policy implications are key to a swift transition to a renewable energy system in Pakistan, and without political will, renewable energy development will be difficult. They added that developing countries such as China, Brazil, India, South Africa, and Senegal made great developments in attaining energy access and sustainability through a rural electrification program due to political support and financing. This was also encouraged by Mugisha et al.'s (2021) study, which looked at Kenya, Rwanda, and Ethiopia in East Africa. They found that, in the three countries, local private investors have less involvement in the off-grid solar business due to the lack of incentives and high upfront costs essentially due to insufficient funds in rural electrification program. By reviewing Castalia's (2017) study, their study found that Cambodia's success story is a combination of good policies that focused on the standardized approach of mini-grids, appropriate tariff regulations that evaluated every power provider individually depending on its cost, and the availability of effective financing mechanisms to private investors. They also listed awareness, availability, and affordability as key drivers of the widespread adoption of off-grid solar technologies in emerging markets (Mugisha et al., 2021). This was supported by Kizilcec and Parikh (2020), who found that most policy recommendations from reviewed manuscripts focused on improving the affordability and accessibility of good-quality solar home systems (SHSs) for households, which could be done by developing a stronger regulatory framework for SHSs. Other drivers included sustainability, the introduction of renewable energy laws such as feed-in tariffs, and community inclusion. For example, the speed-up of renewable energy deployment in South Africa in the past few years was partly spurred by its goal of reducing greenhouse gas emissions.

Currier and Rassouli-Currier (2018) have also emphasised the role of feed-in subsidies, which could bring about higher benefits in the enforcement of a green quota in an electricity market. They added that this has been used in the European Union by countries such as Germany, France, and Spain. Xia, Lu and Song (2020) also set up a theoretical model to explore the mechanism behind excess investment and found that the 'sticky' feed-in tariff and declining costs of wind power generate a high markup for wind power investors, leading to a higher probability of excessive investment. In addition, they evaluated different policies that support renewable energy and found that feed-in tariffs are considerably efficient in promoting the deployment of renewable energy (Xia, Lu and Song 2020).

Another example is the introduction of a feed-in tariff regime, which boosted renewable energy development in Kenya and Uganda. Apart from feed-in tariffs, the government also uses feed-in premiums to boost the deployment of renewable energy. Both are standard power purchase agreements with a set price or premium, which means the developer has a price guarantee for a fixed period. These are well established in Europe and some African countries and have so far helped the development in many countries, such as Germany and Turkey (Dursun and Gokcol 2014; Gullberg, Ohlhorst and Schreurs 2014).

For instance, the introduction of renewable energy law in Turkey had a significant impact on the progress of the Turkish wind sector, which increased from 19 MW to 1,806 MW (Dursun and Gokcol 2014). In addition, the introduction of standardised power purchase agreements in Tanzania in 2010 boosted small-scale renewable power. This led to the implementation of a 40 MW small-scale renewable energy project which now supplies the national grid with enough power to light 54,000 rural households. Furthermore, the introduction of a tendering process in Morocco contributed to the development of a 500 MW plant in Ouarzazate—the world's largest concentrated solar power (CSP) project.

However, despite the role played by the introduction of these laws, renewable energy development still faces many barriers globally, including (Sen and Ganguly 2017; Agbonifo 2021; Ghimire and Kim 2018):

- Limited policy interest and investment levels, inadequate regulatory frameworks, and technical barriers
- Lack of knowledge transfer to indigenous population to accelerate the development of renewable energy
- Political risk—this is classified as a top concern when it comes to investing in Africa
- The high capital cost of renewable energy technologies compared to firewood and charcoal
- Lack of consumer awareness of the benefits and opportunities of renewable energy solutions

Despite its abundant resources, Togo is behind some African countries, such as Senegal in West Africa, when it comes to the use and development of renewable energy. Apart from hydropower electricity, accounting for 78.82% of its total installed capacity (four-fifths of which is imported from Ghana), Togo's renewable energy sources practically account for 9.74% in 2021 (ARSE 2019 ; ARSE 2021).

Togo still depends on imported energy from its neighbours for its energy needs, yet the literature reveals Togo has abundant natural resources, such as solar and waterfalls (Energypedia 2020). Developing solar energy and small-scale hydropower with these resources could potentially make a huge impact on the Togolese energy sector and help improve living standards (especially in rural areas), just as seen in other African countries. An example is Kenya, a country with similar potential for solar energy, which efforts are now being made to exploit.

Although the use of renewable energy is greatly advancing and the technologies are becoming more and more affordable, the use of this source of energy is still struggling for development in many countries, including Togo. Looking at the development so far in Africa and other developing countries, Togo has significant renewable energy potential and could make good use of it. Introducing the use of solar home systems and solar water heaters just as Kenya and Tanzania did is not a major task for a country like Togo. This could help some homes, small-scale businesses, and hotels in off-grid areas of Togo have access to energy, run their businesses, and improve the living standards of the society, as seen in the case of Kenya and Tanzania. Thus, with strong enough will, Togo could make it happen, as seen in Burkina Faso, where solar PV modules delivering about 60–100 PV panels per day are being assembled within the country since the start of the construction of a 30 MW factory in Ouagadougou in 2017 (Spaes 2020). Most sub-Saharan African countries still import renewable energy equipment instead of manufacturing it domestically (Spaes 2020). This is the first facility in West Africa to do so. Other examples are Congo and Cameroon, which took local initiatives to develop locally made small-scale hydro power plants, given the need in remote areas. Policies and regulatory frameworks could also be introduced to promote investment and development in renewable energy, as seen in South Africa and Morocco, and awareness raised on its use and benefits in the country. Another example is the Nigerian government, which seeks to increase local content in solar manufacturing and assembly by offering a long-term low-interest credit on renewable energy products as part of the COVID-19 pandemic response by launching the Solar Power Naija project in December 2020 as part of its sustainability plan. According to Bungane (2020), this project's goal is to give access to 25 million individuals through 5 million new household connections in rural areas. Specifically, these households will be provided with solar home systems and mini-grids by giving a long-term, low interest credit on renewable energy products to prequalified solar home system distributors, mini-grid developers, and manufacturers and assemblers of solar components. Through this project, 250,000 jobs could be created (IRENA 2021). However, it is worth nothing that, despite these improvements in the development of renewable energy, there is still a lot to be done to make a significant difference within these countries.

In all, based on a literature review and research field trip, the identified barriers in the development of renewable sources of energy with respect to Togo are as follows:

- Lack of government interest and support to promote the need for renewable energy development. This was an issue raised by private companies in interview discussions during the November 2015 field visit. They mentioned the reluctance of the government to support their initiatives as they experience a lot of resistance to the forward movement of their project, which is a handicap to their businesses' prospects.

- Lack of policy intervention and inadequate regulatory frameworks in place to promote private investment in renewable energy technologies. Discussions with NGOs and private organisations indicated that the energy sector has no specific rules and regulations in place for renewable energy. This does not help because investors are expecting that governments put in place some sort of subsidies that will encourage installation and operation of different projects.
- The high cost of tariffs on renewable energy equipment. This does not help investors, as no subsidies exist to lower capital and operating costs.
- Lack of awareness of renewable energy technologies and knowledge transfer from developed to emerging economies. Training key personnel on the functionality of renewable energy technologies will be key for development in all stages of the project. During field visit discussions with local communities, some indigenous people mentioned they were not even aware of some of the features renewable energy technologies could offer, such as solar lamps and batteries for charging phones, which would make communication a lot easier for people living in remote areas. Raising awareness about renewable energy will help the community have the knowledge required to make decisions on the use of renewable energy technologies.
- Lack of research to show renewable energy's potentials and identify factors that will help its development.
- Lack of appropriate technology transfer from developed economies.
- Hearsay on the level of corruption involved for personal private businesses from key actors, as discussed in the follow-up.
- Lack of awareness and education. To some extent, renewables have had a minimal impact on solving the energy issues, and others have been unsuccessful due to a lack of skilled personnel in Togo to deliver appropriate training, poor cooperation among the communities and managers, and the

high financial cost implications of imported equipment. This could have been addressed if indigenous capacity for design was built and the communities were more educated on the use and benefits of renewable energy technologies.

2.3.2 Urban–Rural Differences

In Togo, most urban areas have more access to electricity compared to rural areas—88.8% compared to 8% due to the lack of connection to the electrical grid (Energypedia 2020). Many people rely on lamps and biomass energy for their lighting and cooking needs. Moreover, urban areas have a lot of infrastructure and opportunities, causing migration of the youth to urban areas in search of better opportunities and living conditions. On the other hand, rural areas are endowed with a lot of land, rivers, and space for livestock, poultry, and other farming. Making use of these assets could solve many socio-economic issues. However, due to the lack of storage, processing, and transformation units, farmers have no choice but to sell most of their products at low prices to customers who come from urban areas. The development of renewable energy could help mitigate the urban–rural differences.

2.3.3 Factors Influencing High Dependency on the International Market

Apart from biomass produced in Togo and a small amount of renewable energy and hydroelectric plant in Nangbeto (managed by CEB), all commercial energy currently consumed in Togo is imported. Permission has been granted for exploration of offshore crude oil and natural gas, but, to date, no commercial discoveries have been made (World Bank 2013; African Legal Support Facility 2019). Therefore, Togo has no choice but to import energy from Ghana, Côte D'Ivoire, and Nigeria, with a total of 845.76 GWh imported in 2021 (CEET 2021) to meet demand. Part of this is done by CEB importing energy itself through interconnections with Ghana and Nigeria (VRA and TCN) and generating at the Nangbeto hydro (65 MW) it co-owns with Benin (due to the existing equal share agreement between Togo and Benin), ECG Ghana, and SNPT (Société Nouvelle des Phosphates du Togo) and through the ContourGlobal IPP of 100 MW (CEET 2020; World Bank 2013).

2.3.4 Competing Interest Based on Types of Energy Sources

The competition among the types of renewable energy in Togo is seen in the number of people showing interest in a specific energy type. So far, the interest in solar energy development has been advancing greatly due to the simplicity of the technology as well as the cost associated with it. With the lack of connection to the electrical grid, this type of technology is also most suitable and easiest to install in rural areas (Yadav et al. 2019). Nearly all the solar technology is imported (Salifou et al. 2023) from China, Germany, Italy, and France, with trade agreements or dependencies from the providers regarding maintenance of the equipment. However, the government has introduced some tax incentives on these products, coupled with subsidizing the equipment for owners to encourage its acquisition. Aside from solar energy, most other renewable energy types require high investment due to the cost of the technology, or the resources available are considerably low.

2.3.5 Infrastructure

The lack of infrastructure can be one of the major issues for socio-economic development within any country. Over the past two decades, Africa's GDP has doubled, and massive infrastructure projects have been implemented. There has also been a reduction in maternal and infant mortality rates as well as an acceleration in regional integration. This has been made possible due to reasons including the signing of the Continental Free Trade Area Agreement. Togo has been able to keep up with the changes by achieving significant results in terms of economic and social progress, exceeding the continent average on several indicators. A growth rate of 6% has been achieved due to Togo's investments in infrastructure (PND 2018) although deficiencies that include low rates of access to roads, education, healthcare, drinking water, and electricity production still exist. As part of its development plan, Togo is working on the implementation of major investments in logistics and business infrastructure as the main source of short-term growth. This will include a top-quality business centre in the south with many opportunities in the sub-region, particularly through the expansion of the existing infrastructure, multimodal connectivity, and information and communications technology. In terms of the electricity, water, and gas sub-sectors, an average growth rate of 5.6% was expected by the end of 2022, with urban and rural electrification efforts and a policy of access to drinking water. This lack of infrastructure could be a major issue when it comes to adding renewable energy to the energy mix in Togo. To date, the few solar installations existing in Togo are mostly standalone, with low power output that is not injected back into the grid.

2.3.6 Incentives

There have been a few developments relating to taxation, namely (Togo Ministry of Mines and Energy 2019; LSE 2022):

- Law n° 2018-010 of August 8, 2018, relating to the promotion of the production of electricity based on renewable energy sources. This law exempts taxes and customs duties on renewable energy equipment as well as company tax, professional tax, property tax, and VAT for approved off-grid solar companies. It gives priority to renewable energy development and allows an increase in the national electrification rate by opening up development to the private sector under state supervision while guaranteeing the quality of the installations. It encourages organisations to purchase equipment.
- The finance laws of 2020 and 2021 relating to tax exoneration on customs duties and VAT on the import of new electric and hybrid vehicles, which will be applied for a duration of five years.

There have been policies put in place by the government since 2019 to help companies distribute renewable energy technologies at a subsidized price. This subsidizes the cost of a solar kit by 2,000 FCFA (about $3.80) per month for a period of 36 months for any household that acquires a solar kit. The only condition is that the household make its share of the monthly payment for the duration of the period. Renewable energy development in Togo has helped with job creation.

Based on the electrification programme, about 20 shops were opened in 2017. About 700 local jobs were created during construction of the 50 MW solar plant financed by the IRENA-ADFD project, with an additional 120 direct and indirect jobs in operations (IRENA 2021b). With the planned projects, these numbers have yet to increase, and there has been training of some personnel (50 engineers, 100 experts, and 3,000 technicians) in relation to that. All of these factors will improve the socio-economic conditions of the country, with further achievement if renewable energy development increases like that of many other countries.

2.3.7 Renewable Energy Development: Global Context

The need for energy is a key driver of economic development and a necessity in shaping the landscape of the global economic market in all aspects of life, including people's well-being, health education, and commercial activities (Hallack, Rodriguez and Daniel 2019). As a result of this, coupled with the issues associated with the use of fossil fuels—such as rising energy costs, shortage, pollution of the environment, and the high increase in demand based on population growth (Edomah 2016)—there has been an increase in global efforts to generate significant amounts of energy from renewable sources. In all, the power sector has made significant progress in recent years in increasing the use of renewable energy by adding 167 gigawatts (GW) of renewable energy capacity globally in 2017, a growth of 8.3% compared to 2016 and a continuation of previous growth rates since 2010, averaging 8% each year (IRENA 2018). Moreover, in 2018, the deployment of renewables reached record levels in terms of both power generation and capacity, with growth from approximately 0.25% to 19% in total final energy consumption (IRENA 2018a).

The commitment of many countries to renewable energy is affirmed by the investments and effort in extra work done to attain set renewable energy generation targets. For instance, according to the EU, the goal is to reach a 27% increase in the share of renewable energy sources in primary energy in 2030 with respect to the 1990 levels and a 40% reduction in CO_2 emissions with respect to the 1990 levels by 2030 (Dimoudi et al. 2022). Germany aims for an 80% renewable energy share by 2030 according to Meza (2021). China, on the other hand, targets a 40% increase in renewable energy production by 2030 (Lo 2022; Xu and Stanway 2022), India aims for a 50% share of energy from non-fossil fuels and about 500 GW renewable energy capacity by 2030 (The Economic Times 2022), Morocco plans to increase its share of renewables capacity to 52% (20% solar, 20% wind, and 12% hydro) by 2030 (Dettner and Blohm 2021; IEA, 2019), and the Philippines aims for 35% by 2030 (Reynolds 2021). According to the European Commission (2014), renewable energy sources will alleviate the continent's dependence on imported oil and reduce the emissions of greenhouse gases by 20% by the end of the decade (Bloomberg 2014). The development of renewable energy power capacity is advancing greatly around the world. The chart below illustrates the development from 2011 to 2021 (IRENA 2022):

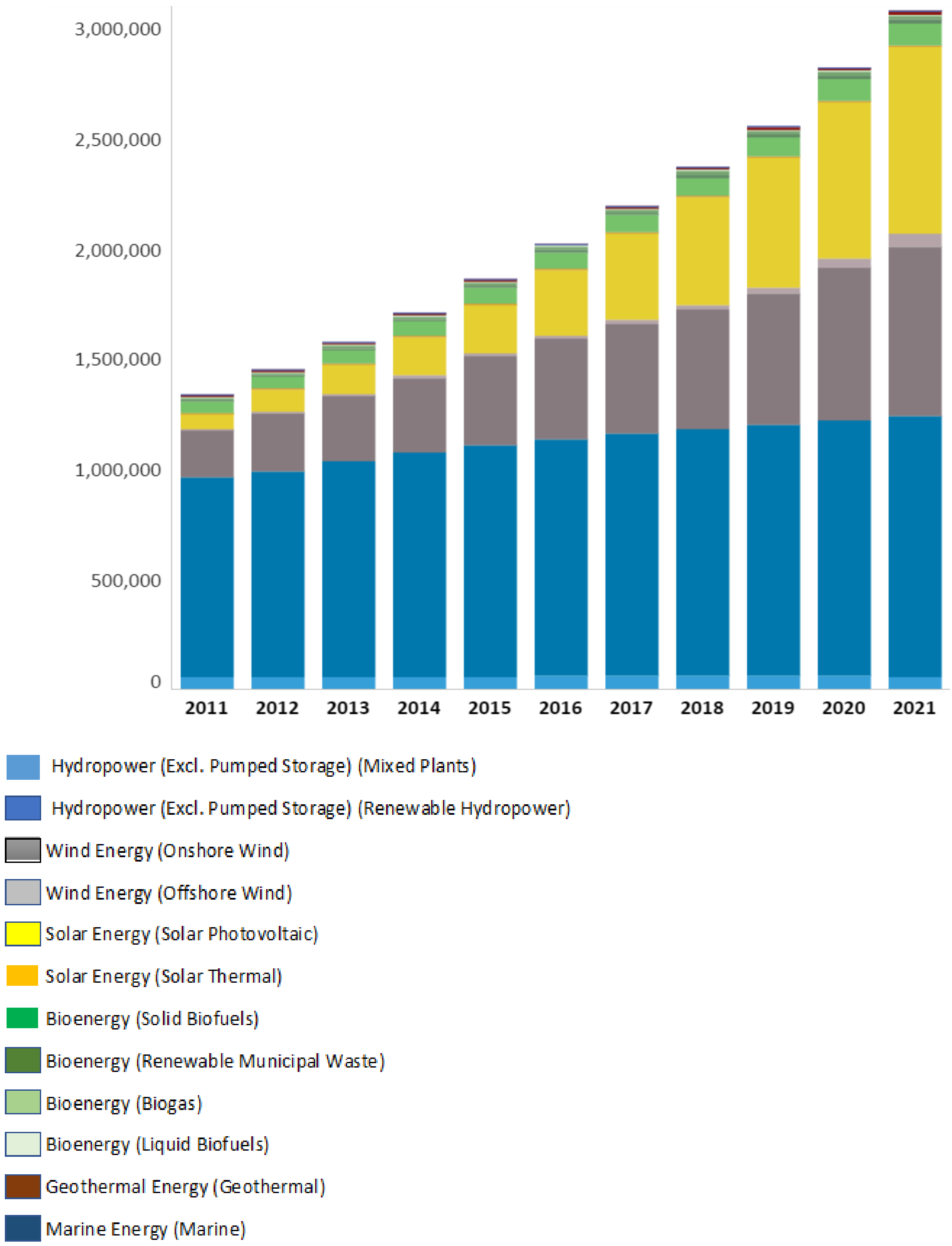

Figure 2-6: Trends in Renewable Energy (IRENA 2022)

Many countries have realised that renewable energy could significantly improve the socio-economic footprint of the energy system and the energy transition cannot be considered in isolation from the socio-economic system in which it is deployed (IRENA 2018). All of these are linked together as shown in Figure 2-7 below. Transitioning to renewable energy can lead to an increase in employment within the energy sector, boost GDP, and improve the welfare of the people (IRENA 2018).

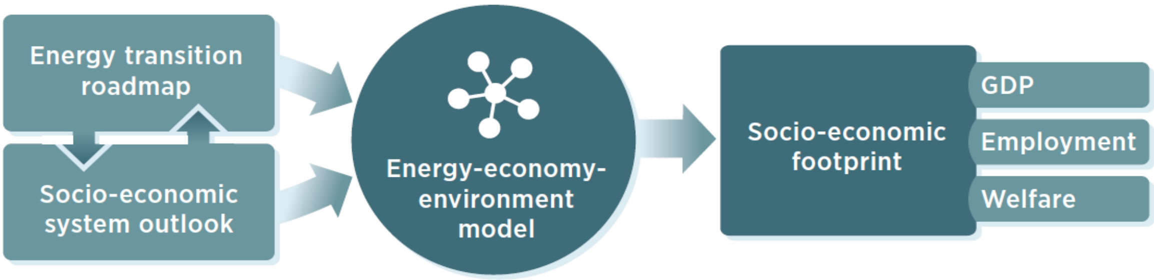

Figure 2-7: Obtaining the Socio-Economic Footprint from a Given Combination of an Energy Transition Roadmap and a Socio-Economic System Structure and Outlook (IRENA 2018).

With all things considered, the shift to renewable energy will create more jobs in the energy sector than are lost in the fossil fuel industry. According to IRENA (2018), the roadmap to Renewable Energy would result in the loss of 7.4 million jobs in fossil fuels by 2050 and create about 19 million new jobs in renewable energy, energy efficiency and grid enhancement, and energy flexibility. Overall, a net gain of 11.6 million jobs will be created. To meet the goals set out in the Paris Agreement, renewable energy needs to be scaled up at least six times faster (IRENA 2018). Many countries have realised the role renewable energy could play in socio-economic development and are making efforts to increase their energy supply from renewable sources. The following Figure 2-8 illustrates the top 10 countries leading in renewable energy based on their current installed capacity.

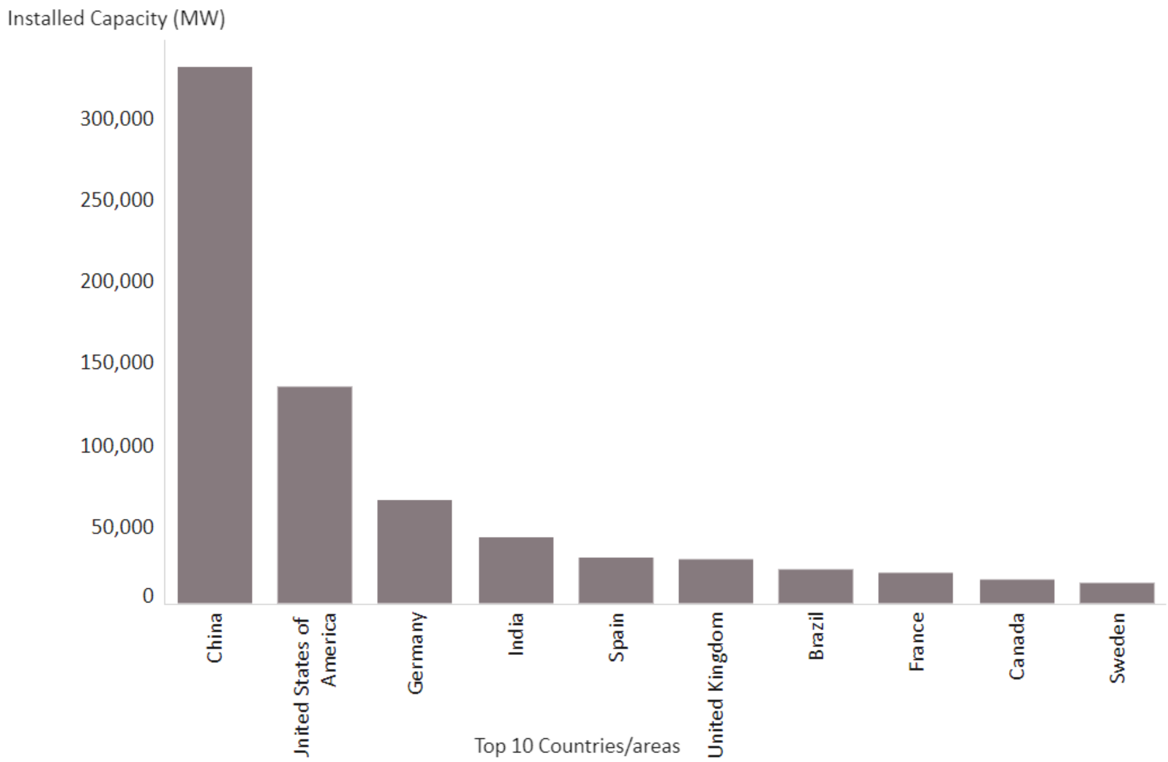

Figure 2-8: Country Ranking (IRENA 2022)

As shown in the graph, China, the US, and Germany are the top three leaders in renewable energy, with 328,973.430 MW, 132,737.600 MW, and 63,760.000 MW installed capacity, respectively. According to Lin et al. (2021), China proposed a clean, low- carbon, safe, and efficient modern energy system to reach the ambition of non-fossil energy, which accounts for more than 20% of the overall energy consumption. In addition, China's president Xi Jinping promised during a speech at the general debate of the 75th Session of the United Nations General Assembly in 2020 that "China will increase its nationally determined contribution, adopt more ambitious policies and measures, strive to reach the peak of CO2 emissions by 2030 and carbon neutrality by 2060" – a key and even decisive force to promote the global response to climate change under new historical conditions (Lin et al., 2021). According to the U.S. Energy Information Administration (2022), generation from renewable energy sources (wind, hydropower, solar, biomass, and geothermal sources) in 2021 totalled 795 million megawatt-hours (MWh), about 21% of all electricity generated in the US, surpassing nuclear power (778 million MWh). This figure excludes electricity generated in the industry, commercial, or residential sectors, such as small-scale solar or wind or combined heat and power systems (U.S. Energy Information Administration 2022). Germany's renewable energy accounted for 42% of electricity consumed in 2021, based on the preliminary calculations by the Centre for Solar Energy and Hydrogen Research Baden-Wurttemberg and the German Association of Energy and Water Industries (Meza 2021). According to IEA (2019), Togo has a diversified energy mix, with about 13% of its final energy consumption coming from renewable energy, in particular hydropower. According to Togo First (2018), Togo for the first time ranked as the world's 33rd largest clean energy promoter and the 10th in Africa. In the West African Economic and Monetary Union (WAEMU), Senegal is the only one with a better rank, occupying 13th place worldwide and second in Africa. Among Economic Community of West African States (ECOWAS) countries, Senegal and Nigeria are ahead of Togo, with Nigeria occupying 14th place worldwide and third in Africa. These figures are not based on the share of renewable energy or installed capacity but are related to clean energy promotion.

In all, the development of renewable energy is on the rise around the world, as it is not only key to solving environmental issues but could also complete the world's energy demand, offer energy security, and protect the environment. In addition, renewable energy will be the best solution for pollution reduction, boosting the economy, providing energy security, and creating jobs (Kumar 2020). Thus, renewable energy could help achieve sustainable economic development. As most countries have realised the need for renewable energy sources, competition among countries that manufacture technologies is on the ascendency as developing nations enter the market. An example is China, which currently plays a key role in driving the manufacture of renewable technologies for wind, solar PV, and solar hot water systems. Based on Gulzar et al. (2020), the solar energy heat utilization industry and the solar photovoltaic industry represent the two main parts of the solar energy industry.

The development of renewable energy is fast advancing and now leads total investment in electricity power generation systems (Arndt et al. 2019). In addition, the commitment of many countries is confirmed by the number of investments and effort in extra work done to achieve the set targets. For example, the global world market for wind energy was estimated at over $125 billion in 2020, and its yearly estimation is to surpass 120 GW by 2027. Increasing investments towards development of renewable energy capacity combined with plans to decrease the carbon footprint will improve the market demand for wind (Global Market Insights 2022). Renewable power installations accounted for 90% of new power capacity expansion worldwide in 2021 and 2022, with solar PV development breaking records with yearly additions of approximately 162 GW in 2022, nearly 50% higher than before the pandemic level of 2019 (IEA 2022).

The development of renewable energy in developing nations is rapidly progressing (Parajuli et al., 2014). They surpassed developed nations in terms of clean energy investment for the first time in 2017 with installations of 94 GW of wind and solar power and 20 GW of nuclear and hydropower from China to Costa Rica to Brazil against 63 GW of zero-carbon energy added by the developed nations. This is helping lower poverty and develop the countries' economies as well as investing in a sustainable future (Borgen Magazine 2019). Several developing countries are improving their policies and investing in sustainable infrastructure. One example is Kenya, which is completely changing its energy infrastructure to electrify rural areas and reduce poverty, with the government-heavy investment in renewable energy making it one of the top eight leading countries for geothermal production worldwide (Borgen Magazine 2019). Another example is Nepal, which started the exploitation of various types of renewable energy, such as micro-hydro plants, after depending on fossil fuel for a while to provide electricity to rural areas where electricity grid penetration is not feasible. This has been possible because of the availability of rivers and water resources as well as the country's hilly terrain (Shrestha et al. 2020).

Bangladesh also experienced significant development with the use of solar PV arrays and solar home systems in isolated remote areas, which had much impact on rural electrification, such as offering women more time to do household work and allowing them to work at night; assisting in children's education, as they student are allowed more time to study; and contributing to environmental impacts, health impacts, and recreational and information impacts and thereby socio-economic development (Sarker et al. 2020).

Other impacts include achievement of a low-carbon electricity system in Norway due to dependence on hydropower and improvements in energy efficiency, living standards, and related health issues in China due to the use of solar cookers, biogas digesters, and energy-saving stoves. Solar home systems are also a solution for sustainable electrification in lot of off-grid areas in sub-Saharan Africa that offers environmental impact to PV-based mini electricity. Additionally, they aid socio-economic development in Singapore due to the introduction of industrial waste management. Singapore is widely recognized as a City in a Garden today, with nearly 50% green cover and 72 hectares of rooftop gardens and green walls. Singapore is among the 20 most carbon-efficient countries, and natural gas generates 95% of its electricity (Singapore Ministry of Foreign Affairs 2018). Operation of biomass co-generation plants and recycling units also helps with job creation; an example is Brazil, with 1 million jobs created in rural areas (Halleraker et al. 2022; Ding et al. 2014; Antonanzas-Torres et al. 2021).

Africa is endowed with considerable renewable energy resources. However, around 600 million people in Africa still have no access to power, representing 48% of the continent’s population (IRENA 2019). The region has approximately 1.1 GW of hydropower capacity, 9,000 MW of geothermal potential, and abundant solar, biomass, and wind potential. Unfortunately, this potential has not been fully exploited, mostly because of the limited policy interest and investment levels. The need to develop renewable energy has started to be recognized, and some wind farms, for instance, have already been installed in Egypt, Morocco, and Tunisia. South Africa currently has the largest renewable energy market by far and is expected to have the largest deployment (83%) in the next five years, as shown in Figure 2-1. Furthermore, several countries in North Africa, including Morocco, Tunisia, and Algeria, have announced ambitious targets for developing renewable energy resources and have begun to put in place some legislation. As a result, Morocco shortlisted six consortia to develop 850 MW of wind capacity across five projects in the Sahara Desert. Unlike South Africa and Morocco, other African countries, such as Kenya and Uganda, established a renewable energy feed-in tariff for small-scale renewables, and Zambia, Democratic Republic of the Congo (DRC), Uganda, and Mozambique have also built large-scale hydro projects. Though the literature highlights these developments, which seem significant, reality reveals that large portions of the population still lack access to energy.

In the approach adopted by these developing countries, priority is given to environmental sustainability, energy security, involvement of the local content, and the urge to decrease pollution and all health-related impacts. The projected objectives of these countries are the development of their own technologies and increasing their standards as producers of value-added goods and services and ultimately sources of innovation.

As a related example, the development of renewable energy (mainly solar cookers, biogas digesters, and energy saving stoves) in the northwest of China has significantly improved the efficiency of energy consumption and considerably altered the health status of the inhabitants as well as their standard of living (Ding et al. 2014). Moreover, in Brazil, renewable energy projects generated nearly 1.2 million jobs in 2020. Overall, despite the pandemic, renewable energy sector jobs grew to 12 million worldwide in 2020 (IRENA 2021), as shown in Figure 2-9 below. The replacement of firewood with clean energy has also reduced the susceptibility of women, who are often exposed to smoke pollution, to respiratory disorders.

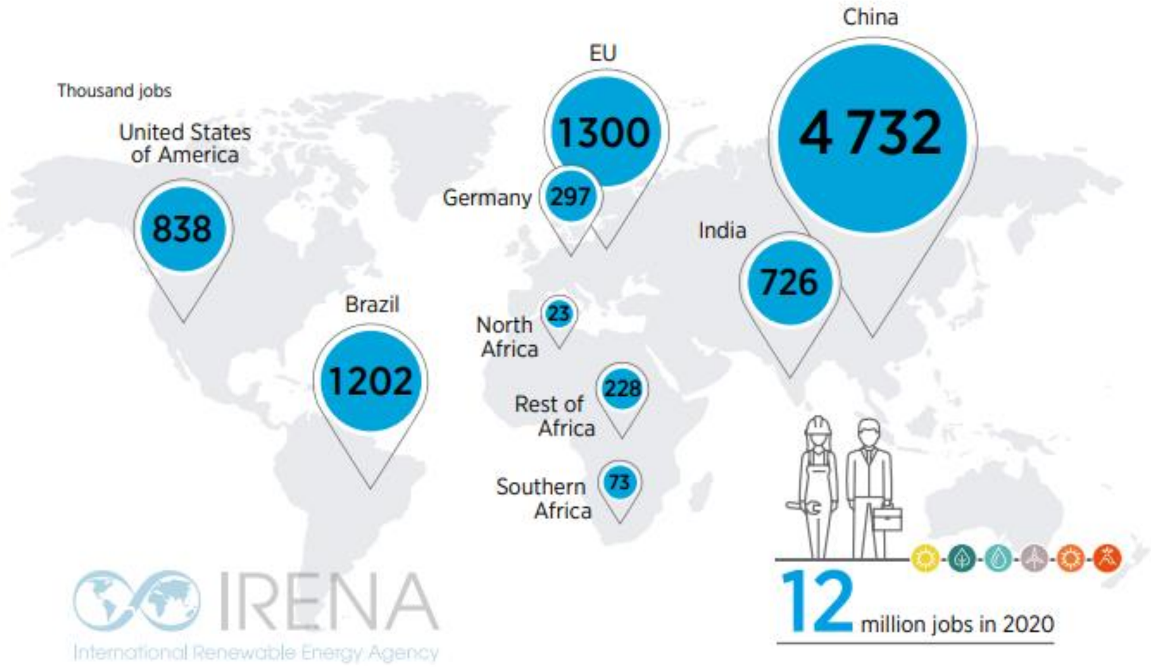

Figure 2-9: Renewable Energy Employment in Select Countries (IRENA 2021)

The development of renewable energy in several African countries has had a lot of positive impacts. The increase in developments is due to factors such as the introduction of standardized PPAs and power purchase tariffs; in Tanzania, for example, this led the national utility to undertake standardized PPAs for 40 MW of small renewable energy power projects. As a result, these projects now supply the national grid with enough clean electricity to light 54,000 rural households. Rwanda, meanwhile, benefited from micro hydropower projects. Its rural communities hardly have access to grid power. The introduction of a 200-kW micro hydropower plant provides electricity to over 800 households as well as various schools, health centres, and small businesses in a rural district (Franco et al. 2017). Moreover, in Uganda, a 60-kW hydropower plant that was the only source of electricity for a hospital in a small rural village was upgraded to 300 kW. This increase in capacity allowed the hospital to sell its surplus electricity to around 800 customers, including 400 households and 194 small businesses, in proximity to the hospital (Franco et al. 2017).

As discussed in above, Kenya is now one of the world-leading markets for off-grid solar use, with an estimated installed capacity of over 10 MWp and more than 320,000 solar home systems. Kenya's solar PV market can be subdivided into three different parts: solar home systems for residential purposes, small-scale commercial PV for mobile phone charging and small business applications, and solar PV used to provide electricity for off-grid schools, health centres, missions, and other social institutions in rural areas. The first two have peak capacity lower than 100 W, and the latter have capacity greater than 100 W (Ondraczek 2013). Apart from solar PV, in 2009, approximatively 55,000–70,000 systems of solar water heaters (SWH) were also used in Kenya. These were mainly owned by rich households and hotels in urban areas that wished to cut their bills. Other countries with similar projects include Tanzania, which has approximately 4 MWp, a minimum of 40,000 solar home systems, and about 1,000–3,000 installed SWH. In Democratic Republic of the Congo, Central Africa, some people have taken some local initiatives (given the need in remote areas) and run more than 30 micro hydro plants in the Democratic Republic of the Congo to help inhabitants in remote areas.

The use of renewable energy in Africa has significantly improved in the past decade. This increase was inspired by the rise of awareness of the effects of climate changes as well as government incentive programs aimed at improving the development and use of green energy (African Development Bank Group 2014). This notwithstanding, Africa still lags other regions of the world with regards to electricity generation and usage, and approximately 90% of inhabitants in rural areas of sub-Saharan Africa lack access to electricity. Meanwhile, Africa is rich in renewable energy resources such as hydropower, which is estimated at around 1,750 TWh, and geothermal energy, estimated at 9,000 MW (African Development Bank Group 2014). More than 80% of the continent receives about 2,000 KWh per square meter of solar resources per year, and a solar generating facility covering just 0.3% of North Africa could supply the full energy requirement of the European Union (African Development Bank Group 2014). Other reports also state that Africa has a substantial amount of renewable energy potential, which can be used to generate a large quantity of energy in a more affordable and secure way. This can contribute to global access to modern energy and reduce environmental issues (IRENA 2019). Like other countries (such as China, India, and EU countries), some African countries have also set targets to achieve a certain percentage of electricity obtained from renewable energy sources. These are Ghana (10%), Egypt (20%), Madagascar (75%), and South Africa (13%). This will assist in job creation, reduction of greenhouse gas emissions, development of the industrial sector, and improving human capital. The UN also predicted that the renewable energy market in Africa would be worth $57 billion by 2020 (NASA 2014), and an update from Renewable Energy World News stated that the African Renewable Energy Funds (AREF) secured $100 million for the development of grid-connected renewable energy projects in sub-Saharan African countries (Renewable Energy World 2024).

2.3.8 Energy Policy and Regulation

There are currently few policies for renewable energies. According to the Togo Poverty Reduction Strategy Paper, Interim (PRSP-I) for 2006–2008, the government has pursued several objectives in the energy sector, including implementation of policies for the promotion of renewable energy, the increase of electricity supply for rural areas, and the implementation of regulatory institutions. Furthermore, energy policies and strategies have been developed since 2012 by the Togolese Ministry of Energy and Mines through the help of consultants. This has covered the following:

- A diversification of the energy mix with the objective of increasing energy security. This encourages the use of new energies to substitute for imported petroleum products, such as promoting Togo's sedimentary basins (for oil and gas exploration).
- Special emphasis on the energy mix in rural areas and the development of rural electrification and of renewable energies.
- An increase in participation of the private sector due to the public sector's inability to finance the increasing requirements for energy infrastructure.

- An update of the regulatory framework and the implementation of new regulations.

- Strengthening the coordination amongst the various entities involved in the Togolese energy sector and ensuring the availability of reliable energy data through continued support to the energy information system.

The existing renewable energy laws are as follows.

The renewable energy laws put in place include LAW 2018-018, which relates to the production of electricity from renewable energy sources in Togo. This law provides texts for its application in four decrees: orders relating to approval, licensing, connection to the electricity distribution network, and the management of waste from electricity production installations based on renewable energy sources and technical documents, in particular the network connection specifications and the national plan for the construction of electricity production infrastructures based on renewable energy sources. In 2019, 3 out of 4 decrees were issued (Togo Ministry of Mines and Energy 2019):

- Decree no 2019-18/PR of 6 February 2019, setting the conditions and procedure for the conclusion and termination of the concession agreement for the production and marketing of electric energy based on renewable energy sources.
- Decree no 2019-019/PR of 6 February 2019, fixing the power thresholds of the different legal regimes for projects of electricity production based on renewable energy sources.
- Decree no 2019-021/PR of 13 February 2019, setting the conditions and terms for issuing and withdrawing licenses for the production, distribution, and marketing of electrical energy based on renewable energy sources.

Approval orders have also been issued as follows (Togo Ministry of Mines and Energy 2019):

- Inter-ministerial decree no 058/MME/MEF/2019, setting the terms and conditions for issuing approval for the import of materials and equipment to produce electricity from renewable energy sources.
- Inter-ministerial decree no 059/MME/MEF/2019, fixing the costs of examining the application file and the costs of granting approval for the import of materials and equipment to produce electricity from renewable energy sources.
- Decree no 060/MME/CAB/20219 on the creation, attribution, composition, and operation of the approval commission for the benefit of tax and customs exemptions provided for by Law 2108-010 of 8 August 2018.

Based on the above, it is clear that a few energy policies and strategies have been developed, and some renewable energy laws have been put in place. However, there are issues associated with these when it comes to renewable energy development. These are discussed below.

2.3.8.1 Energy Policy, Framework, and Regulations

It has come to light that there are a few policies which, according to the stakeholders, are "merely on paper" and not being put in application. Some of these policies have been implemented in the past, and policy approaches and retroactive changes have led to reduced investor confidence (Salifou et al. 2023). Additionally, some of these policies and regulations are complex, unclear, and lacking in transparency when it comes to key roles and responsibilities of stakeholders. There is a need for the government to revisit the policies in place to enable fair sharing of risks and benefits among all stakeholders (Salifou et al. 2023).

2.3.8.2 Diversification of the Energy Mix

The Diversification of the Energy Mix law encourages diversification of the energy mix with the objective to increase energy security in Togo. On the other hand, this becomes difficult if sufficient resource information is unavailable. More research needs to be carried out to determine the viability, availability, and applicability of renewable energy technologies as well as other sources of energy that could be used to supplement the energy mix. This calls for collaboration with international businesses and experts to develop and make available the required information that would serve as a guideline. Real mapping of technologies as well as resource assessments need to be developed to provide readily available information for investors to use. In addition, technologies and components are not standardized, which leads to various risk when it comes to deployment as well as performance (Salifou et al. 2023). Collaboration on standards with externals is key to addressing this.

2.3.8.3 Public–Private Sector Partnership

The Public-Private Sector Partnership law calls for an increase in participation of the private sector due to the inability of the public sector to finance the increasing requirement of energy infrastructure. Though this is crucial, the current risk of investment is considered too high. First, the complexity and lack of transparency when it comes to the policies and regulations does not help. Should there be government support through a quota obligation system, for example, this could encourage private sectors to invest. Second, during data validation conducted in 2020, stakeholders discussed about the fact that tax exoneration benefits organisations with public interest. This makes private companies reluctant to invest because of the lack of fair treatment. There is a need to reevaluate the existing regulations so that each organisation is given the same resources and opportunities irrespective of their existing need. Third, there is a lack of engagement with private companies when it comes to decision-making relating to the production, sale, and adoption of renewable energy. This should be considered along with creating a market environment so that the private sector can innovate, compete, and benefit from these investments (Osu 2017).

2.3.8.4 Institutional and Administrative Barriers

Coordination amongst the various entities involved in the Togolese energy sector remain complex. The sector is said to be weak, lack dedicated institutions, have unclear responsibilities, and lack coordination between agencies. According to Salifou et al. (2023), the situation is slow, with non-transparent permitting procedures, which is mostly due to insufficient capacity to manage applications in a timely manner. The lack of communication and cross-discipline coordination remains a barrier to development. In addition, developers lack knowledge when it comes to putting together applications, which leads to difficulty in acquiring projects connected to the grid (Salifou et al. 2023).

2.3.8.5 Knowledge Exchange and Capacity Building

Ensuring the availability of reliable energy data through continued support for the energy information system is key to development. According to ECN (2005) and Osu (2017), human and institutional capacity building is necessary at every stage to maintain the relevant skills when it comes to the design, development, fabrication, and maintenance of renewable energy technologies. It is argued that there is a lack of local experts, which may limit the choice of projects and number of installations that could be developed (Salifou et al. 2023). Currently, Togo is still relying on experts from other countries when it comes to the field of renewable energy, which leads to a high cost of operation and maintenance due the lack of qualified local staff. Togo is encouraged to learn from advanced and knowledgeable organisations to build the skills needed within the country for better development. Additionally, capacity building is needed at a local level to improve the sustainability of renewable energy projects.

2.4 Assessment of the Development of Renewable Energy

A widely used approach to studying the suitability, opportunities, and transition of renewable energy is the Delphi method. This is a systematic method of gathering opinions from a group of experts through a series of questionnaires, where there is a feedback mechanism through 'rounds' of questionnaires while maintaining the anonymity of participants' responses (Ishak and Barus 2020). The Delphi method is used for forecasting to predict and explore future trends, possibilities, and probabilities of occurrence and desirability based on the expertise of respondents (Rikkonen, Tapio and Rintamäki 2019; Banno, Tsujimoto and Kataoka 2020). It gives room to review the findings and issues of the study in different rounds and discuss any ambiguity found after analysis of previous interview data for accuracy. The use of this method provides insight into future views (Rikkonen, Tapio and Rintamäki 2019) and presents numerous advantages. The Delphi method can help identify the driving forces by involving many knowledgeable and skilled participants from multiple backgrounds. It can also help reliably identify driving forces with the help of large-scale samples across the Delphi survey rounds, which makes the selection process more scientific (Chen et al., 2020). This method has been successfully used in many studies. As an example, Pätäri et al. (2016) conducted a Delphi study on the importance of investing in energy efficiency, policy interventions, organisations and enablers of energy service companies' business, and project outcomes. Their results suggested that customers', especially small and medium enterprises' (SMEs'), unawareness of the energy service companies' business, current financial situation, and high transaction costs in relation to potential savings are among the key factors hindering Finnish energy service companies' sector development. In addition, Solangi et al. (2019) employed the Delphi method to define and select the most important criteria for the selection of renewable energy resources, namely economic, environmental, technical, and socio-political aspects.

Chen et al. (2020) integrated the Delphi method into scenario planning, which they argued could help decision-makers and researchers better understand the factors that influence the development orientation and strategy of renewable energy towards 2030 in China. Their findings showed that the "breakthrough of renewable energy technologies," "growing ecological awareness," and "national energy pricing" were the top three key drivers of renewable energy development in China. Furthermore, Guerrero-Liquet et al. (2016) identified risk management tools in solar photovoltaic facilities based on the Project Management in the Dominican Republic guide using the Delphi method. This enabled them to not only extract the knowledge of experts but also identify the causes and effects that help make the best decision.

Further, Rikkonen, Tapio and Rintamäki (2019) focused on growth opportunities in distributed energy systems by presenting the agricultural, farm-level possibilities of fostering the renewable energy business in Finland. They showed how the Finnish expert community within agriculture and agri-based small-scale renewable energy production saw the future of renewable energy possibilities in the Finnish national context. They reported that, among national renewable energy and agricultural experts, the most preferred energy sources for increasing renewable energy business on farms were wood, biogas, and solar PV. Elsewhere, Jahanshahi et al. (2018) assessed economic criteria and their relative importance for the development of wave and tidal energy technologies based on experts' judgment. They based their study on a two-round Delphi methodology. They found that selling the energy produced and tax incentives were identified as the most important factors that could push the development of the marine renewable energies. The reasons for choosing Delphi method in this study are explained in Chapter 3, section 3.1.11.

2.5 Challenges and Opportunities for Renewable Energy Development

Another useful research tool is the PESTEL framework, which is used to assess political (P), economic (E), social (S), technological (T), legal (L), and environmental (E) factors. To identify and overcome obstacles relating to development of the waste-to-energy (WTE) incineration industry in China, Song, Sun and Jin (2017) and Bao et al. (2020) used the PESTEL framework to analyse the macro-environment of industry. They concluded that municipal solid waste management in China is controlled by many administrative departments that lack coordination (Song, Sun and Jin 2017). They also found that, by including comprehensive references and suggestions, such as policy changes, PPPs, and guidance on encouraging efficient project operations, the study was expected to facilitate investment, operation, and management in WTE incineration projects and pave the way for potential private investors who intend to enter the Chinese market (Song, Sun and Jin 2017).

The PESTEL framework was also used in Zalengera et al.'s 2014 paper to outline a novel approach for addressing challenges that constrain the development of renewable energy technologies in Malawi. They observed that, although the Malawi National Energy Policy clearly lays out the steps towards improving the country's energy situation, unreliable financing mechanisms for large-scale energy projects, a shortage of trained human resources, lack of coordination among local institutions, an unclear regulation framework, and in some cases political governance, impede the sustainable execution of energy projects. They concluded that holistic approaches are crucial for strengthening Malawi's energy sector, and this requires radical political and governance decisions (Zalengera et al. 2014). PESTEL can provide more detailed guidance to decision-makers on issues that are likely to impact the success of their initiatives (Bell and Rochford 2016). Despite its relative strength in describing multi-dimensional aspects of an issue, the use of PESTEL analysis is necessarily narrative, restricted to the identification and conceptual evaluation of the relative importance of contextual issues to determine those that should be subject to a more detailed analysis. Such issues include, for example, political drivers of change, social values that must be protected, environmental systems sensitive to adverse impacts, and legal or regulatory requirements (Iacovidou et al. 2017).

The use of SWOT, which analyses strengths, weaknesses, opportunities, and threats, has proven itself in many studies in the field of renewable energy development. It was used by Niyibizi (2015) to analyse the challenges and prospect of renewable energy in Africa. He found that efforts are being made in many countries in all renewable energy segments and at all scales, but to meet Africa SDGs, they need to be increased and better coordinated. He added that this could be achieved by an extensive, intensive, planned deployment of renewable energy in all its forms, depending on local availability, and to succeed, conditions such as a more conducive environment for private investment in the renewable energy sector, more sustained training of manpower, and a strong and coordinated political commitment at all levels are needed. Meanwhile, Igliński et al. (2022) made use of SWOT to analyse the current progress, prospects, and policy implications of the renewable energy sector in Poland. They concluded that solar and wind energy have the greatest chances for development, and these developments would mean the creation of jobs in and around the renewable energy sector; this coupled with large project financing possibilities may cause Mazowieckie Voivodeship to be a leader in renewable energy production in Poland. Furthermore, Mukeshimana, Zhao and Nshimiyimana (2021) adopted SWOT analysis and interpretive structural modelling to evaluate strategies for the development of renewable energy in Rwanda. They used SWOT analysis to identify factors affecting the energy sector in Rwanda and proposed strategies that have the capability to influence the whole renewable energy sector. They derived four key strategies: raising investment for renewable energy, providing incentives and policy support, creating favourable conditions for private investment, and strengthening institutional management. The relevance of PESTEL and SWOT frameworks for this study is explained in Chapter 3, sections 3.1.2 and 3.1.11.

2.6 Concluding Summary

This chapter discussed the energy situation in Togo and the current energy policies and strategies in place while providing insight in relation to the study. Based on this chapter, it is clear that access to electricity is key to sustainable development. Key findings showed that, as Togo still struggles with energy access, many measures could be taken to develop renewable energy in Togo as seen in other countries. The chapter showed that, despite the efforts made, Togo continues to rely on outside sources for its energy needs when it has great potential for renewable energy development. There has been some investment and work done to improve the energy situation; however, most of the population still relies on biomass and imports. Reviewing literature based on other countries showed that the introduction of policies and regulations has helped in many cases. However, it was noted that in Togo, these are either lacking, far too complex, unclear, or lacking in transparency on key roles and responsibilities of stakeholders.

Among the continents, Africa (mainly West Africa, where Togo is located) was found to be one of the most affected by lack of access to electricity. In all, the literature review revealed key gaps in provision that are hindering the development of renewable energy. These include but are not limited to a lack of policy interest and the level of investment in renewable energy development, which requires financial capability to stimulate faster development. Also noted in this chapter were the inadequate regulatory frameworks, such as the lack of incentives, policies, and standards, posing a barrier to developing renewable energy. In addition, it was noted that many countries, including Togo, still struggle with technical barriers associated with renewable energy development. The high cost of equipment coupled with uncertainty on the return make investors reluctant to invest in renewable energy development. Other key issues found relate to the lack of knowledge transfer and lack of awareness.

Furthermore, legal and licensing provisions are necessary to attract long-term investment in renewable energy, which were found to be lacking. This could help developers reduce operational risks. The above gaps and issues form the basis of this research to provide understanding and guidance on the process of renewable energy development in Togo and its value for creating a better energy solution.

3 RESEARCH METHODS

This section reviews the research methodology used in this study. It explains the research paradigm that supports this study and discusses its relationship to the research methods adopted. A clear explanation of the research methods used, the process adopted, and the research data collection is provided. In this research, both qualitative and quantitative approaches are utilised to collect data, correlate, and analyse them to draw relevant conclusions (Creswell, 2007; Osu, 2017). A combination of exploratory, descriptive, and explanatory research techniques is used to tackle the objectives. An overview of the methodology is shown in Figure 3-1 below. This is based on Kumar’s (2011) type of research, illustrated in Appendix C1.

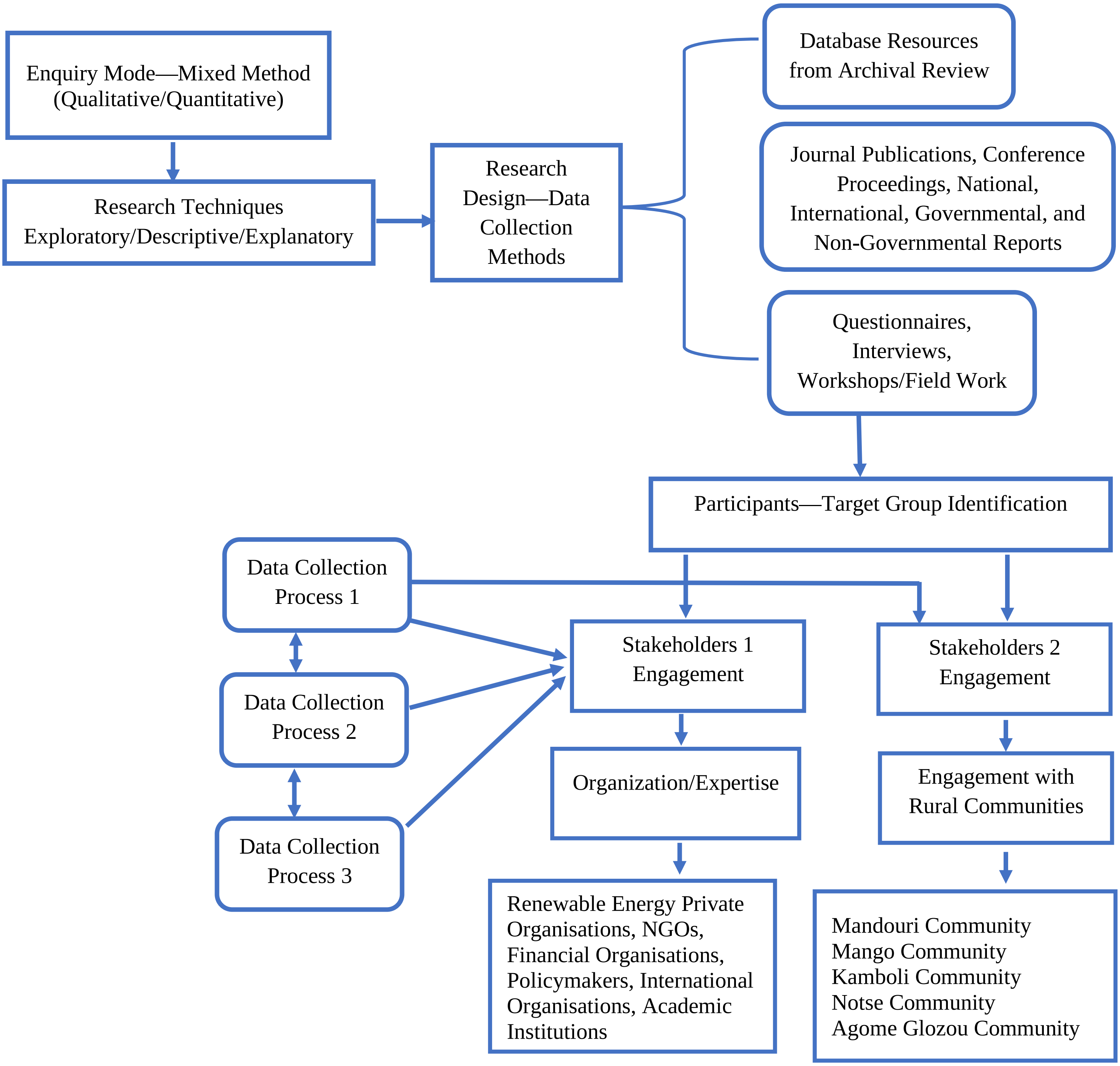

Figure 3-1: Overview of the Research Approach, Process, and Included Participants

3.1 Research Philosophy and Methodology

3.1.1 Research Paradigm and Philosophical Stance

A research philosophy is a system of beliefs and assumptions about the development of knowledge (Saunders 2009). It reflects beliefs about the way in which data about a phenomenon should be gathered, analysed, and used. The objectives and philosophical assumptions of a researcher are inseparably linked to the research he or she does. As explained by Grix (2004), the way the researcher views the constructs of social realities and knowledge affects how he or she will go about uncovering relationships among phenomena and social behaviour. In addition, how one evaluates his or her own and others' research to understand the philosophical thinking that informs the choice of research questions and the methodological approach is a key initial step of developing clear and accurate research.

Another crucial step is choosing the research paradigm. A research paradigm is "the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed" (Kuhn 1962, quoted in Vinodkumar and Anoop 2020). According to Kivunja and Kuyini (2017), in *The Structure of Scientific Revolutions*, American philosopher Thomas Kuhn (1962) first used the word "paradigm" to mean a philosophical way of thinking. The word has its etymology in Greek, where it means pattern. In educational research, the term "paradigm" is used to describe a researcher's worldview (Mackenzie & Knipe, 2006). This worldview is the perspective, thinking, school of thought, or set of shared beliefs that informs the meaning or interpretation of research data. As Lather (1986) explains, a research paradigm inherently reflects the researcher's beliefs about the world that he or she lives in and wants to live in. It constitutes the abstract beliefs and principles that shape how a researcher sees the world and interprets and acts within that world.

Paradigms are thus important because they provide beliefs and dictates, which, for scholars in a particular discipline, influence what should be studied, how it should be studied, and how the results of the study should be interpreted. The paradigm defines a researcher's philosophical orientation it has significant implications for every decision made in the research process, including choice of methodology and methods (Kivunja and Kuyini 2017).

Other definitions of a paradigm are proposed by Patton (1990), who suggests that it is a perspective that serves as a means of breaking down the complexities of the world in which we exist, and Guba (1990), who explains a paradigm as an interpretive framework that is structured around a set of feelings and beliefs about the existence of the word, our understanding of it, and how it should be studied (Akinsete 2012).

Dill and Romiszowski (1997) stated the main functions of research paradigms as follows:

- Define how the world works, how knowledge is extracted from this world, and how one is to think, write, and talk about this knowledge
- Define the types of questions to be asked and the methodologies to be used in answering them
- Decide what is published and what is not published
- Structure the world of the academic worker
- Provide its meaning and its significance

According to Creswell (1998, p. 74), the components of a research paradigm are summarized by the three terms shown in the Figure 3-2 below. These are further explained in relation to this research.

Figure 3-2: Research Paradigm. Source: Sialoombe (2020).

- Ontology—What is reality? This explains how one views reality.
- Epistemology—How do you know something? In other words, the understanding of the nature of knowledge.
- Methodology—How do you go about finding it out? In other words, the processes of inquiry.

The diagram below explains the above terms and the relationships among them, on which this research is based (Patel 2015):

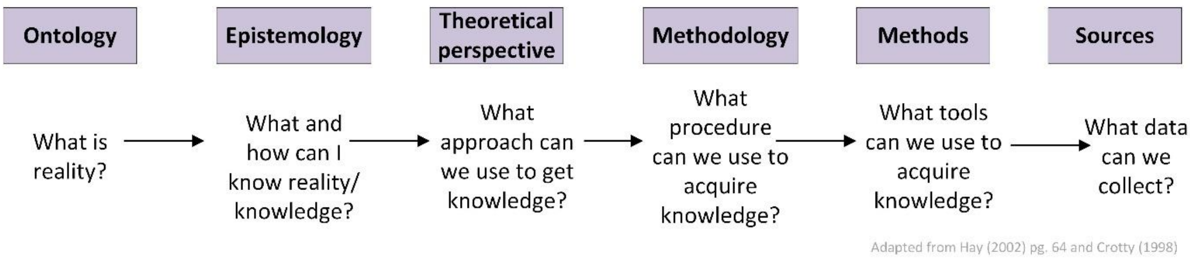

Figure 3-3: Components of a Research Paradigm and the Relationships Among Them. Source: Patel (2015).

Ontology is concerned with the assumptions we make in order to believe that something makes sense or is real, or the very nature or essence of the phenomenon we are investigating. It helps us to conceptualise the form and nature of reality and what we believe can be known about that reality (Scotland

2012; Kivunja and Kuyini 2017). In this research, assumptions are made with regards to the research objectives about the reality of the subject matters that are being investigated without basing them on the researcher's own feelings and thoughts but on reality. Philosophical assumptions about the nature of reality are crucial to understanding how we make meaning of the data we gather (Kivunja and Kuyini 2017). These assumptions, concepts, or propositions help to orientate the researcher's thinking about the research problem, its significance, and how the researcher might approach it to contribute to its solution, as stated by Kivunja and Kuyini (2017). Therefore, the shaping of this research is based on a series of assumptions due to the goals of the research as well as the researcher's knowledge and experience. Accordingly, the researcher addresses the research question through simple beliefs about the existence of numerous realities underpinned by a range of social, economic, political, situational, observations, experimental, and personal factors.

Epistemology has its etymology in Greek, where the word "episteme" means knowledge. Put simply, in research, epistemology is used to describe how we come to know something—how we know the truth or reality and what counts as knowledge (Guba and Lincoln 2005). It highlights the perceptions of research findings as an observer or as an intersubjective product constructed by the relationship between the researcher and the system under study (Guba and Lincoln 2005). Epistemology focuses on the nature of human knowledge and comprehension that the researcher can possibly acquire so as to be able to extend, broaden, and deepen understanding in the field of one's research (Kivunja and Kuyini 2017). The present research incorporates a social science approach and considers the perspectives of multiple stakeholders to determine the truth or what counts as knowledge, which can be heavily influenced by the context. It takes into consideration the impact of the researcher and their background within the context of the research and relies on the views of the research participants on the subject being studied.

3.1.2 Theoretical approaches

The research builds on existing theories, looking at similar developments from other countries to understand the relationship between them. Chapter 2 finds gaps in existing literature that informed the researcher on the selection of important principles that helped development of this research. Research questions were developed by integrating practices, similarities, and findings. In addition, the study investigates the complexity, realities, and applicability of different theories to Togo. This served as a guideline in developing new theories for this research.

Existing theories on Delphi method provided theoretical understanding on how other researchers used multiple round data collection to evaluate possibilities, barriers, and solutions for energy growth. This served as a guide on which this research was based, to coordinate with relevant stakeholders in the evaluation of possibilities, barriers, and solutions for energy growth, while discussing the views of respondents in relation to renewable energy development in Togo. Furthermore, the study reviewed different theoretical approaches on the use of PESTEL and SWOT analysis to understand important principles necessary for consideration when investigating factors affecting renewable energy development in Togo. These have been chosen for this study to help identify factors that could change or mitigate the risks, while taking advantage of opportunities that are needed to remain competitive and developing a better long-term strategy. This was done by closely looking into the impact of social, economic, political, legal, and technological factors affecting renewable energy development. Finally, the research built on the use of existing theories conducted in other countries and fed back key principles and practices that are applicable to this study context.

3.1.3 Research Methodological Approach

As discussed in Sections 1.4 and 3.1.1, the decision to adopt a pragmatic philosophical stance, using a mixed method approach to data collection, to achieve the aim of this study is based on its appropriateness given the interdisciplinary nature (such as social, economic, political, environmental, and technical aspects) of the research subject. Applying one particular research method would not be sufficient in addressing the research questions. A mixed method approach is adopted where qualitative and quantitative data collection are combined to achieve results as reported elsewhere in the literature (Avsar, Fischer and Rodden 2016; Bisaga, Parikh and Loggia 2019; Buldur et al., 2020). This has been successfully done in many other studies. For example, Buldur et al. (2020) used mixed methods to investigate the effects of a nature education project on middle school students' perceptions of renewable energy. They explored participants' views on renewable energy by collecting both qualitative and quantitative data. The data agreed that, while the participants already had positive perceptions of renewable energy before the study, significant contributions were made to increasing their perceptions and awareness levels about renewable energy during the nature education project.

Meanwhile, Bisaga (2018) used mixed methods to address the gap in literature existing around behavioural aspects of energy use among SHS adopters in Rwanda. She used a three-dimensional energy profile framework to explore needs, aspirations, and energy use at a household level while taking into consideration gender differences, diverse poverty groups, as well as system packages consisting of a range of appliances. Her findings included a considerable decrease in the use of candles, kerosene, and batteries for lighting, with continued fuel stacking practices post-SHS adoption, and basic business applications (e.g., lighting, phone charging, access to information and entertainment). She also found that policy and regulatory frameworks remain important factors in scaling up off-grid energy access as key market enablers and channels of awareness-raising and trust-building among off-grid communities (Bisaga 2018). In addition, Avsar, Fischer and Rodden (2016) used a mixed methodology to investigate the potential benefits and challenges of touchscreen technology on flight decks, and their findings were used to construct a framework that showed the relationships among the four key factors—environment, physical, virtual, and user. Furthermore, Bisaga, Parikh and Loggia's (2019) study explored challenges and opportunities for sustainable urban farming as an integrated environmental management strategy for the upgrading of informal settlements in South Africa, using three case studies in Durban. By applying mixed methods and action research approaches, the study investigated community perceptions around the implementation of urban agriculture (UA) and assessed the three sustainability dimensions of UA proposed by van den Berg's framework (Bisaga, Parikh and Loggia 2019; Akinsete 2013). This enabled the authors to assess the coverage of urban farming activities through quantitative evidence and understand key barriers and opportunities through qualitative evidence.

The mixed methodology used in this research is intended to open up options to find out more about different methods used by previous studies, how they worked, and their shortcomings. Based on the literature review carried out, this study uses a combination of field visits, workshops, focus group discussions, and a broad range of interviews with relevant stakeholders and actors. This will help gather more relevant views from all angles, such as local communities, private and public organisations, NGOs, and policymakers. The study plans to incorporate the use of a bottom-up approach (which considers the integration of the community with policymakers) to capture all views to include in analysis. For instance, discussing with the local community will help better identify existing energy needs and the types of activities or businesses energy is being used for to provide appropriate solutions required.

The case study is based on Togo renewable energy sustainability and employs qualitative and quantitative research to achieve the result. The qualitative research part of this study is focused on obtaining data through open-ended and conversational communication. This method is used to understand people's beliefs, experiences, attitudes, behaviours, and interactions (Pathak et al., 2013). Qualitative methods help reveal the behaviour and perceptions of a target audience with reference to a particular topic. These features of qualitative research coupled with the exploratory nature of this research and the aim of this study make this method most suitable for this study. It will help us gain an understanding of people's opinions and motivations as well as providing insights into the aims and objectives of this study. Quantitative research is also used in this study to quantify the problem by way of generating numerical data and formulating facts. The quantitative data collection for this thesis included an online survey whereby a questionnaire was sent out to a target audience to complete by email and return. Paper surveys were also used in some cases, where a physical copy of the questionnaire was shared with the respondents. The other types of quantitative data collection used in this research included face-to-face interviews and telephone interviews. A breakdown of the participants per group per phase is listed in Table 3-2 below. The field study is discussed in Chapter 4, while the discussions with stakeholders are tackled in Chapter 5.

3.1.4 Research Design – Data Collection Methods

The data collection method in this research is based on mixed methods that include three groups of data, namely primary, secondary, and tertiary data collection. These included interviews, questionnaires, field notes and observations, as well as literature review and database resources from archival review. The full process of the design of the questionnaire is discussed in Section 3.2.4 below. The validation of the questionnaire was done in three steps to identify whether the questionnaire contained the right questions and whether they were clear enough, understandable, consistent, and not too ambiguous. Building up on existing theories by comparing the research topic to the literature served as a first reference step to designing and validating the research questions. A thorough search of numerous databases for journal papers in the field of renewable energy development was carried out to identify similarities and guidance on how best to frame the research questions. The researcher looked into how other researchers tackled their studies and what could be the key components of discussions in this study as suggested in previous studies (Bell 1999; Oppenheim 1992). This included looking at some feasibility studies and using credible published studies, looking at various case studies and their results. Various reports were reviewed, key points noted, and recommendations investigated to ensure transparency and replicability of the used methods. This was done taking into consideration the philosophical stance behind this research as discussed in Section 3.2.1 above, which helped in developing the research questions.

The second step in the questionnaire design involved testing the face validity of the questionnaire through a pilot test. Eight participants initially looked at the developed questionnaires—one research student, two experienced researchers, two NGO staff members, one energy consultant, and two professors—all with experience in renewable energy development, with particular emphasis on Africa. Their various feedback and suggestions were taken into consideration to develop clear and concise questions that were then used for the interviews. These were done through face-to-face meetings coupled with email exchanges, Skype meetings, and telephone calls. These questions were also checked by the professors supervising the research and the research degree staff at the university. Upon completion of this validation step, another pilot test was done in

Africa with four key participants—one University of Lomé senior lecturer in renewable energy, two NGO staff members, and one policymaker within the energy sector—to ensure the questions were concise, clear, understandable, and not ambiguous. Feedback was provided, and several recommendations were given by the participants. These were taken into consideration, and adjustments were made accordingly, such as rephrasing some questions that were too vague and deleting unnecessary questions and repetitions. All the feedback received during the pilot test was valuable and helped improve the formulation and design of the questionnaires. This helped prevent issues during the main data collection phases, as participants found no issues with the questionnaire that was presented to them.

The last step that helped in framing the questionnaires was the researcher's own observations and experience in line with the research field and topic. The overview of the research approach, process, and included participants is shown in Figure 3-1. A schematic diagram of the thesis flow is shown in Figure 3-4 below.

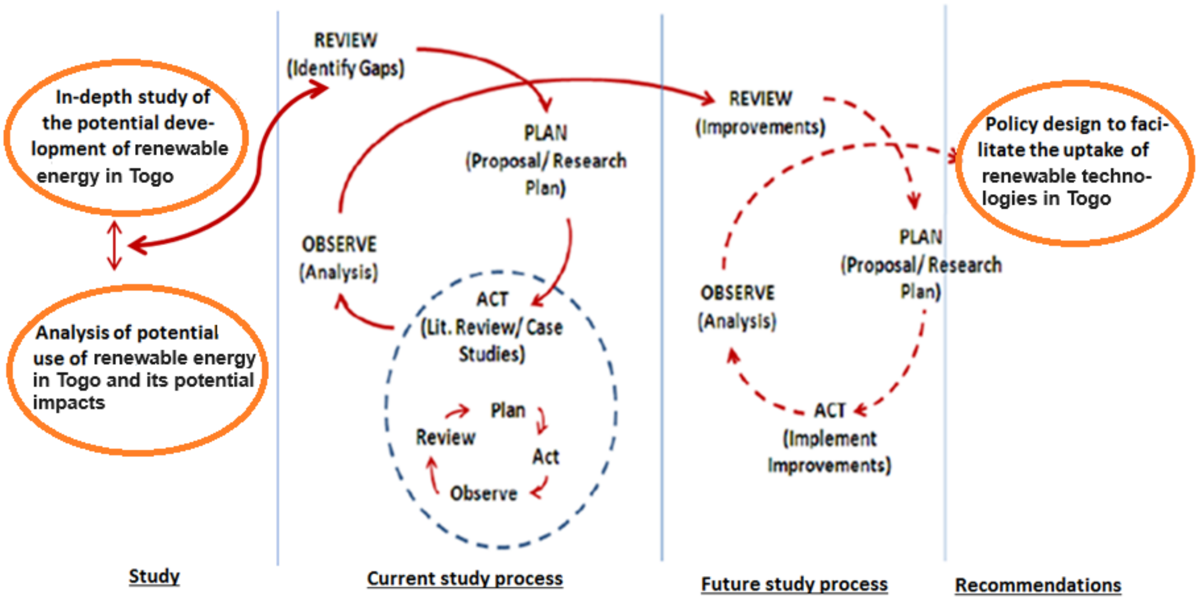

Figure 3-4: Schematic Diagram of the Thesis Adapted and modified from Akinsete (2012).

A summary of the methodology used per task is shown in Table 3-1 below.

Table 3- 1: Methodology Used per Task for the Study

No.	Research Tasks	Data Collection Methods	Data Analysis Methods	Research Questions (RQ)
1	To critically review the energy situation in Togo and outline factors resulting in high dependency on the international market	Documents from the following sources were used: journal publications, conference proceedings, national and international standards, governmental and non-governmental reports, interviews, and field visit notes	Qualitative analysis of content	***PHASE 1*** **RQ1.1** Do you have access to energy for your daily life and activities? **RQ1.2:** Would you know what form of renewable energy is produced/generated in Togo itself? **RQ1.3:** Who are the current actors within the energy sector in Togo? **RQ1.4:** Could you see other forms of renewable energy being produced/generated in Togo in the future? **RQ1.5:** Are there any issues caused by the current energy in place, such as pollution, health issues, etc.? **RQ1.6:** In your opinion, what are the issues facing the energy sector in general? ***PHASES 2 & 3*** **RQ1:** What type of energy is generally used: In urban areas of Togo? In rural areas of Togo? **RQ2:** Do you know how much power is produced from the 230 MW installed generating capacity? **RQ5;** In your opinion, why have the wind projects planned by Delta Wind failed to start? Please explain. **RQ7:** What are the existing laws that promote the use or development of renewable energy? What are the benefits or disadvantages of these existing laws?
2	To critically review the knowledge on renewable energy penetration and investigate the potential of different renewable energy sources.	Mixed methods were used, including observations, interviews, field work, documents from field visits, interviews, and publications	Qualitative analysis of content and quantitative analysis of statistical data	***PHASE 1*** **RQ2.1:** What are the potential renewable energy sources in Togo? **RQ2.2:** Have there been any renewable energy developments within the country? **RQ2.3:** Are there types of renewable energy that are currently used within your area? **RQ2.4:** What is the level of knowledge in renewable energy in terms of skills? For example, are there experts in the field of renewable energy technologies in Togo to take care of installations, operations, and maintenance? ***PHASES 2 & 3*** **RQ6:** What is the latest on the discovered oil in Togo? Has there been any progress in terms of exploitation? Assuming yes, what has been done? Otherwise, what has been the drawback?
3	To outline the potential impact of renewable energy usage on the environment and socio-economic development	Mixed methods were used, including interviews, observations, field work, documents from field visits, interviews, and publications	Qualitative analysis—impact assessment	***PHASE 1*** **RQ3.1:** Would you advise the use of renewable energy in Togo? **RQ3.2:** Can the use of renewable energy contribute to your daily life and activities? **RQ3.3:** How can the use of renewable energy improve any health issues? **RQ3.4:** What impact can the use of renewable energy have on the: Community? Regional level? National level? **RQ3.5:** Do you think the use of renewable energy can reduce energy costs in the future? **RQ3.6:** What other impacts can the use of renewable energy produce on sustainable development (environment, socio-economic development)?

				PHASES 2 & 3 **RQ4:** Solar energy was installed in 22 villages from 2013 to 2016 with the aid of a West African Economic and Monetary Union (WAEMU) project named "PRODERE" ("Programme Régional de Développement des Énergies Renouvelables et d'Efficacité Énergétique"). Do you know how those villages use the installed solar energy?
4	To make recommendations on approaches to becoming self-sufficient	Mixed methods were used, including interviews, observations, field visit notes, and documents	Qualitative analysis—languages, actors, and stakeholders' analysis	***PHASE 1*** **RQ4.1:** What are the best practices that can be identified within the energy sector? (E.g., are there any adopted rules and regulations that help or favor the population? Is there any introduction of standardized power purchase agreements and power purchase tariffs to encourage development? Etc.) **RQ4.2:** What improvements can be recommended? **RQ4.3:** Who are the key policymakers***, who are other important key players, and why? **RQ4.4:** What actions could be taken by policymakers to encourage wider adoption of renewable energy in Togo for sustainable development? What actions could be taken by other important key players? **RQ4.5:** Do you think the use of renewable energy technologies is cheaper or more expensive? Can you explain your answer? **RQ4.6:** Would you be happy to invest in renewable energy technologies? **RQ4.7:** What type of renewable energy would you recommend and why? **RQ4.8:** What payback period would you expect should you invest in renewable energy technologies? **RQ4.9:** What other suggestions could you recommend? ***PHASES 2 & 3*** **RQ3:** Are you engaged in energy use/utilization, buying, or decision-making? How much estimated power is needed to meet the 2030 vision? What would you suggest in terms of percentage increase to the current electric power consumption? **RQ7:** What are the existing laws that promote the use or development of renewable energy? Can you make suggestions for improvement, if any? **RQ8:** How is the management system for renewable energy in terms of processes? Would you suggest something different? **RQ9:** How can policymakers address the absence of framework regulations that govern the energy sector? **RQ10:** Should renewable energy be prioritized? If so, why? **RQ11:** Should diversification with regards to renewable energy be promoted? If so, why? **RQ12:** Should renewable energy research be promoted? If so, why? **RQ13:** Do you have any other suggestions to recommend?

3.1.5 Workshops, Questionnaire, and Interviews

Workshops were conducted with a range of participants, including members of the community, such as the indigenous farmers, fishermen, and artisans, as well as key stakeholders in energy, policymakers, private organisations, and financial institutions, amongst others. The participants included both men and women, and their ages ranged from 16 years to 61 years old and above, as detailed in Appendix C2-3. The level of education ranged from no formal education (especially when it came to the indigenous, such as indigenous farmers, fishermen, and artisans) to tertiary education. The research also considered the number of years spent in the community, which ranged from less than 5 years to 20 years and above, as shown in Appendix C2-3.

The design of the questionnaire was based on the steps shown in Figure 3-5 below (Kopper and Parry 2021). Prior to the design of the questionnaires, steps 1 through 3 were crucial because it was necessary to identify the research scope thinking carefully about what the questionnaire was going to include before starting to design the questionnaire. In this research, the first step was to decide on the information required and methods that could be used to achieve the results. Before administering the interviews, the validity and reliability of the interview questions was tested through an exploratory pilot study to ensure the questions were not confusing or too vague.

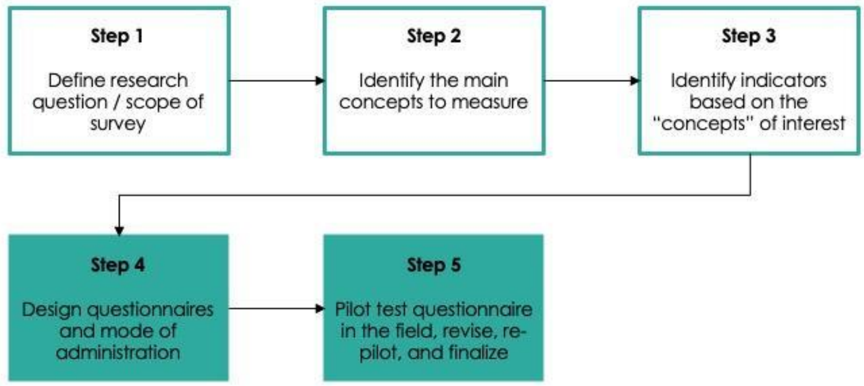

Figure 3-5: The Process of Survey Design. Source: Kopper and Parry (2021).

Decisions on the methods of reaching out to the participants, such as emails, paper surveys, face-to-face interviews, and telephone interviews, were carefully considered. Once all these steps were clear, the content of the questions was formulated. Prior to undertaking the interviews, the questionnaires were translated from the English language to French to allow easy communication and understanding since French is the mother language spoken in Togo. This was also to help speed up the interview process and minimise the risk of in-field translation errors. The translation was first done by the researcher due to her fluency in French and because the researcher had a good understanding of what the study sought to determine. Once the questionnaires were translated into French, they were submitted to a professional translator to double-check the translation. Finally, the translated questionnaires were sent to a French professor to proofread and correct mistakes prior to distributing it to the various respondents. The questionnaires were distributed to most of the participants to look at prior to undertaking the interviews. However, in a few cases where the questionnaire could not be sent to the participants due lack of email or ability to access the internet, the questionnaires were distributed at the interviews, and participants asked questions before the interviews.

3.1.6 Participants – Target Group Identification

The next steps involved deciding on the target respondents. Based on the aim of the research, it was deemed important to gather data from different participants, starting from occupations in the communities, such as the indigenous farmers, fishermen, and artisans, and extending to participants including key stakeholders in energy, policymakers, private organisations, and financial institutions, amongst others. The respondents were picked based on their ability to provide responses in the field of this study. Before the interviews, an upfront consultation was done by the researcher with the target group via emails and phone calls. This was to request permission to meet with the participants before travelling to Togo for the first round of interviews. Once permission was granted and appointments arranged, the formulated questionnaires were sent to participants prior to the in-person meetings. On the day of the meeting, the researcher sought consent from the participants to record the discussions during the face-to-face interview process. The number of participants and details are broken down in Table 3-5. In addition, handwritten notes were taken during the interview to summarise the discussion points. The recorded discussions coupled with the notes were then reviewed, transcribed, and summarised for analysis. The interview time per participant was about 45 min to allow enough time to answer all questions, and participants were given the option to request to stop at any time if they did not wish to continue. There were three stages of interview questionnaires in this research. Questionnaires were sent to the participants to answer prior to meeting them in person for discussion, particularly for the first data collection and during the data validation. There were not face-to-face interviews in the second round, as this was done without travelling to Togo. The stages and details of the research questions are shown in Table 3-1 above, and the breakdown of the number of participants for the rural communities is shown in Table 3-2 below.

Table 3-2: Participants per Group

Stakeholders from rural communities	First-round respondents
Kamboli	25
Mango	25
Mandouri	10
Notse	8
Agome Glozou	12
Total rural communities	80[3]

3.1.7 Ethical and Integrity Considerations

Ethical and integrity considerations are very important when conducting research due to the growing concerns about research misconduct. According to Cossette (2004, p. 215), research misconduct is defined as "any deliberate conduct that goes against the more or less explicit ethical rules that a community of researchers has agreed on at a specific point in time concerning the behaviour to adopt when preparing or publishing the results of a research project". In a research setting, ethical and professional behaviours should be considered together, and research authors should equally uphold both sets of standards, emphasizing integrity, accountability, and transparency throughout the entire research, publishing, and presentation processes (Gordon, 2017). Ethical and integrity considerations were taken into account at different stages of this research, considering the university's ethical procedures. Other observations of ethical issues concerned with policy intervention and culture were taking into consideration as well based on the researcher's familiarity with the country. A research information sheet was shared with participants, providing them with a brief about the research, modalities for

[3] This involved a group of people who were part of the first-round data collection through a workshop at five different locations, namely Kamboli[1] located in central Togo, Mango[2] and Mandouri[3] located in the north of Togo, as well as at Notse[4] and Agome Glozou[5] (existing site) located in the south, as discussed in Section 1.2.

participation, data storage arrangements, the benefits and risks (see Appendix C2-1). Furthermore, an informed consent form was provided to participants (see Appendix C2-2) prior to completing the interview questionnaires. To maintain the participants' confidentiality, codes were used to represent research participants' responses. To store the data, handwritten notes were taken during the interviews summarizing the meeting minutes, as detailed in Appendix C2-1. The interviews were also recorded on a digital voice recorder to allow the researcher to go back to the discussions. Afterwards, a copy of the recording was saved on an external hard drive for a duration of 3 years. All personal data are subject to UK Data Protection Act 1998 and are stored securely.

3.1.8 Data Coding and Data Collection Schedule

The coding use for qualitative data is shown below. The number shown in parentheses indicates the total number of participants at the meeting.

Appendix C4 provides more detailed descriptions of the codes used.

PFG1 – Focus Group 1 (9)

PFG2 – Focus Group 2 (9)

PFG3 – Focus Group 3 (6)

PFG4 – Focus Group 4 (8)

PFG5 – Focus Group 5 (7)

IFG1 – Focus Group 6 (7)

IFG2 – Focus Group 7 (7)

IFG3 – Focus Group 8 (10)

AFG1 – Focus Group 9 (7)

EFG1 – Focus Group 10 (5)

WG1 – Workshop Group 1

WG 2 – Workshop Group 2

WG 3 – Workshop Group 3

WG 4 – Workshop Group 4

WG 5 – Workshop Group 5

WG 6 – Workshop Group 6

WG7 – Group 7

SI – Stakeholder Interview (1–31)

S1 – Survey (1–17)

DVSI – Stakeholder Interview (1–16)

In addition, the following table summarises the schedule on which data has been collected throughout the study starting from the planning stage and preliminary meetings through the data collection. As shown in Table 3-3, this was based on a multistep process. Details on respondent age group, gender, level of education, employment status, and number of years in the community are discussed in Chapter 5.

Table 3-3: Data Collection Breakdown Displaying the Sequential Order in Which Data Has Been Collected Throughout the Study.

DATE	METHOD	LOCATION	TARGET GROUP	GOAL
Planning Stage – UK-Based				
August 2013–October 2013	Emails, phone calls	Lomé	Key stakeholders with various expertise from PFG1, PFG2, PFG3, PFG4, PFG5, IFG1, IFG2, IFG3, AFG1, EFG1	Set ground and intentions for research prior to field trip
Field trip 1: Preliminary Meeting				
November 2013	Focus group discussions (4 to 10 participants per group)	Lomé	Stakeholders with various expertise from PFG1, PFG2, PFG3, PFG4, PFG5, EFG1	Open discussions for scoping topic of research
November 2013	Workshop – Hotel Eda Oba	Lomé	Stakeholders with various expertise, members of the public (WG1)	Present information about inclusion of Renewable Energy in Togo's energy policy to get feedback based on public opinion
Field trip 2				
May 2014	Focus group discussions	Lomé	PFG1, PFG2, PFG3, PFG4, PFG5, IFG1, IFG2, IFG3, AFG1, EFG1	Further discussions with stakeholders and to allow visits to rural areas
May 14	Engagement with local communities and site observation Observation	Kamboli Mango Mandouri Agome Glozou Dapaong	WG2, WG3, WG4, WG5 WG7	Understand the needs, practices, problems, current energy situation
Field Trip 3				
November 2015–December 2015	Engagement with local communities and site observation	Notse	WG6	Understand the needs, practices, problems, current energy situation
November 2015–December 2015	Face-to-face interviews	Lomé	Stakeholders with various expertise, including academic staffs (SI: 1–31)	Get responses to open-ended questions
Survey – US-based				
December 2018–July 2019	Survey	Lomé	Key stakeholders with expertise in Renewable Energy (S1: 1–17)	Get responses to questionnaires
Field trip 4				
January 2020	Face-to-face interviews	Lomé	Key stakeholders with expertise in Renewable Energy (DVSI: 1–16)	Data validation

3.1.9 Briefings and Permissions

The study initially took a comparative approach between the urban and rural areas of Togo to obtain in-depth views from both sides and how the lack of energy affects the population. An initial contact/collaboration started in 2013 with emails and phone calls to various key stakeholders with regards to the electricity challengers being faced by the Togolese government, the potential of introducing renewable energy as part of the energy mix in Togo, and the level of support required to drive the development of renewable energy. This was to help set the ground and intentions for the research prior to travelling for a field visit for in-person meetings in November 2013. In addition, the conversations were based around understanding the current energy situation as well as identifying views relating to the introduction of renewable energy technologies. The stakeholders included personnel from CEET, the Ministry of Environment, the Ministry of Energy, the Parliament, the Ministry of Agriculture, some NGOs, African Biofuel, renewable energy companies which work to promote renewable energy and energy-efficient technologies, academic institutions, the Economic Community of West African States (ECOWAS), and the Food and Agriculture Organization (FAO). This first visit mainly consisted of open meeting discussions to help with scoping the topic of this research. Each meeting group was made up of four to eight people in total, depending on the organisation visited, and the meetings lasted about 1 h each. Table 3-4 below summarises the meeting discussions.

Table 3-4: Summary of Meeting Discussions – November 2013 & May 2014

Stakeholders	Views of renewable energy technologies
PFG1	No strong will, as renewable energy is at an early stage, and measures are being taken to address energy issue by potentially constructing a generating power plant which will run on charcoal.
PFG2	Little existing experience in renewable energy; introduced a policy in 2009 encouraging independent companies to invest in and install new power plants in Togo. There is no policy for renewable energy.
PFG3	Expressed concern about environmental issues needing general participation, not just from the government, and strongly encouraged the development of renewable energy.
PFG4	Highlighted potential for wind and solar development as well as marine energy and biomass. Lack of transformation/processing units is currently an issue facing farmers. Recommended development of renewable energy, which will be a plus to the agricultural sector. Currently, the use of solar energy is being considered to pump water from rivers for agriculture.
PFG5	Renewable energy is at an early stage, and its development is strongly recommended. This will make life easier in rural areas because most small villages only need a small amount of power.
IFG1	Supported the idea of developing renewable energy and the use of a social science method to understand communities as explained in the previous section.
IFG2	Expressed interest to collaborating as a facilitator for developing the use of renewable energy.
IFG3	Mentioned that there is lack of existing knowledge on renewable energy technologies. Working towards the development of renewable energy by providing, training, and raising awareness.
AFG1	Supported the development of renewable energy; however, policies and regulations in place do not help its advancement. Also expressed difficulties in getting government interest and support towards Renewable Energy research.
EFG1	Working to promote awareness for the use and development of renewable energy; however, there is now a lack of trust in the system towards NGOs due the negative effect of corruption experienced in the past, making local communities' participation difficult.

**Note: Stakeholders' names have been anonymised in the report due to confidentiality.*

A workshop was also organised in Lomé (capital city of Togo) on 27 November 2013 at Hotel Eda Oba to present information about the inclusion of renewable energy in Togo's energy policy to get feedback based on public opinion. This workshop was open to representatives from the above-listed organisations, some financial institutions, and a few members of the public. The meeting and workshops ended with strong enthusiasm from the participants to progress the potential for renewable energy development, and arrangements were made for future discussions. Therefore, the research carried out appropriate planning for follow-up meeting visits by identifying suitable dates, the main themes for discussion, and the required research participants for the meetings or pilot study.

Based on the insights from the first scoping visit and meetings held, the researcher planned a second field visit in May 2014 for further discussions with more stakeholders and to allow visits to rural areas, engagement with the local communities, and observation of the sites. This was because rural areas of Togo were found to be the most affected economically, socially, and environmentally based on both discussions and literature. Chapter 4 provides more information relating to the engagement with rural areas.

3.1.10 Field Study, Workshops, and Observations in Rural Areas of Togo

The aim of these workshops was to get an in-depth understanding of the needs, practices, and problems of each area. Specifically, they sought to find out more information regarding existing resources, the types of activities and businesses conducted in those communities, and potential requirement to improve their living standards. This information would form the basis for analysis to identify the potential issues and solutions. Prior to organising the field visits in rural areas, permission from key political staff was sought. Amongst these were the prefect of each area to allow visitation and workshops in his district because the perfect is the regional governor of the area and the Ministry of Security in case any security issues were to arise. The researcher also sought the permission of the Ministry of Agriculture, Livestock and Rural Development since it oversees that sector. Five rural communities were involved as discussed above, namely Mandouri and Mango located at the north, Kamboli in central region, and Notse and Agome Glozou in the south. A workshop was organised with the participants of each of the selected communities accompanied by appropriate regional government officials. The participants were composed of farmers, fishermen, and artisans. A schematic diagram showing the step-by-step process and included participants for the workshops in rural communities is shown in Figure 3-6 below.

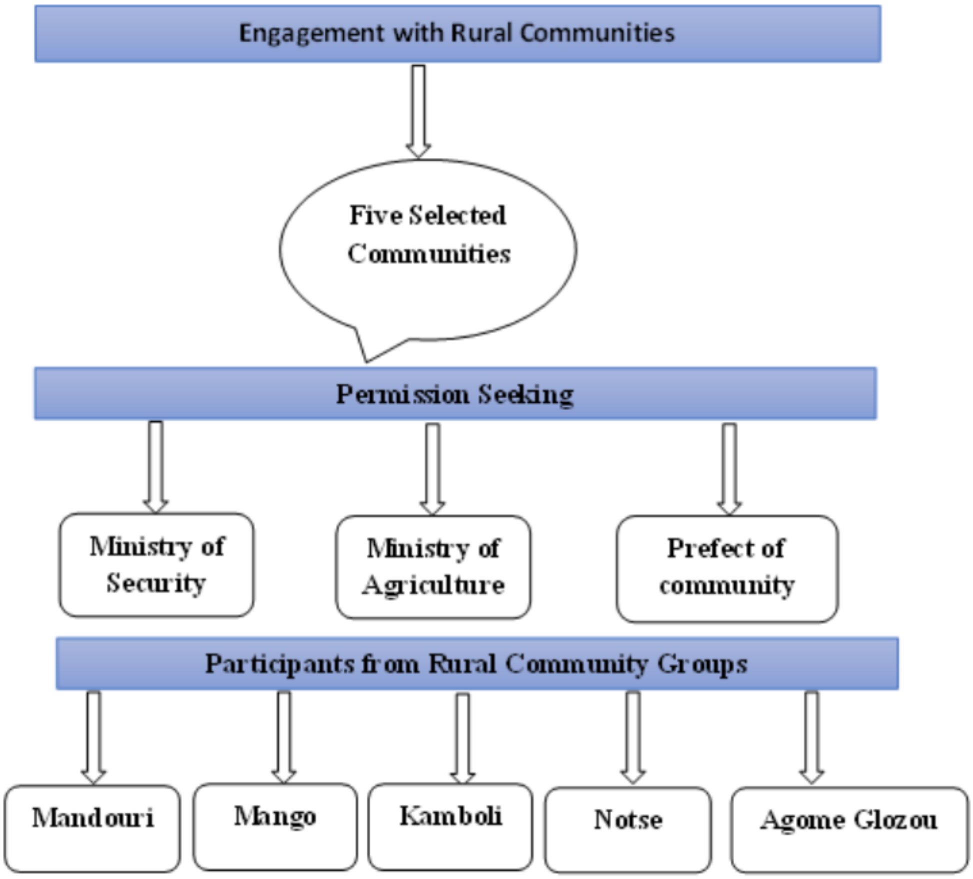

Figure 3-6: Schematic Diagram Explaining the Process and Included Participants for the Workshops in Rural Communities

The workshop in the central region (Kamboli) was done with a group subdivided into two: one for women and the other for men. This was not the researcher's choice but that of the elders of the Kamboli community due to their religious (Islam) beliefs. The questions were based around available resources and produce in their communities, the stages involved, the current needs and the available skills.

Engagement with the Mango rural community involved discussion with a group of farmers, fishermen, and artisans. This group did not include any woman, as they were mostly engaged at home or commercialising produce in the market. Just as in the workshop in Kamboli, the questions were based around available resources and produce in their communities, stages involved, current needs, and available skills.

Questionnaires were used for the community in Mandouri and its surrounding villages to capture information indicating population, existing activities, and the needs of people.

As part of this field visit, the researcher also attended a formal workshop organised by the Ministry of Agriculture in Agome Glozou located in the south, one of the existing sites for the Ministry of Agriculture, to engage in discussions with the youth and to see the site and make observations.

The need to visit the rural community of Notse located in the south was due to information regarding solar streetlamps in the community. This was to engage with the community and learn about the impact of these installations.

3.1.11 Data Analysis Process

A combination of qualitative and quantitative methods was utilised to analyse the data collected. Quantitative data, including data from surveys, pre-existing statistical data, and numerical data collected were analysed using Microsoft Excel statistical packages.

Qualitative data, including data from open-ended questionnaires, interviews, and observations, was coded and analysed using thematic coding with a data-led grounded theory approach as shown in Appendix A6. The objective was to find important ideas and classify them into categories of sections within the data (Taylor and Gibbs 2010). As part of this process, key points were marked with a series of code that was extracted from the text and grouped into similar concepts to make the data more workable. This helped determine trends and patterns of words used, their frequency, their relationships and structures, and discourses of communicating, as illustrated by Vaimoradi et al. (2013). Appendix A6 shows how this progressed step by step.

Once the data was gathered, sampling was done to uncover the meaning of the information in the larger data set. These samples were examined in detail, and key notes were taken. The next step involved using different codes to mark the data to classify them easily and record reflective notes regarding what was being learnt from the data. In addition, the data were grouped per respondent categories, and answers were compared to find how responses varied from one another as well as how they related. This was done for data clarity reasons, so the similarities and differences were clear and repetitions eliminated.

Data triangulation was used to increase the credibility and validity of the research findings. This was to cross-check the findings and results obtained from the research as well as capture different dimensions of the same fact. It involved interviewing different groups of people and using multiple data sources as explained above to develop a comprehensive understanding of the facts in relation to renewable energy development. In addition, questionnaires were used in different rounds to cross-check the data collected and to capture any differences. Furthermore, the use of different data collection methods, including primary, secondary, and tertiary data collection, served to minimize the risk of errors and avoid uninformed decisions.

Analysis was carried out as data was being collected to keep track of findings and any difference that would require follow-up. The data sample involved results from interactions with 80 participants from rural communities; and stakeholders with expertise, namely 31 respondents from the first data collection, 17 respondents from the second data collection, and 16 respondents from the third data collection. The participants were from different groups of expertise, as detailed in Figure 3-8. Once the first part of the data collection was completed, analysing the data set showed that there was enough data explaining the needs and practices of the communities; however, there were gaps in the data set that was gathered through face-to-face interviews. This was because some responses were vague and showed that some of the participants did not have a clear understanding of the subject matter. Furthermore, after analysis, questions arose requiring a better understanding of the stakeholder entities' engagement in energy use, buying, or decision-making. In addition, questions arose relating to understanding some of the existing laws and how these work, as well as views on how to address the absence of framework regulations that govern the energy sector, amongst others. All of these issues identified from analysing the first-round data set made it clear that a second data collection involving key stakeholders with expertise in the field of the study was necessary to explore the subject further with another set of stakeholders to capture in-depth responses. Likewise, a third data collection was necessary to fill in the gaps that arose from analysing the second data set and to validate the data.

The Delphi method was used as part of the analysis to evaluate the decision-makers' engagement in relevance to renewable energy, as detailed in Chapter 5. Furthermore, strategic frameworks such as PESTEL and SWOT were used for analysing renewable energy impact, as explained in Chapter 6. More insight relating to the use of these methods is provided below.

Delphi Method

Different approaches could have been used to achieve the objective of this research, including conducting in-depth semi-structured interviews with researchers in Togo to collect data for analysis; however, this approach was not taken, as few researchers had investigated issues pertaining to the energy situation and energy growth in Togo. A three-dimensional analysis framework, which has been used in many other studies (Bisaga, 2018; Jiang, Han and Zhu 2023), could also have been used in this study to explore energy needs, practices, and problems, but this research went beyond that to explore possible solutions, technology development, and industry level and time, making the three-dimensional framework not suitable for this study. Further, the nominal group technique (NGT) and the Delphi method can both be used to achieve a general agreement or convergence of opinion around a certain topic (McMillan, King and Tully 2016). They are both used for evaluating and prioritizing ideas. The NGT uses four key stages—silent generation, round robin, clarification, and voting or ranking—and has been used to explore consumer and stakeholder views, while the Delphi method is commonly used to develop guidelines with professionals (McMillan, King and Tully 2016). Carefully considering these two, it appears that the NGT requires participants to personally attend meetings, while the Delphi method can be employed via the use of different approaches, including questionnaires, making it a good choice for this study. In addition, NGT is usually used to inform less consequential decisions and can be performed quickly while relying on the knowledge of participants without the time to conduct further research (Directorpoint LLC 2023). Based on these constraints, NGT did not meet requirement for this research, as sending questionnaires to participants at some stage of this research was deemed necessary in case in-person travel was not an option. Furthermore, the Delphi method preserves participants' anonymity if required, which was key to this research and another reason for choosing this method for this study. Delphi has been used in many studies to assess the development of renewable energy, as discussed in Chapter 2.

In this research, a three-round Delphi method was used to evaluate the potential of renewable energy technologies and the impact of its development in the energy mix of Togo. The aim was to review the following key points:

- Understanding the energy situation in Togo and the reasons for its high dependence on the international market for its electricity needs.
- Reviewing awareness of renewable energy penetration, in-country skill levels, and the potential of different renewable energy sources.
- Determining the potential impact that could help renewable energy development in Togo and how best to move towards self-sufficiency.

Figure 3-7 below indicates the steps in the consultation process.

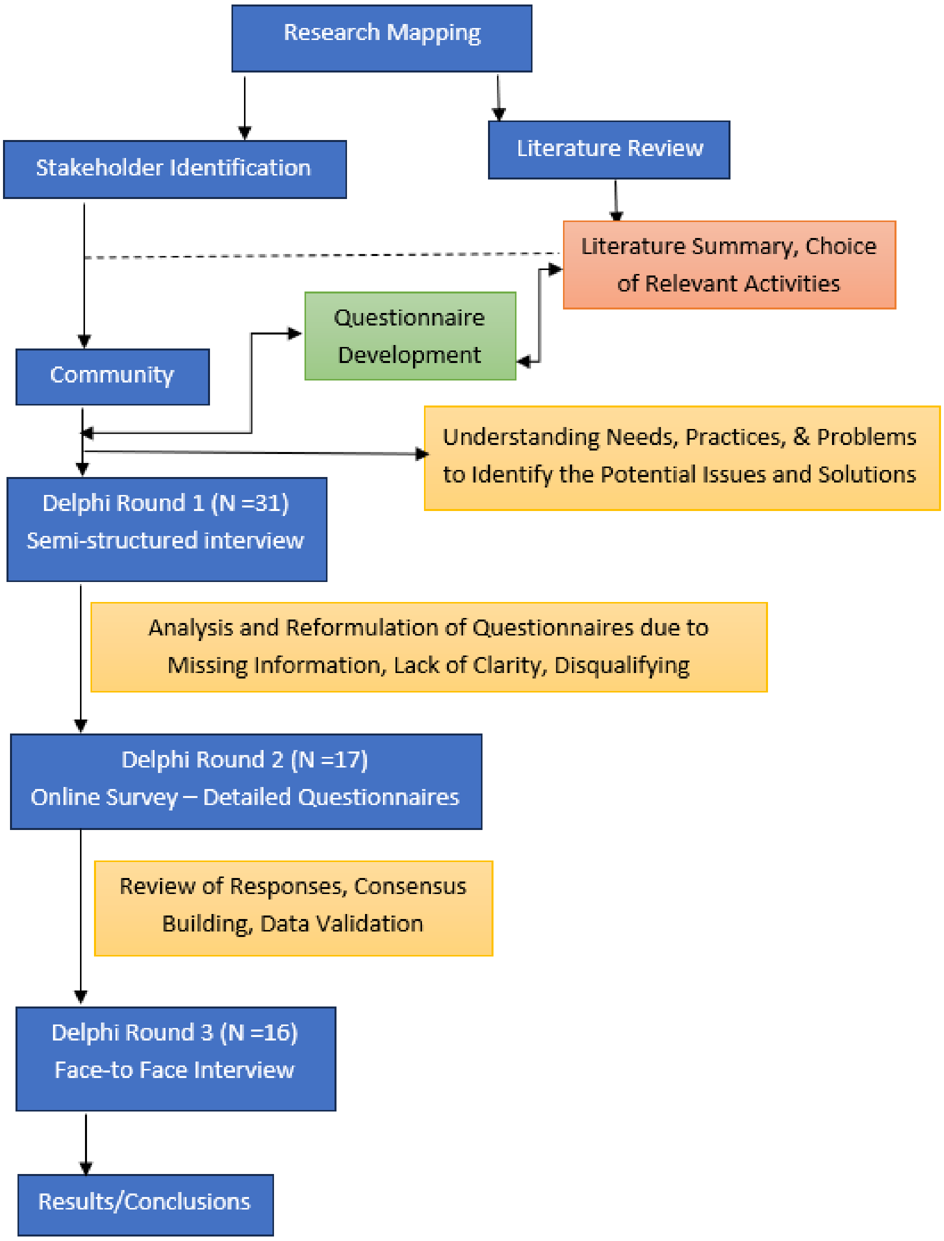

Figure 3-7: Delphi Diagram Flow Chart Indicating the Steps in the Consultation Process

Table 3-5: Participant Breakdown

Stakeholders/Expertise	First-round respondents (2015)	Second-round respondents (2018)	Data validation respondents (2020)
Private Renewable Energy organisations	6	5	4
NGOs	5	3	2
Financial organisations	3	0	2
Policymakers	9	4	3
International organisations	3	2	3
Academic institutions	5	3	2

The first and second rounds made use of questionnaires and interviews to collect data, and the third round was mainly based on interviews conducted in January 2020 with the purpose of validating answers from previous interviews. The three rounds were corelated. The first round targeted a wide range of participants, and most renewable energy experts in this round also participated in the second-round interview. The third-round interview was a subset of the second-round interview that sought to validate data collected in the first and second rounds. The time lapse between the interviews was due to a brief pause in the research, and it was deemed necessary to carry the out the third round to validate the data because there had been a few changes in the analysis and results, especially in terms of development, planning, and training.

A semi-structured interview was done during the first round using open-ended questions with 31 key participants with different expertise, as shown in Table 3-5 above. This was to get an in-depth understanding of the needs, practices, and problems. These insights formed the basis for analysis to identify the potential issues and solutions. These were based around understanding the current energy situation as well as identifying views relating to the introduction of renewable energy technologies. Questionnaires were sent to participants via email prior to the face-to-face interviews. A comparative approach was taken between the urban and rural areas of Togo to understand the current energy situation from both sides and determine how the lack of energy affects the population. This targeted a wider range of participants, including policymakers, academic institutions, financial institutions, non-governmental institutions, and private companies, as shown in Figure 3-10. Participants were selected based on their ability to provide information in their different fields of work. The results and findings are discussed below. The second-round data collection targeted experts with knowledge in renewable energy for feedback on questionnaires which were sent as an online survey (this included participants with technical, research, policy management, and political expertise). These questionnaires were formulated based on the feedback from the first data collection. A total of 17 experts completed the questionnaires, as shown in Table 3-5 above. Questions were refined with the purpose of getting in-depth information from experts and were centred around:

- Discussing the potential issues behind the gaps found after analysis of the first-round interviews, finding potential solutions and recommendations for better approaches moving forwards.
- Finding out specific details regarding the type of energy used, the power production and installed generating capacity, and what can be done to meet the Togolese government's energy vision for 2030.
- Finding out details about the successes and drawbacks of recently implemented developments in terms of renewable energy resources, existing laws that promote the use of renewable energy, the management system, and how policymakers could best address the absence of framework regulations, which was one of the key findings in the second-round interviews.
- Asking if renewable energy should be prioritized, research promoted, and diversification done in terms of renewable energy promoted.

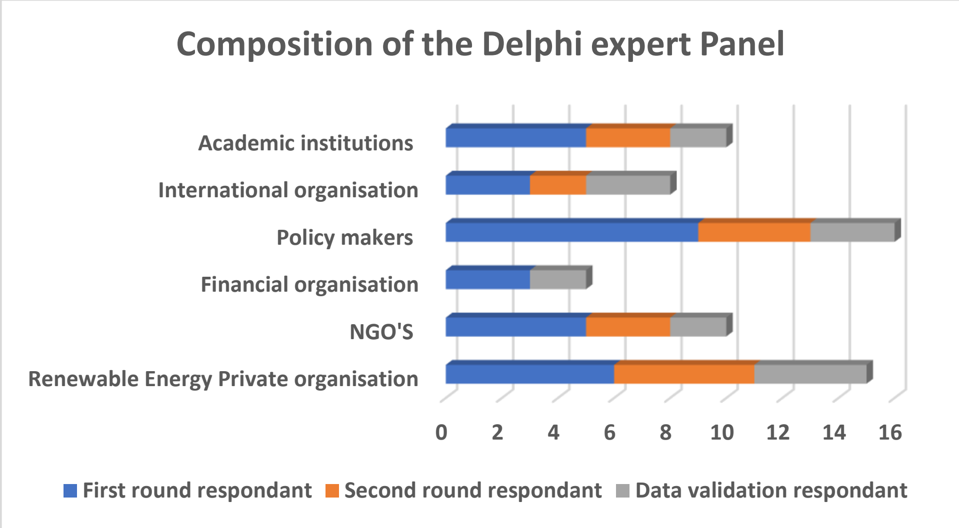

Figure 3-8: Composition of the Delphi Expert Panel

The third round was mainly focused on a face-to-face interview with the aim of cross-checking data and validating previous responses in relation to recent developments based on changes that might have occurred in the past few years. This was also a semi-structured interview that targeted experts with knowledge in renewable energy with technical, research, policy management, and political expertise, as shown in Figure 3-8 above. A total of 16 experts were interviewed. Open-ended questions were asked, allowing for a discussion with the interviewee to cross-check previous-round responses. Figure 3-9 below shows the step-by-step methodological approach undertaken using the Delphi process from research problem definition to the study report.

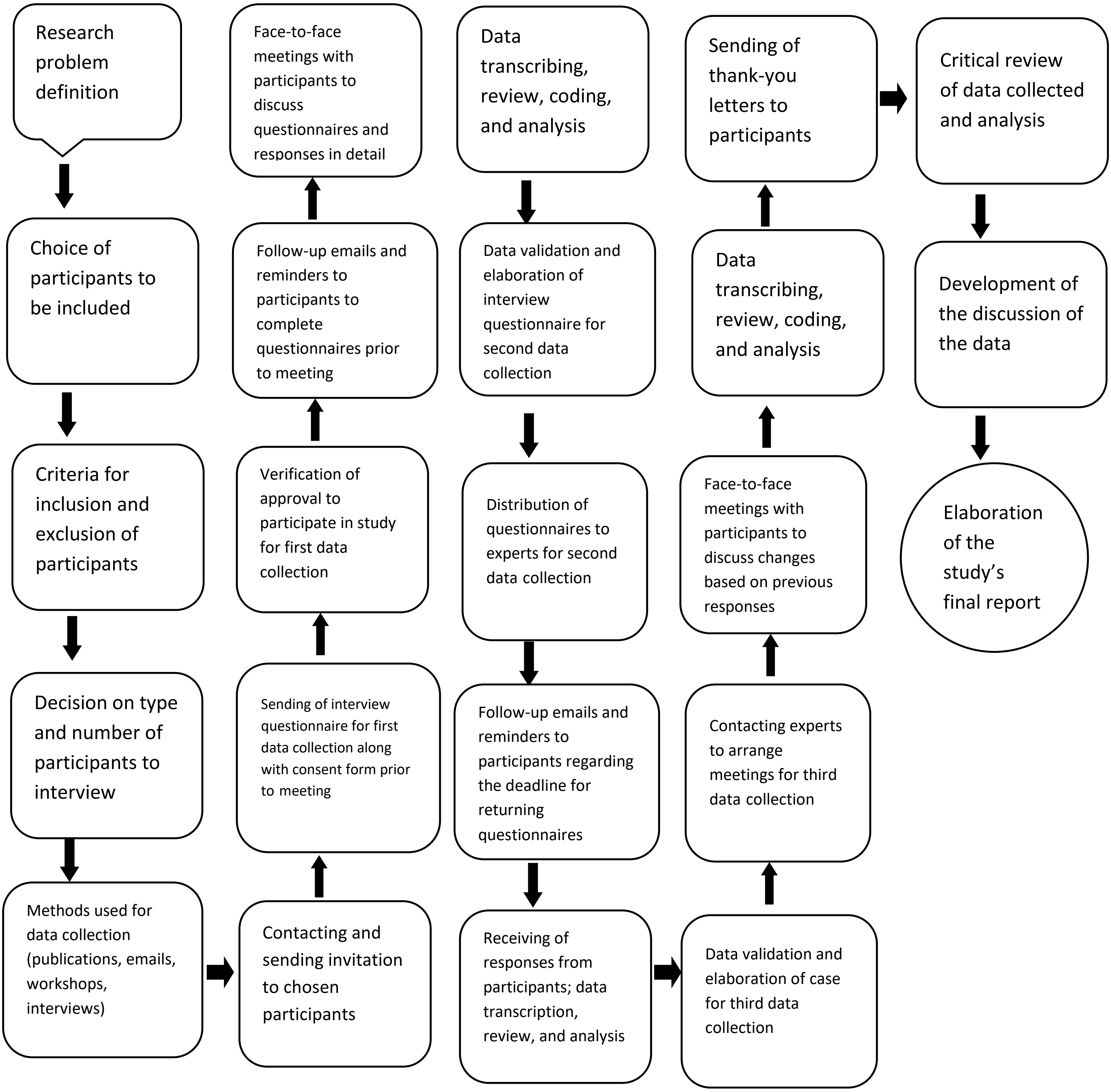

Figure 3-9: Schematic Diagram Explaining the Methodological Approach of the Delphi Process from Research Problem Definition to the Study Report

The choice of participants included in the study was based on criteria such as the ability to provide information on the current energy situation, energy technology use, impact, policies in place, functionalities, and current and future plans for renewable energy developments in Togo. Figure 3-10 shows the profile of the expert panel that took part in this study.

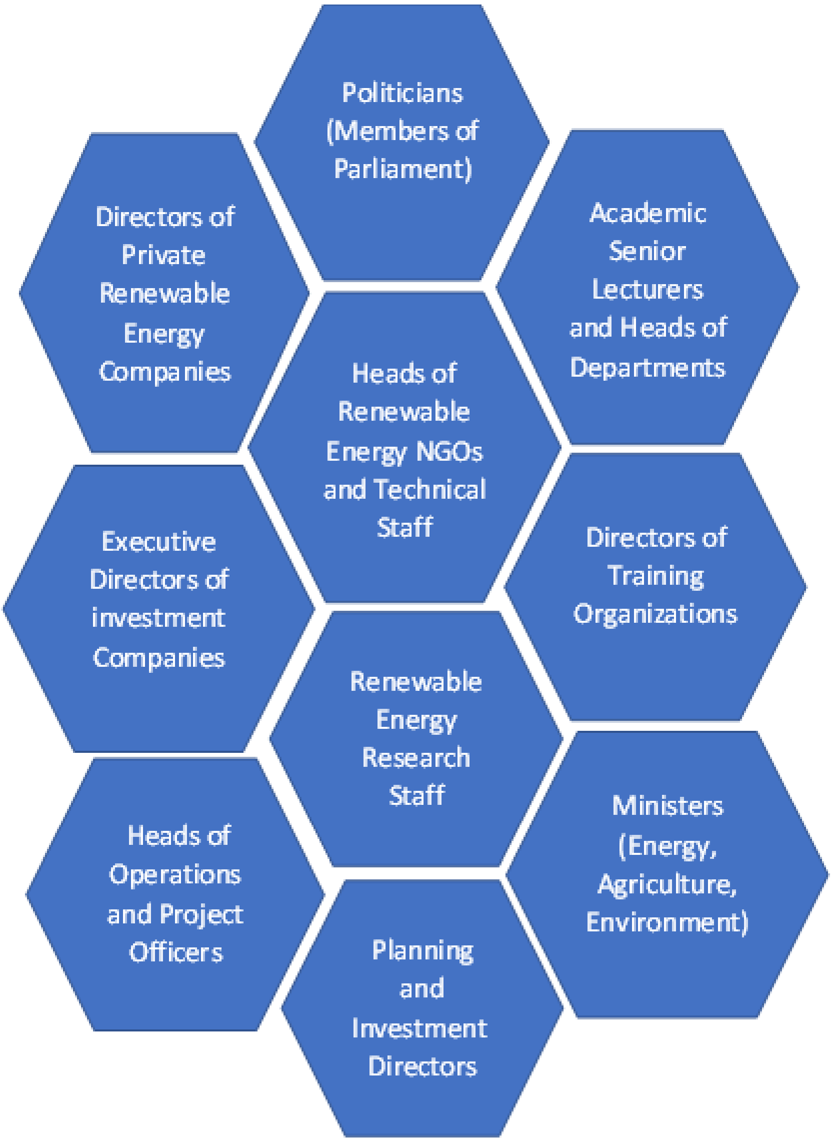

Figure 3-10: Schematic Diagram Profiling the Expert Panel's Current Roles

Use of PESTEL and SWOT Analysis as a Framework in Deriving the Impact of Renewable Energy Development

To analyse the current impact of renewable energy in Togo and to illustrate the issues facing the country as well as providing recommendations on best way to move forward, several frameworks have been considered to analyse the impact of renewable energy development, such as the Environmental Impact Assessment (EIA), International Organization for Standardization (ISO) regulations, PESTEL (political, economic, social, technological, legal, and environmental) analysis, and SWOT analysis. This research is focused on better understanding renewable energy development in Togo to analyse its impact, find new opportunities, and identify potentials threats regarding its development. Looking at the different frameworks listed, the EIA would have been most suitable if the focus of the research is based on environmental impact assessment, which is not the case here, as there are many other factors that need to be considered. ISO regulations are more about quality management standards that help work be more efficient and reduce product failures. This is a good framework that is used in energy management practices and analyses of energy efficiency and reduction of greenhouse gas emissions, amongst others. This research does not only look at quality management standards that could improve the efficiency of renewable energy products but has broader areas to consider in discussing the impact of renewable energy development in Togo. This includes economic, social, environmental, political, and technological factors. The ISO framework would not allow for an in-depth look into these various factors and thus was not the best framework to use in this research. Looking further, PESTEL is a framework used to analyse the key factors influencing an organisation from the outside and was first designed as an assessment tool of the external macro environment in which an industry or business operates (Iacovidou et al., 2017). It was found to be useful in identifying and understanding the key political parameters that are likely to affect an industry, the key environmental and economic considerations and associated societal aspects making it a good choice for this study. Moreover, it helps to identify and comprehend the technological innovations that are likely to occur, as well as the current and impending legislation that may affect the industry

(Iacovidou et al. 2017; Kralj 2009), which is useful to this study. Finally, PESTEL offers professionals insight into the external factors impacting their organisation and will help identify factors affecting Togo. It has been used in many studies to identify and overcome a variety of obstacles to development, as discussed in Chapter 2.

SWOT analysis is also used to identify strengths, weaknesses, opportunities, and threats. However, while PESTEL analysis only concentrates on external factors, SWOT analysis can look at the internal and external strengths and weaknesses that are affecting the development of renewable energy in Togo as well as broader opportunities and threats. It can be used to explore possibilities for new efforts or solutions to problems, make decisions about the best path for an initiative, determine where change is possible, and help adjust and refine plans mid-course (University of Kansas 2022). SWOT and PESTEL analyses are used to perform a systematic and thorough evaluation of a new business or project. They are decision-making tools, where PESTEL analysis helps investors to make decisions about investments and SWOT analysis supports policymakers in further development, which are key reasons for choosing them for this study. These processes give decision-makers a better awareness and understanding of the changes that may occur and the impact that these changes may have on their business (Woodruff 2019). While PESTEL analysis provides a thorough overview of the external environment in which an organisation operates, SWOT analysis identifies the internal environment of the organisation (Woodruff 2019). The combination of both in this study will help to understand what is being done well and derive a strategy for better development of renewable energy in Togo, with a positive impact on socio-economic development.

PESTEL Analysis

PESTEL analysis is used to identify strengths, weaknesses, opportunities, and threats. It looks at external factors and is primary used for market research. This research focuses on the use of renewable energy development in Togo and its impact on socio-economic development. Based on the findings of the interviews, observations, field work, workshops, and various documents discussed above, several impacts were identified, including economic, social, environmental, and technological. To better look at these in detail, a PESTEL approach was considered because it could help provide a better understanding of current external influences that affect the development of renewable energy. In addition, it could help identify factors that could change, ways to mitigate the risks, and how to take advantage of opportunities needed to remain competitive and develop a better long-term strategy for Togo. Moreover, the use of this framework will allow us to closely look at the impact of social, economic, factors, political, legal, technological, and political factors on renewable energy development and provide a comprehensive framework for addressing the sustainability challenges (Zalengera et al. 2014) facing the Togolese energy sector, making it relevant for this study.

SWOT Analysis

Just like PESTEL analysis, SWOT analysis is also used to identify strengths, weaknesses, opportunities, and threats. However, while PESTEL analysis only concentrates on the external factors, SWOT analysis will look at the internal and external strength and weakness factors that are affecting the development of renewable energy in Togo. This will help us understand what is being done well and derive a better strategy for better development of renewable energy, thereby yielding a better impact on socio-economic development. The use of the SWOT analysis in this research answers the following questions as summarised in Table 3-6 below:

Table 3-6: SWOT Analysis Matrix

Strengths	**Weaknesses**
• What is been done well in Togo in terms of renewable energy development? • What unique resources does Togo have? • What do others see as strengths?	• What are the issues, and what can be improved? • Which resources are lower compared to others? • What could be seen as weaknesses?
Opportunities	**Threats**
• What opportunities are opened to Togo? • What trends can the Togolese take advantage of? • How could the opportunities be turned into strengths?	• What are the possible threats? • What are other countries doing that could be a threat if Togo copies them blindly? • What types of threats are clearly shown?

Using the data collection method presented above, questions, observations, and documents from field work related to the impact or renewable energy development were collected. In particular, research questions RQ3.1 to RQ3.6 and RQ4 from Table 3.1 helped provide further insight into the impact of renewable energy development in Togo.

These research questions were addressed to different groups of stakeholders from rural communities, private renewable energy organisations, NGOs, financial organisations, policymakers, international organisations, and academic institutions. This was done via organizing interviews with respondents from each group of stakeholders during the first and third rounds of data collection and getting participants to complete questionnaire that were sent to them during the second round of data collection. The results are detailed in Section 5 of Chapter 5. In addition, findings from observations, field work, and workshops with rural communities and documents from field work also served as input for determining the impact. Table 3-7 below gives a detailed breakdown of the aim, methods used, and task at hand and provides framework approaches for better development.

Table 3-7: Summary of Process Used for Impact Analysis

Aim	**Methods**	**Task**	**Framework**
Outline the impact of renewable energy on the environment and socio-economic development	- Interviews - Observations - Field work - Documents from field work - Literature	- Examine social impact: By understanding local and regional settings and how people live in their society and understanding the community, identify and assess potential social impact - Economic impact: This looked more into analyzing the economic impact of renewable energy development, such as employment/job creation and increase in household revenue. - Environmental impact: This included impact on the climate and demographic impact (productivity growth, living standard)	Framework for addressing the sustainability challenges facing Togo through a PESTEL analysis approach that looks at political, economic, social, technological, environmental, and legal factors. A SWOT analysis is also used to identify internal/external strengths and weaknesses affecting the development of renewable energy in Togo.

Below is a breakdown of how the different methods listed in Table 3-6 will be used to derive the impact of renewable energy development in Togo. A framework for addressing the sustainability challenges facing Togo is provided based on the analysis. The method here is based on:

- Interviews: From the interviews, key points resulted from the responses of the participants per research questions 3.1–3.6 of the data collection interview questionnaires and RQ4. Some of these points clarified the impact renewable energy has had in Togo based on recent developments, while others indicated the potential impact renewable energy could have in Togo and provided recommendations on means of better development.

- Observations, field work, and workshops with questions based around determining available resources, production, the stages involved, the current needs, and the available skills in the communities discussed above helped in understanding the needs, practices, and problems of each chosen community. In addition, the observations on the ground based on various site visits during the first data collection showed evidence of some of the highlighted resources and issues. The analysis of these served as an informational factor in identifying the potential issues and solutions.

- Literature review: Several pieces of literature used represent the existing facts and current state (University of North Carolina Writing Center 2022; University of Arizona Global Campus Writing Center 2022) of renewable energy development in general. The literature used in this section served as guidance for learning lessons that are applicable to this research. It allowed the researcher to derive the impact or best solutions for renewable energy as well as recommendations for better development. In addition, correspondence with participants yielded further literature information, such as promotional materials, annual reports, company reports, and concept notes. Some of the field note documents are qualitative notes recorded during the research, which helped in understanding the research subject and provided answers. The other documents explained various activities and strategies some of the companies were engaging in or planning. The findings in this section are used to discuss renewable energy’s impact as well as future potentials.

4 CHAPTER 4 – FIELD STUDY ON TOGO RENEWABLE ENERGY IN RURAL AND REMOTE AREAS OF TOGO TO UNDERSTAND THE NEEDS, PRACTICES, PROBLEMS, AND POSSIBLE SOLUTIONS

4.1 Introduction

This chapter is based on field data collection to explore the need for appropriate energy delivery, placing emphasis on the role of the indigenous people in developing their future needs in a bid to better understand the needs, practices, problems, current energy situation, and possible solutions. The study stems from the fact that Togo, like most African countries, has a lot of natural resources, such as solar, wind, and hydro-electric power, required to implement a nationwide sustainable energy system—yet only 57% of Togolese have access to electricity.

This chapter looks at the energy situation in Togo, incorporating critical elements such as the identification of local energy needs, what is being done, and factors that can help with sustainable energy implementation. Based on various interactions with participants, such as farmers, fishermen, and artisans, the study results show the strong will to develop renewable energy technologies. However, there are key barriers due to inadequate framework regulations that govern the energy sector, lack of policies and strategies that encourage the use of feasible technologies, and lack of capacity development. The findings will be discussed in detail and conclusions drawn from the discussion.

4.2 Results and Discussion

This section covers the results and discussion of the work done in rural areas of Togo. Chapter 5 will discuss the engagement with stakeholders from different organisational and policy levels.

4.2.1 Data Collection Results in Rural Areas

To address the objectives, the research took into consideration the following action plans:

- Outline the current energy situation

- Identify gaps
- Identify current issues and barriers facing the energy sector
- Identify the reasons for high dependency
- Identify current stakeholders and actors within the energy sector and their key roles and functions

Several research questions were asked in a bid to find answers.

In the first phase of data collection, the following questions were addressed to find answers to the first objective **"To critically review the energy situation in Togo and outline factors resulting in high dependency on the international market"**:

- Do you have access to energy for your daily life and activities?
- Do you know what form of renewable energy is produced/generated in Togo itself?
- Who are the current actors within the energy sector in Togo?
- Could you see other forms of renewable energy being produced/generated in Togo in the future?
- Are there any issues caused by the current energy in place, such as pollution, health issues, etc.?
- In your opinion, what are the issues facing the energy sector in general?

The results for the first question, RQ1.1, ***"Do you have access to energy for your daily life and activities?''*** were as follows.

Eighty participants, starting from occupations in the communities such as indigenous farmers, fishermen, artisans, and commerce workers, as listed in Table 3-2, took part in the workshop held in five communities during the first phase of data collection. The percentage of participants per community is shown in Figure 4-1 below.

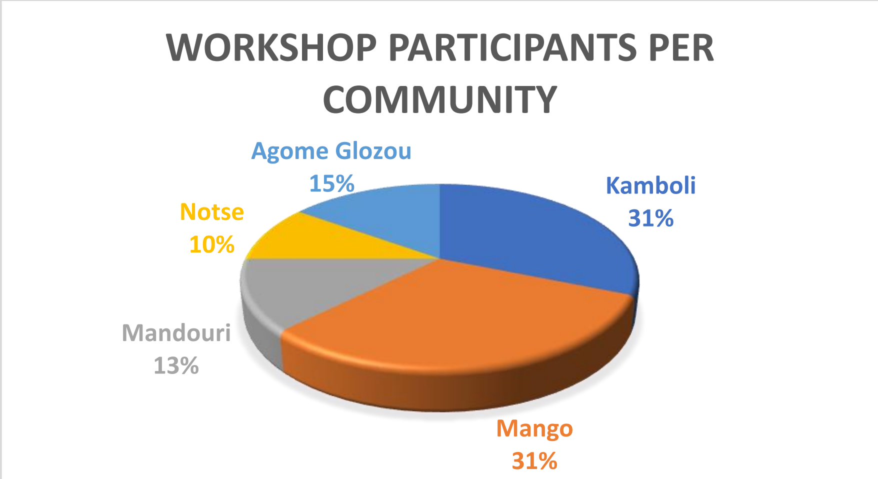

Figure 4-1: Percentage of Workshop Participants per Community

Barely 20 among the 80 participants had access to energy for their daily lives, as shown on Figure 4-2 below (mainly for electrification and to charge a few appliances). The remaining 60 stated that they used firewood and charcoal for cooking and heating purposes and relied on kerosene lamps for lighting at night. It is worth nothing that this access rate was slightly higher compared to the national average for rural communities. This is because the participants who showed up lived in the centre of the rural areas, and the rate was lower when we moved further inside each town. Most of these participants had primary education or no education at all and did not have contributions to make regarding RQ1.2 to RQ1.4 and RQ1.6. However, with regards to RQ1.5, issues caused by the current energy in place, they mentioned being exposed to smoke due to the continuous use of firewood for cooking and heating, which causes respiratory disorders and other health issues.

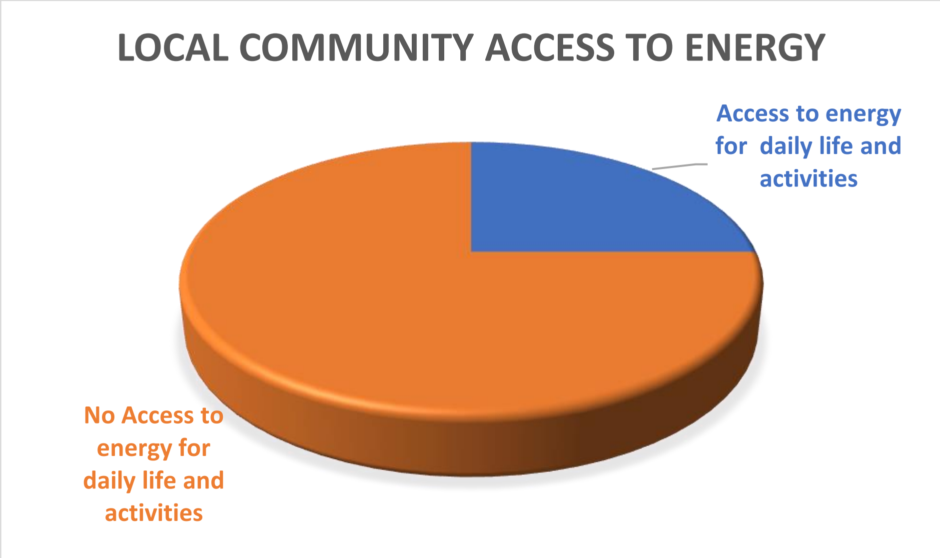

Figure 4-2: Local Community Access to Energy

Discussions with the 80 participants from WG2, WG3, WG4, WG5, and WG6 were done via workshop. Given their low education levels, questionnaires prepared for the first data collection could not be used line by line to seek answers. A general discussion was instead conducted, taking into consideration key points of the questionnaire. This was done to obtain more insight about their daily lives and use of and access of electricity and get a viewpoint from the community level to better understand the people's needs, which will help come up with better recommendations that could improve their daily lives and activities. It was difficult to separate these participants per group according to profession because each farmer was involved in many other activities at the same time, such as fishing, artisanal work, livestock, and commerce, as they sold most of their agricultural, fishing, and livestock products. The workshop discussions and results are discussed in Section 4.2.2 below.

4.2.2 Result of Field Studies, Workshops, and Observations in Rural Areas of Togo

A summary of the discussions during the field visits and the observations made is provided below.

A- Engagement with Rural Community WG2

Table 4-1 below summarises the results of the discussions. In the workshop discussions, soya beans, cashews, cassava, and tomatoes were listed as available produce in WG2. The soil is prepared and fertilised before and during the growing of the produce. At maturity, these produces are harvested, processed, stored, packaged, and distributed for sale in the market. The men are mostly engaged in the farming, while the women serve as helpers in planting the seeds as well as taking care of domestic chores, including cooking, and bringing food to the farms for the men. Once the produce is harvested, the women mostly deal with selling the produce in the market. There is a lack of equipment for storage, packaging, and distribution processes. The excess is managed, making most of the produce go to waste or get spoilt. Due to the lack of storage and processing equipment, the farmers are forced to sell most of this produce, such as tomatoes, at low prices to southern women who bring them to the south for resale at high prices. The same scenario happens for produce like soya beans and cassava, which ends up being sold at very low prices to the women that who from the south, and these women in turn either resell the produce at high prices in the south or transform it into soya oil, flour, bread, and cassava gari and tapioca for sale for more gain. There is no means to process the cashew nut; external technical assistance is needed for cashew nut oil production.

In terms of livestock products, the community farms chickens, goats, and cows. Apart from using them themselves or selling them in the market, they have no skills in terms of processing, storing, packaging, and distributing these. Finally, the community is also involved in aquaculture, where they farm fish and shrimp. Financial capital is needed for water tank or soil preparation. There are no skills in the harvesting, processing, storage, packaging, or distribution of this produce.

Table 4-1: Summary of Discussion from Face-to-Face Stakeholder Engagement with WG2

Agriculture	**Stages**	**Requirements**	
Produce		**Equipment/material**	**Skills**
Soya beans, cashews, cassava, tomatoes, corn	Soil preparation (tilling, fertiliser, etc.)	Access to fertiliser Access to water	Techniques to produce organic fertilisers, farming techniques
	Harvesting	N/A	N/A
	Processing (peeling, drying, & grinding)	Soya oil, soya flour, soya bread, cashew nut oil, cassava gari flour, cassava tapioca flour Building—bakery	Knowledge exchange from southern Togo for soya oil, flour, bread, and cassava gari and tapioka External technical assistance for cashew nut oil production
	Storage	Managing excess production	N/A
	Packaging	Retail packaging	N/A
	Distribution	Access to market	Access to market
Livestock	**Stages**	**Requirements**	
Produce		**Equipment/material**	**Skills**
Chickens, goats, cows	Site preparations (caging, farms, stocking)	Financial capital	Minimum skills
	Harvesting	N/A	Minimum skills
	Processing	N/A	Nonexistent
	Storage	N/A	Nonexistent
	Packaging	N/A	Nonexistent
	Distribution	N/A	Nonexistent
Aquaculture	**Stages**	**Requirements**	
Produce		**Equipment/material**	**Skills**
Fish and shrimp	Water tank or soil preparation	Financial capital	Nonexistent
	Harvesting	N/A	Nonexistent
	Processing	N/A	Nonexistent
	Storage	N/A	Nonexistent
	Packaging	N/A	Nonexistent
	Distribution	N/A	Nonexistent

B- Engagement with Rural Community WG3

Table 4-2 below summarises the results of the discussions.

Table 4-2: Summary of Discussion from Face-to-Face Stakeholder Engagement with WG3

Agriculture	**Stages**	**Requirements**	
Produce		**Equipment/material**	**Skills**
Rice, soya beans, tomatoes, chillies, corn	Soil preparation (tilling, fertiliser, etc.)	Access to fertiliser, access to equipment and machinery, access to water	Shortage of workers
	Harvesting (cutting, peeling, etc.)	Access to equipment and machinery, waste straw handling	Shortage of workers
	Processing (drying & grinding)	Access to equipment and machinery	Shortage of workers Technical skills
	Storage	N/A	N/A
	Packaging	N/A	N/A
	Distribution	Access to market	Access to market
Livestock	**Stages**	**Requirements**	
Produce		**Equipment/material**	**Skills**
Chickens, goats, cows	Site preparation	Financial capital	Minimum skills
	Harvesting	N/A	Minimum skills
	Processing	N/A	Nonexistent
	Storage	N/A	Nonexistent
	Packaging	N/A	Nonexistent
	Distribution	N/A	Nonexistent
Aquaculture	**Stages**	**Requirements**	
Produce		**Equipment/material**	**Skills**
Fish (and potential others, e.g., shrimp)	Waterbed preparation	Financial capital Dam management	Nonexistent
	Harvesting	N/A	Nonexistent
	Processing	N/A	Nonexistent
	Storage	N/A	Nonexistent
	Packaging	N/A	Nonexistent
	Distribution	N/A	Nonexistent

Based on the responses, the main agriculture produce is rice, corn, soya beans, tomatoes, and chillies. Some farmers make use of cows to help with farming. Harvesting, such as cutting and peeling, and processing, such as drying and grinding, are done manually, and access to equipment and machinery is needed. The responses indicated that there is a lot of available soil, but there is a shortage of workers. Storage and packaging are difficult because the farmers have no means to store a lot of produce and are forced to sell most of their produce in the market as soon as possible. Most of the corn produced is used for cooking in their households. The livestock's produce includes chickens, cows, and goats. Minimum skill sets exist in handling and managing them. There are no skills for processing, storing, packaging, and distributing these. About 25% of the produce is consumed domestically and 80% is commercialised in the market. Finally, the community is also involved in aquaculture, where they grow fish and shrimp. Financial capital is needed for water tank or soil preparation. There are no skills in the harvesting, processing, storage, packaging, and distribution of this produce. The participants mentioned that aquaculture was very developed because of the Oti River, which is one of the biggest in the country at about 520 km (323 mi) long; 20% of the fish caught are used in the household, and 80% are sold in the market and the street.

C- Engagement with Rural Community WG4

The summary of the data gathered is shown in Table 3-6 below. The communities have similar needs, resources, and activities. They have one rainy season and after harvesting are forced to sell their produce at very cheap prices due to the lack of transformation, processing, and storage units. This results in famine throughout the region as the communities run out of food due to the long wait before the next rainy season. The rainy season in the north usually starts in April and last through early September. The dry/windy season, called harmattan, lasts from September to March. This differs from the south, where there are two rainy seasons—the first one from March to June and the second one from September to November. This helps them farm twice a year, thus offering an advantage for the communities in the south. It has been observed that climate change has affected the seasons in Togo. The rainy season in the north for the year 2021, for example, did not start until mid-June and ended in August, while the south has experienced a slightly prolonged second rainy season.

The communities have a high proportion of young people. Due to the lack of electricity and leisure centres, the farmers in general have limited entertainment activities in the evening and usually have a high birth rate. Most of their children are used as a workforce to help their parents with farming activities. The lack of electricity also does not help women run their commerce at night. They are forced to stop activities early, and this does not help the economic situation of the communities either. In the discussions, most of the communities indicated a need for irrigation, food processing/transformation units, capacity building, leisure centres, and healthcare facilities.

Table 4-3: Summary of Questionnaire Responses from WG4 and Its Surrounding Villages

City/village number	Resources	Site location	Need	Skills required
1 (2,412 inhabitants)	River: Tcham and Kigbenaon 4 manual water pumps **Main activities:** agriculture, vet, commerce **Conservation:** drying, smoking	Kegbenaon and Tcham river USP Kolina	Irrigation for agriculture Processing and storage Refrigeration/cooling system for food conservation and storage Leisure centre Adding value to agriculture produce for commercialisation Grinding and food processing system, lab	Training capacity building
2 (15,512 inhabitants)	2 water pumps that use solar 4 manual water pumps **Main activities:** agriculture, vet, commerce, artisan **Conservation:** drying, smoking	Adjaga (100 people) Mandouri	Provide irrigation for agriculture over 1,000 ha Transformation/processing unit Refrigeration system for hospital Hospital equipment Have 4 transformation units for rice and soya Leisure centre	Training and skills development Need for more schools and staff
3 (4,036 inhabitants)	River: Djandjandjal 1 manual water pump **Main activities:** agriculture, vet, commerce, artisan **Conservation:** drying, smoking	Gnale	Refrigeration/cooling system Maternity hospital Lighting for 6 classes Grinding system for rice and maize Tomato transformation system Rice production	Polytechnic
4 (2,839 inhabitants)	River: Tikpiligou and Kpendjal 1 manual water pump **Main activities:** agriculture, vet, commerce, artisan **Conservation:** drying, smoking	Kontenga	Develop the river areas of 246 ha Medical centre Maternity centre Refrigeration system Food processing/transformation for rice, yam, and maize A dam to store water Aquaculture	Need for more schools
City/Village	**Resources**	**Site location**	**Need**	**Skills required**
5 (6,732 inhabitants)	River: Tikpiligou Dam: Bagtchana	Bagre	Agriculture for rice over 152 ha Transformation system	Polytechnic

	1 manual water pump 1 solar water pump **Main activities:** agriculture, vet, commerce, artisan **Conservation:** drying, smoking		Refrigeration system Midwifery (hospital staff) Pharmacy Grinding system Aquaculture	Training centre
6 (1,500 inhabitants)	River: Kpendjal 1 manual water pump **Main activities:** agriculture, vet, commerce, artisan, fishing **Conservation:** drying, smoking	Donga	Irrigation system Hospital Refrigeration system School lighting IT for secondary schools Transformation system Leisure centre	Polytechnic
7 (4,575 inhabitants)	River: Kpendjal 3 manual water pumps **Main activities:** agriculture, vet, commerce, artisan, fishing **Conservation:** drying, smoking	Tambigou	Irrigation to help with rice farming over 18 ha Health centre Transformation system, storage units, cooling system to store fish Aquaculture Potable water	Need more classrooms, schools
8 (24,324 inhabitants)	River: Sansargou 4 solar water pumps **Main activities:** agriculture, vet, commerce, artisan, **Conservation:** drying, smoking	Borgou	Irrigation to help with rice farming over 120 ha Refrigeration system for vaccine Transformation system, grinding, storage units	IT system
9 (11,711 inhabitants)	**Main activities:** agriculture, vet, commerce **Conservation:** drying, smoking	Sanloaga	Irrigation to help with rice farming over 50 ha Health centre, staff, and equipment Transformation system, grinding, storage units	Polytechnic

D- Engagement with Rural Community WG5

The existing rivers are Mono and Aloe, and the main activities include agriculture, vet, commerce, artisan, and fishing. The highlighted needs were health centres, sport centres, and social centres. Rice is cultivated in the region, and the community also showed the need to develop the market as well as the agriculture sector. The community also showed the need for schools and skilled staff. Figure 4-3below shows engagement with the youth in WG5.

Figure 4-3: Engagement with the Youth in WG5

As part of the WG5 visit located in a rural area of southern Togo, observations were made. Figures 4-4 and 4-5 show photos of broken-down equipment taken during this field visit. The water pumps and tractors shown below were equipment from EU financial aid to support the local community. According to most of the engaged community, these only worked for a short period of time and are now left unused at the site. If proper sustainability planning was done before implementation, issues like hurried application of inappropriate technology, which end up leaving behind disused equipment, would have been avoided.

Figure 4-4: Broken-Down Water Pumps Supplied by a Previous Project in Southern Togo

Figure 4-5: Disused Tractors on Irrigation Project Site in Southern Togo

E- Engagement with Rural Community WG6

According to the youth, solar streetlamps have helped students in WG6 make use of the light for study. Other benefits include helping women sell their products in the evenings without having to close their shop too early at sunset. This has allowed them to stay open for longer periods, thereby achieving better sales, leading to an increase in income. Most of the soil in WG6 is very rich, and most of the community farms a lot of produce, including maize, yam, tomatoes, avocadoes, oranges, bananas, and cassava. A lot of migrants come from the north to WG6 due to the advantages of the season, the soil, and better living conditions.

F- Observations in Rural Community WG7

Based on observations made in WG7 and questionnaire responses from some of the participants, the main sources of income are from craft manufacturing, trade, livestock, and agriculture. The principal rainfed crops grown include maize, sorghum, millet, jatropha, and tomatoes. These are mainly for subsistence. Cotton is also cultivated and is mainly for sale. Cultivation of tomatoes has increased since the year 2000, and a significant amount of the production is exported to Lomé. Most of the city is electrified by the Akosombo Dam, but there are lot of problems in water sanitation and public health. The community benefits from one rainy season as well and faces the same issue as other communities of having to sell its produce at cheap prices due to the lack of transformation, processing, and storage units. This results in famine as the community runs out of food due to the long wait before the next rainy season. The community indicated a need for irrigation, food processing/transformation units, capacity building, and healthcare facilities.

4.2.3 Discussion Based on Rural Community Workshops and Observations

Based on discussions held with five rural communities and observations from six rural communities, it was found that there is a lot of produce from agriculture, livestock, and aquaculture; however, storage is an issue, and processing and transformation skills are lacking, leading to the selling of agriculture, livestock, and aquaculture produce at exceptionally low prices. As seen from Tables 4-1, 4-2, and 4-3 above, many of the difficulties highlighted by agricultural communities are consistent in each area, though the prioritisation of addressing these difficulties varies from community to community. There is a substantial opportunity for renewable energy, particularly solar PV, to provide an important bridge in enabling north Togo's agricultural communities to build a brighter economic future for themselves. All communities spoke of the need for processing, storage, and marketing of crops, coincident regional surpluses leading to poor prices being obtained for crops, lack of micro-financing for initiating new ventures, and the need for irrigation to extend the growing season. Many North Togolese farmers face significant challenges in accessing existing markets in Lomé, whilst limited options for obtaining financing for fertilisers force rice growers in Mango to effectively grow their crops for no cash value. As an example, due to poor access to commercially viable transport, north Togo has excess tomato production needing market uptake, whilst on the other hand, lorries of tomatoes from Burkina Faso are being driven to Lomé past Togo's own tomato suppliers. Should there be a means of processing and storing these in north Togo, it would benefit the communities in the north and improve their economy and living conditions.

The study also identified that those most affected by the lack of energy are living in rural areas of Togo, especially in the northern region, with no access to the electricity grid, as shown in Table 4-4 below and lack access to basic services as discussed in chapter 2 (CEET 2017; CEET 2018; CEET 2019**;** CEET 2020; CEET 2021; World Bank 2021). This lack of resources leaves the youth with no other choice than to migrate to urban areas in search of employment, education, or better living standards, which results in urban areas being overpopulated. Resolving this lack of resources could stop the youth migration and help them engage in productive activities or small-scale businesses in their communities. This is supported in Kirubi et al. (2009), who found that access to electricity in Kenya extended the operating hours of businesses and allowed longer hours for households to produce handmade goods. It also allowed small and micro-enterprises to use electrical equipment and tools. This boosted productivity by 100% to 200%, depending on the task at hand, with a corresponding growth in income levels on the order of 20–70%, depending on the product made. Access to electricity simultaneously enables and improves the delivery of social and business services from a wide range of village-level infrastructure (e.g., schools, markets, and water pumps) while improving the productivity of agricultural activities (Kirubi et al. 2009).

Table 4-4: Rate of Access to Electricity by Region (CEET 2017; CEET 2018; CEET 2019; CEET 2020; CEET 2021)

Region	Population 2021	Area (km^2)	Rate of Access to Electricity in Percentage (%)							
			2014	2015	2016	2017	2018	2019	2020	2021
Maritime Lomé	1,766,585	120	80.46	85.94	92.47	91.40	98.37	94.77	96.70	98.55
Rest of Maritime	1,766,420	5,980	14.81	17.50	19.76	23.52	44.86	64.00	65.52	73.89
Plateaux	1,718,550	16,975	11.47	12.72	14.46	14.61	19.10	22.30	23.84	27.64
Central	776,310	13,317	14.85	17.32	18.36	19.26	24.69	28.51	31.61	35.95
Kara	983,813	11,738	17.55	18.92	20.29	22.16	27.49	31.33	33.91	36.65
Savanes	1,052,231	8,470	8.91	10.46	11.20	12.22	16.08	18.11	20.09	22.39
Grand Total	8,063,908	56,600	30.27	33.03	35.81	38.07	45.09	50.30	53	57.82

Table 4-5 below shows a summary of the resources, activities, and requirements based on the data gathered from the north.

Table 4-5: Summary of Data Collected from the Workshops

Location	Available resources for energy generation	Activities/ businesses	Requirements for energy use
WG4	Many medium-size rivers (Kpendjal, Ouale, and Sansargou) Abundant solar radiation Biomass	Agriculture, livestock, commerce, fishery, and artisan	Transformation/processing units, refrigeration/cooling systems for food conservation and storage and vaccine storage, grinding systems, irrigation for agriculture, potable water, aquaculture, school lightning, leisure centers
WG3	Oti River of length 520 km passes through Mango Solar radiation Biomass	Agriculture, livestock, commerce, fishery	Refrigeration systems; peeling, drying, and grinding systems; irrigation for agriculture; aquaculture; processing; storage systems; potable water supply
WG2	Mono River Abundant solar radiation Biomass	Agriculture, livestock, commerce, fishery	Transformation/processing units, refrigeration system, irrigation for agriculture, aquaculture, processing, storage systems, potable water supply

From the results, subsistence farming and commerce are the main economic activities for the majority of the population who live in rural areas of the north and the south. A clear rural energy gap in the agriculture sector exists and needs to be bridged to increase economic development. The introduction of renewable energy in several countries has had a broad range of positive effects on all areas of society, such as education, health, small- and large-scale business, households, and agriculture, as shown in Chapter 2. Moreover, if its use is found to be feasible, it could create a more viable natural environment and therefore lower risks to human health. The important social benefit of rural energy development is its ability to create employment and therefore provide income for rural households (Kemausuor, Bolwig and Miller 2016). As an example, Ahmed and Fernando's (2017) research revealed that significant implications for improving household incomes as well as food and nutrition security were achieved for agricultural groups with the use of solar-powered drip irrigation systems in rural Benin.

Based on the results presented above, proposed examples of mitigation actions are provided in Tables 4-6 and 4-7 below for WG2 and WG3, respectively. The lessons from one site can easily be transferred to other sites.

Table 4-6: Summary of Potential Mitigation Measures for Issues Identified in WG2

Agriculture	**Stages**	**Mitigation measures**		
Produce		**Equipment/material**	**Skills**	**Energy**
Soya beans, cashew, cassava, tomatoes	Soil preparation (tilling, fertiliser, etc.)	Utilising local organic resources Basic soil testing kit Mechanical tilling and ploughing (human–animal-powered) Irrigation/pumping equipment (water from boreholes using renewable energy sources/water from river barrage?)	Technical—organic farming Technical—basic soil analysis Technical—machinery setup and maintenance for soil preparation and irrigation	Renewable energy generation for irrigation and pumping
	Harvesting	Mechanical cutting etc (human – animal powered)	Technical—organic farming	N/A
	Processing (peeling, drying, & grinding)	Mechanical peeling, drying, & grinding etc (renewable energy driven)	Process design management—timing, moisture levels Technical—machinery setup and maintenance	Renewable energy generation Refrigeration systems and cooling Energy efficiency Energy conservation
	Storage	Better storage structure and refrigeration system		
	Packaging	Package design Handling requirement (stacking, palleting, etc.)		
	Distribution	Policy strategy Corrected market Market identification Micro-financing Functioning cooperative units	External support in building: Management skills Business skills Marketing skills Legal skills	Transport fuel—sources Energy generation for refrigeration
Livestock	**Stages**	**Mitigation measures**		
Produce		**Equipment/material**	**Skills**	**Energy**

Chickens, goats, cows	Site preparation	Communal feeding and health checking	Livestock breeding and selection Manure management	N/A
	Harvesting	N/A	N/A	N/A
	Processing	N/A	N/A	N/A
	Storage	N/A	N/A	N/A
	Packaging	N/A	N/A	N/A
	Distribution	Local market	N/A	N/A
Aquaculture	**Stages**	**Mitigation measures**		
Produce		**Equipment/material**	**Skills**	**Energy**
Fish	Waterbed preparation	Stocking cages for fish fry, access to pontoons, monitoring equipment, flood, and sediment control	Aquaculture management	N/A
	Harvesting	Nets	N/A	N/A
	Processing	N/A	N/A	N/A
	Storage	Refrigeration	Equipment maintenance	Solar-powered refrigeration
	Packaging	N/A	N/A	N/A
	Distribution	Local market	N/A	N/A

Table 4-7: Potential Mitigation Measures for Issues Identified in WG3

Agriculture	**Stages**	**Mitigation measures**		
Produce		**Equipment/material**	**Skills**	**Energy**
Rice, soya beans, tomatoes, chillies	Soil preparation (tilling, fertiliser, etc.)	Utilising local organic resources Basic soil testing kit Mechanical tilling and ploughing (human–animal-powered) Irrigation/pumping equipment (water from river using renewable energy sources)	Technical—organic farming Technical—basic soil analysis Technical—machinery setup and maintenance for soil preparation and irrigation	Renewable energy generation
	Harvesting	Mechanical cutting, etc. (human–animal-powered)	Technical—organic farming	N/A
	Processing (peeling, drying, and grinding)	Mechanical peeling, drying, grinding, etc. (renewable energy-driven)	Process design management—timing, moisture levels	Renewable energy generation for

			Technical—machinery setup and maintenance	refrigeration and cooling Energy efficiency Energy conservation
	Storage	Storage structure Refrigeration		
	Packaging	Package design Handling requirement (stacking, palleting, etc.)		
	Distribution	Refrigeration system Policy strategy Corrected market Market identification Micro-financing Functioning cooperative units	External support in building: Management skills Business skills Marketing skills Legal skills	Transport fuel—sources Costs (real and variable) Renewable energy generation for refrigeration
Livestock	**Stages**	**Mitigation measures**		
Produce		**Equipment/material**	**Skills**	**Energy**
Chickens, goats, cows	Site preparation	Communal feeding and health checking	Livestock breeding and selection Manure management	N/A
	Harvesting	N/A	N/A	N/A
	Processing	N/A	N/A	N/A
	Storage	N/A	N/A	N/A
	Packaging	N/A	N/A	N/A
	Distribution	Local market	N/A	N/A
Aquaculture	**Stages**	**Mitigation measures**		
Produce		**Equipment/material**	**Skills**	**Energy**
Fish (and potential others, e.g., shrimp)	Waterbed preparation	Stocking cages for fish fry, access to pontoons, monitoring equipment, flood, and sediment control	Aquaculture management	N/A
	Harvesting	Nets	N/A	N/A
	Processing	N/A	N/A	N/A
	Storage	Refrigeration	Equipment maintenance	Solar-powered refrigeration
	Packaging	N/A	N/A	N/A
	Distribution	Local market	N/A	N/A

Figure 4-6 below also indicates the complementary overlap among WG4, WG3, and WG2 and the contribution that they could make to the overall picture of agriculture in north Togo.

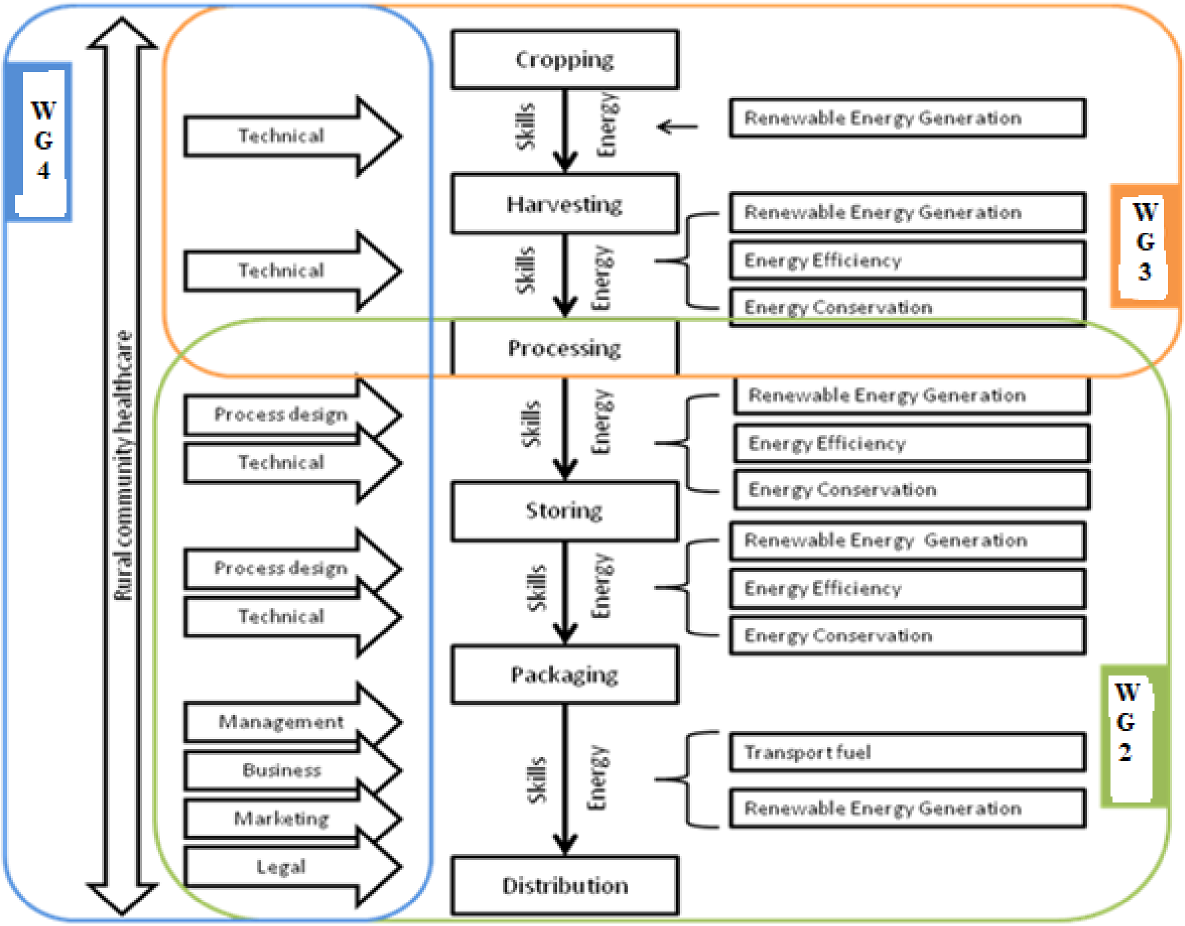

Figure 4-6: Site Interface Diagram, Indicating the Complementary Overlap Among WG2, WG3, and WG4 and the Contribution That They Could Make to the Overall Picture of Agriculture in North Togo

There is a direct need for water supply and energy provision for agricultural practices. Some areas of development require technical and policy/strategy intervention at a broader scale. Some suggestions for discussion with relevant decision-makers could include the establishment of locally managed cooperatives which function to provide:

- Access to healthy markets and finance availability for small village producers

- Transportation assistance for ease of distribution in collecting farming produce

As a matter of fact, assuming renewable energy technologies are developed allowing storage, processing units, and transformation units or even irrigation systems with solar water pumps, for instance, this could improve energy access in Togo and could add value to the production of existing crops, such as soya beans, cashew nuts, cassava, and tomatoes. This could help the agricultural sector and improve the living standards of these societies. Putting in place a solar-powered value-added crop processing unit could help farmers grow, process, and store more agricultural products in all seasons of the year, thus reducing poverty as shown in other research. For example, Reza and Sarkar (2015) implemented the idea of solar irrigation in real practice and showed the economic and technical viability of a directly coupled solar photovoltaic irrigation pump system operating in Gaibandha, Bangladesh. Furthermore, Singh, Jha and Nandwana (2012) also developed a solar-powered pump controller, using a fuzzy logic control strategy to feed water for cultivation. This was tested with the growth of vegetables like tomato plants and resulted in savings of 50–60% in water consumption as well as the cost of energy generation (Singh, Jha and Nandwana 2012).

The data also showed that the north of Togo has rivers which could potentially be used with solar-powered plants to develop irrigation. With the use of simple components such as a converter, transformer, pump, and battery, solar pumps could be integrated into a solar irrigation system designed for specific local needs to help agriculture. An example layout of a solar PV irrigation system is shown in Figure 4-7 below:

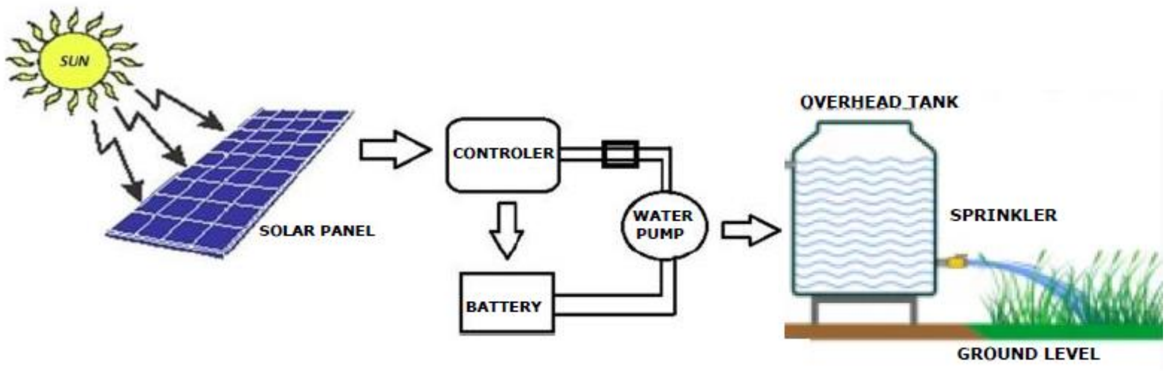

Figure 4-7: Layout of a Solar PV Irrigation System (Adopted and Modified from Kumar et al. 2020)

These solar water pumps could enable people to move water from its remote source to where they need it, without access to power lines. Solar pumping has three primary uses: domestic use for washing, cooking, and drinking, livestock watering, and irrigation (Beaudet 2016).

In addition, healthcare has been highlighted by the people as a much-needed area of support, and the availability of healthcare within the agricultural communities is a critical factor in their successful development. The installation of solar panels in hospitals could also help store vaccines and drugs and improve access to vaccines, anti-venom, etc., thus increasing availability in these localities and saving lives. It was also suggested that the use of renewable energy could improve health issues because it would help reduce the use of firewood, thereby decreasing the amount of smoke, which could lead to a reduction in respiratory diseases.

Other potential impacts based on the findings include improved water availability for rice production and improved drinking water quality for the village to support full utilization of the land area available. The technical capabilities of the rice growing cooperative can also be enhanced to include management of a solar-powered irrigation system.

Furthermore, the construction of a traditionally built and locally resourced base structure (including the use of renewable energy power) providing accommodation and leisure facilities for tourism could increase local employment, establish stronger retail for hotel need supplies, and highlight Togo’s importance in wildlife conservation. Additionally, local capacities could be built up in process design and management to significantly enhance the business case for these crops (example rice, etc., listed above).

The design and construction of a multifunctional dam for managing the water supply and providing a suitable facility for fish production could be helpful in developing the assets of this city. Furthermore, building on local capabilities will enhance irrigation and aquaculture management.

From the above results, the study shows that the development of renewable energy in Togo will be beneficial to the communities in many ways. Its growth will not only help improve health issues and reduce pollution affecting the communities but will also provide a clean environment and help with socio-economic development that is much needed. This could be a game-changer that improves the living condition of the people, contributes to regional development, and boosts national economy development. The viewpoints in relevance to renewable energy development based on policy makers and stakeholders with various expertise are discussed in the next chapter.

5 CHAPTER 5 – EVALUATION OF THE DECISION-MAKERS' ENGAGEMENT IN RELEVANCE TO RENEWABLE ENERGY

This chapter presents the viewpoints of stakeholders from private renewable energy organisations, NGOs, financial organisations, policymakers, international organisations, and academic institutions in relation to the current energy situation in Togo while accounting for the planned development actions to increase energy access using renewable energy. In this chapter, the researcher engages with stakeholders with more knowledge in renewable energy who contribute to decision-making, whether financially, politically, or with their expertise. The reason for this engagement is to incorporate a bottom-up approach into this research that considers the integration of the community with policymakers to capture all views in the analysis as well as encouraging cross-sector cooperation. The discussions with rural community members helped identify the available resources, types of activities or businesses, and existing energy needs, which will help in determining possible solutions and recommendations that will best suit the needs of the people. However, this would be inefficient without also talking to the policymakers to find out what their stake is, what could be done, what is available, what is needed, and ways to achieve the required results. This chapter is deemed necessary to provide directions on how to proceed to achieve the best results. To achieve the best results, the research uses an innovative system shown in Figure 5-1 below that incorporates social, technical, economic, policy, political, and environmental factors and the application of appropriate technology.

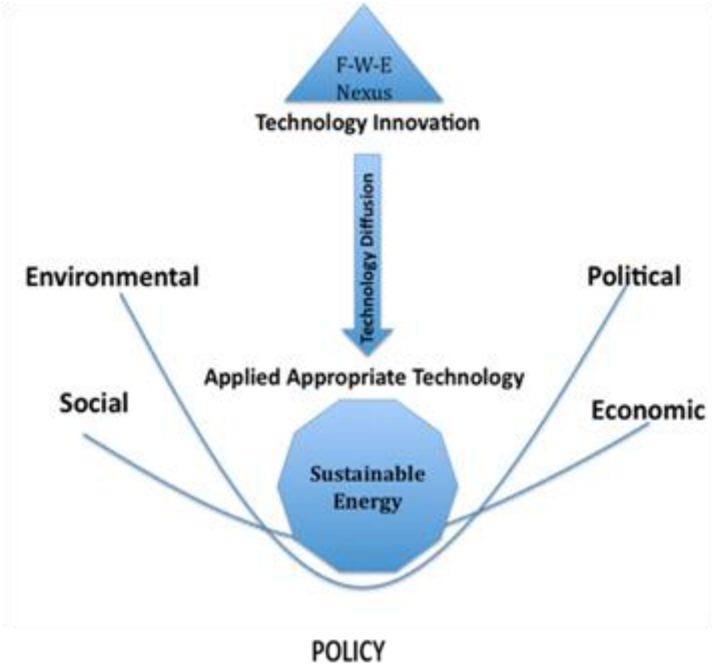

Figure 5-1: Sustainable Energy Innovation System Source: Kruijsen et al. (2012). F-W-E: Food-Water-Energy.

The Delphi method is used to analyze the possibilities, barriers, and solutions for energy growth, and the experts are drawn from policymakers, academic institutions, financial institutions, non-governmental institutions, and private companies. By using this method, the chapter's aim is to carry out an assessment of renewable energy development in the energy mix of Togo, highlighting the current energy situation and actions planned for development to increase energy access in Togo. The results of this research could assist policymakers in decision-making on renewable energy technologies regarding the most suitable sources to develop to improve economic growth and enhance the energy mix to reduce dependence on fossil fuel in Togo. Renewable energy in this context refers to solar, hydropower, wind, tidal, wave, and geothermal energy. In general, the number of iterations of the Delphi questionnaire can range from two to five, where each subsequent questionnaire is developed based on the responses from the previous questionnaire round. In this chapter, the work presents and discusses stakeholders' viewpoints based on three phases of field work undertaken.

Specifically, three interview exercises were conducted in Togo with experts in energy systems, academic institutions, policymakers, and financial organisations. The approach used for this study, including the Delphi method and the expert panel that took part in the study, are presented in Chapter 3. The study results and main findings are discussed in this chapter.

The results show that raising the renewable energy business share in Togo through accelerated access to small-scale solar PV and hydropower is the most feasible route for electrification. To date, few adopted rules and regulations exist within the energy sector, and few incentive measures in taxation exist that favour companies with public interest. The study shows the need to prioritize renewable energy based on socio-economic and environmental rationale while promoting its diversification for better suitability depending on the location, greater access, and reliability. The research suggests that if these practices are taken into consideration, it will significantly boost agricultural and small business. The monopoly and non-liberalization of the energy sector and lack of trained workforce were identified as the main inhibitors of private investment. The study recommends the optimization of the system for better performance, creating local manufacturing plants to promote national production of solar system components along the assembly lines.

5.1 Results

This section discusses the engagement with stakeholders from different organisational and policy levels. The interviews and questionnaires in all rounds targeted keys stakeholders with knowledge in the energy field. Figure 5-2 below shows the percentage of participants per expertise for the first-round data collection. As detailed in the figure, 19% of the 31 participants worked with private renewable energy companies; 16% worked with non-governmental organisations; 10% worked with financial institutions with the capability of financing projects; 29% were policymakers, including personnel from CEET, Ministries (Energy, Agriculture, Environment), and members of Parliament; 10% worked with international organisations; and the remaining 16% worked with academic institutions such as universities.

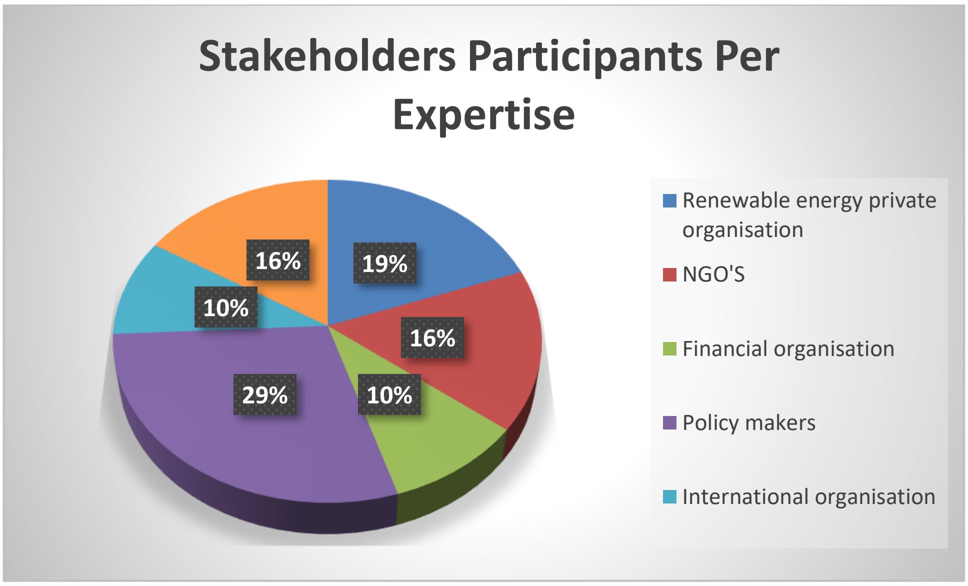

Figure 5-2: Stakeholder Participants per Expertise

The participants included various demographics. In all, only two participants were female, and the remaining 29 were male. This was not deliberate but purely because there were more males occupying posts with knowledge in renewable energy. In addition, women were mostly considered housewives, and for many years, some families were not sending women to school, leading to fewer women found in posts, especially for professional work. This has caused a big gap leading to gender inequality in the overall workforce in Togo that could potentially affect the findings of this research. In addition, there were 16 respondents between 29 and 39 years old and 15 respondents between 40 and 60 years old, as shown in Table 5-1 below. However, there were no discernible differences in the type of responses according to age. More of the gender and age implications of this study are discussed in Section 5.5. In terms of the level of education, only five of the participants had a technical level of education, and 26 had at least a tertiary level of education. The employment status of the respondents included public-sector (9), private organisation (12), NGO (5), academia (4), and retired (1). Finally, the questionnaire incorporated questions regarding the number of years the respondents had spent in the community, 5 or fewer years to more than 20 years.

Most participants had lived in their specific community for 6 years or longer, as shown in Table 5-1 below.

Table 5-1: Summary of Demographic Data for the First Data Collection

Expertise	Gender		Age Group		Level of Education		Employment Status					Number of Years in the Community				
	Male	**Female**	**25–39**	**40–60**	**Technical**	**Tertiary**	**Public**	**Retired**	**Private**	**Academia**	**NGO**	**≤5**	**6–10**	**11–15**	**16–20**	**>20**
Private Renewable Energy Organisations	6	0	5	1	2	4	0	0	6	0	0	2	2	0	2	0
NGOs	3	2	2	3	2	3	0	0	0	0	5	2	2	0	1	0
Financial Organisations	3	0	2	1	0	3	0	0	3	0	0	0	1	0	2	0
Policymakers	9	0	4	5	1	8	8	1	0	0	0	2	1	4	0	2
International Organisations	3	0	1	2	0	3	1	0	2	0	0	0	1	0	1	1
Academic Institution	5	0	2	3	0	5	0	0	1	4	0	0	1	1	2	1
Total	29	2	16	15	5	26	9	1	12	4	5	6	8	5	8	4

The results are discussed per task and research question. To address task 1, **"To critically review the energy situation in Togo and outline factors resulting in high dependency on the international market"**, several research questions were asked as listed below:

- Do you have access to energy for your daily life and activities?
- Do you know what form of renewable energy is produced/generated in Togo itself?
- Who are the current actors within the energy sector in Togo?
- Could you see other forms of renewable energy being produced/generated in Togo in the future?
- Are there any issues caused by the current energy in place, such as pollution, health issues, etc.?
- In your opinion, what are the issues facing the energy sector in general?

RQ1.1: Do you have access to energy for your daily life and activities?

Thirty-one stakeholders from SI completed the questionnaires, and all 31 answered that they had access to energy for their daily lives and activities for lighting, charging of appliances, and storage and to perform their work and operate air conditioning units. However, they still faced a lot of load shedding issues and power outages. A few differences were noted for example, answers from international organisations, academia, private organisations, and policy makers were more likely to be "*Yes*", compared to NGOs. However, most responses were*:" Yes, but with load shedding problems."*

With regards to the type of energy, hydropower, thermal power plant, diesel generators, and biomass were listed.

RQ1.2: Do you know what form of renewable energy is produced/generated in Togo itself?

To this question, participants from SI answered yes and listed hydropower, solar photovoltaic in small quantity, wind in very small quantity, and biomass accounting for 71% (firewood, charcoal, vegetable waste, etc., most of which is unclean and highly pollutant when burnt). Participants said the equipment used for power generation is imported from China, Germany, Italy, and France, and there are dependencies on the providers, especially when it comes to maintenance of the equipment.

RQ1.3: Who are the current actors within the energy sector in Togo?

To this question, participants from SI answered CEB (Communauté Electrique du Bénin), CEET (Compagnie Energie Electrique du Togo), the Ministry of Energy, DGE (Direction Générale de l'Énergie), ContourGlobal, private renewable energy companies, government, NIOTO (Nouvelle Industrie des Oleagineux du Togo SA), ARSE (Autorité de Régulation du Secteur de l'Electricité), and SABER (La Société Africaine des Biocarburants et des Energies Renouvelables), also called ABREC in English (African Biofuel and Renewable Energy Company), an international organisation with its headquarters in Lomé. SABER's capital is held by 15 shareholder states (Bénin, Burkina Faso, Cap Vert, Côte d'Ivoire, Gambie, Ghana, Guinée, Guinée Bissau, Mali, Niger, Nigéria, Sénégal, Sierra Léone, Tchad, and Togo) and six financial institutions (BIDC, BOAD, Ecobank, FAGACE, IEI, and NEXIM). This organisation has the following objectives: the promotion and financing of renewable energy projects and energy efficiency in the public and private sectors, the transfer of new green technologies for the development of renewable energy industries, capacity building, and guidance to governments and the private sector to derive maximum benefit from clean energy and carbon markets.

RQ1.4: Could you see other forms of renewable energy being produced/generated in Togo in the future?

All 31 participants from SI answered yes to this question and said solar PV, biogas, hydropower, and wind energy could be produced due the presence of solar radiation, abundance of small rivers, possibility of using agricultural products to produce energy, and presence of wind. However, they suggested that political will must be increased, and in-house capability built by training personnel. One participant from the NGOs group stated: *"The government gives little importance* *to renewable energy, reason why there are no strategies in place to help developed the sector"*. Participants also mentioned the lack of feasibility studies and suggested that more studies must be done to determine suitability for best results.

Participants mentioned the cost of accessibility and lack of financing and political will as inhibitors to the production of this type of energy.

RQ1.5: Are there any issues caused by the current energy in place, such as pollution, health issues, etc.?

To this question, 90% of participants from SI answered yes and listed issues like pollution, which leads to health issues, PCBs (liquid lubricant used in engines), POPs (persistent organic pollutants), the use of diesel generators, which pollute the environment, and thermal power stations, which cause industrial air pollution.

About 10% of the participants from SI answered no and said that pollution within the country in not directly related to production, as most of the energy is imported, and the main cause of pollution within the country relates to car emissions.

RQ1.6: In your opinion, what are the issues facing the energy sector in general?

To this question, 70% of the participants from SI answered that there is little production, while the growth of the population is on the ascendency, and the need for energy increases every day. This is an issue, and measures must be taken to resolve this issue by increasing in-house production.

About 30% of the participants from SI mentioned that the lack of investment does not help development, and the country continues to depend on other countries for its energy supply.

The participants added that the energy sector is obliged to practice load shedding techniques by interrupting the energy supply to certain areas to balance the electricity supply and demand of all customers. They said this slows down economic activities and retards development.

To address task 2, **"To critically review the knowledge on renewable energy penetration and investigate the potential of different renewable energy sources"**, Phase 1 of the data collection was based on the following questions:

- **RQ2.1:** What are the potential renewable energy sources in Togo?
- **RQ2.2:** Have there been any renewable energy developments within the country?
- **RQ2.3:** Are there types of renewable energy that are currently used within your area?
- **RQ2.4:** What is the level of knowledge in renewable energy in terms of skills? For example, are there experts in the field of renewable energy technologies in Togo to take care of installations, operations, and maintenance?

RQ2.1: What are the potential renewable energy sources in Togo?

Solar and hydropower were listed as the most dominant and favourable renewable energy sources present in the country. Each participant from SI listed more than one type of energy. Amongst them, 80% of the participants suggested solar, and 70% of the participants suggested hydropower energy. Other potential sources were listed as well, such as biomass energy (40% of participants), petroleum (30%), solar thermal (15%), onshore wind (12%), offshore wind (8%), geothermal (6%), tidal (4%), and wave (4%). Figure 5-6 in Chapter 5 details the findings.

RQ2.2: Have there been any renewable energy developments within the country?

Solar was listed as one of the renewable energies that had seen a recent increase in use compared to the past 5 years (2015–2020). Some developed projects included 19 built pumping wells and 1,500 free solar panels installed in 22 villages with no access to the grid as part of the UEMOA project. Participants from SI added that telecommunications companies were so far the biggest users of solar within the country and mentioned they have five stations of 8 kVA at Glei and Anie in the south, Blitta in central Togo, and Bombouaka and Cinkasse in the north of Togo.

RQ2.3: Are there types of renewable energy that are currently used within your area?

Figure 5-3 below illustrates the results. Among all the participants from SI, 12 answered yes but stated that this is at an early stage. Nineteen participants answered no and mentioned that a few were previously installed; however, they have not been functional for as much as 10 years.

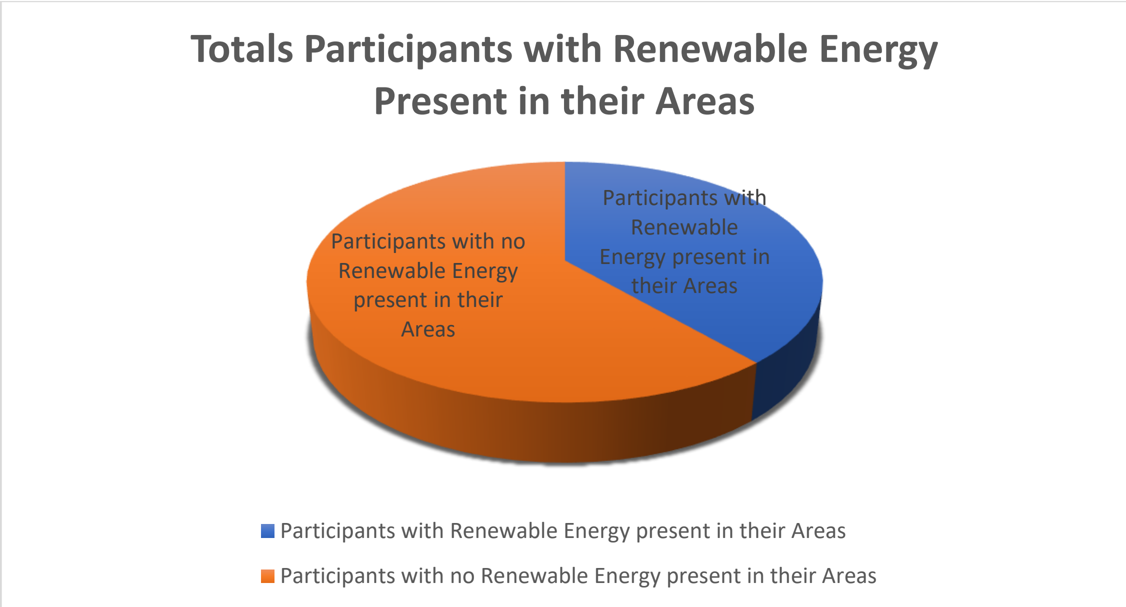

Figure 5-3: Totals Participants with Renewable Energy Present in Their Areas

RQ2.4: What is the level of knowledge in renewable energy in terms of skills?

Respondents from SI answered that there are some trained technicians, such as technicians from Green Power. A participant from the NGO group added: *"Some few technicians exist, but the university now has a laboratory to test renewable energy product mainly solar".* However, most of the in-house technicians have little knowledge, and the majority of experts come from other countries, such as China, Germany, Italy, and France.

Task 3 of the research was **"Outlining the potential impact of renewable energy usage on the environment and socio-economic development''**. For this, the first phase of data collection tackled the following questions:

- **RQ3.1:** Would you advise the use of renewable energy in Togo?
- **RQ3.2:** Can the use of renewable energy contribute to your daily life and activities?
- **RQ3.3:** How can the use of renewable energy improve any health issues?
- **RQ3.4:** What impact can the use of renewable energy have on the:
    - Community level
    - Regional level
    - National level
- **RQ3.5:** Do you think the use of renewable energy can reduce energy costs in the future?
- **RQ3.6:** What other impacts can the use of renewable energy have on sustainable development (environment, socio-economic development)?

RQ3.1: Would you advise the use of renewable energy in Togo?

All participants from SI answered "*Yes*." One of the arguments was: "*This will help in bill reduction, stating, for example, areas where solar streetlamps are installed; lighting is available and helps students in rural communities' study*."

Another stated: "*A few solar panels that have been installed in some hospitals help with vaccine storage; in some houses, they help with food storage, and for some offices, there is an improvement in working conditions due to installed solar panels.''*

Participants also stated that most people do not have access to electric energy, and this will be great in helping the rural population make their daily lives and activities better.

In all, the majority of the participants from SI believe that the use of renewable energy will add value, for example, to produce, where farmers can take the opportunity to grow their products even in dry seasons if, for example, solar irrigations system are installed due to the abondance of solar within the country. This will help them generate revenue. They also believe this will help in having a clean environment with no pollution, thus reducing global warming and emissions of CO_2, one of the main greenhouse gases responsible for climate change.

Finally, SI participants believe renewable energy will help with health issues associated with the constant use of unclean biomass and help the population carry on with their activities. Majority of the respondents within the age group of 25 to 39 years strongly believe it could significantly change their life. A participant stated: *"Renewable energy will be of great help to rural population, adding more value and generate revenue."* It will increase energy autonomy and create new business opportunities, thus helping with economic development and providing a clean environment. In addition, it will help with the development of community centres and activities around multifunctional platforms, thus reducing the rural exodus and keeping the youth in their localities instead of migrating to urban areas in search of better living conditions as they face poverty, food insecurity, and lack of employment, amongst other issues, in their community due to the lack of energy.

RQ3.2: Can the use of renewable energy contribute to your daily life and activities?

Participants from SI answered yes to this question. Some believe the use of renewable energy will help in bill reduction. SI participants mentioned, for example, that in some rural communities where solar streetlamps have been installed, energy is available, and instead of the indigenous community buying kerosene for their lamps to allow their children to study, the children make use of the streetlights instead, which are in fact much clearer and save money. In addition, renewable energy will help improve living conditions, generate income, and enable education, especially in rural areas.

Responses also included, "*The use of renewable energy will improve working conditions, provide hot water, assist with food storage, and prevent many respiratory diseases if the use of charcoal and wood for cooking is reduced.*"

Furthermore, one of the SI participants mentioned, *"The use of renewable energy will encourage professional activities, create entrepreneurship activities, and help generate income."* He added, *"The lack of power forces most people in rural areas to sleep by 7 pm, whereas more time could have been spent continuing their activities, improving productivity, and thus reducing poverty and bringing about a lot of economic benefits."*

RQ3.3: How can the use of renewable energy improve any health issues?

There were several answers to this question from SI participants. Answers included that the installed solar panels in some locations help provide lighting for health centres, thereby assisting in product storage (vaccine, medications) for the best functionality of the hospitals. Moreover, the use of solar refrigerators will make it possible to store pharmaceutical products and use renewable energy as an alternative to power equipment in case of power shutoff to prevent product damage instead of relying on diesel generators, which cause pollution. Furthermore, one of the SI participants in the policymaker group gave an example where "*Power outage caused the death of a child who was under oxygen in his village as well as a few deaths resulting from the bite of a snake due to the lack of injections caused by the inability to store vaccines in the village hospitals.*" Other SI participants mentioned that this could reduce the use of firewood and could help see a decrease in the number of people affected by respiratory diseases due to inhaling smoke produced by burning wood for cooking. Other answers mentioned improvements in water availability due to solar pumping providing clean drinking water to the communities.

RQ3.4: What impact can the use of renewable energy have on the: community level, regional level, and national level?

Answers from SI participants included that this would reduce energy dependence on the exterior, improve the living conditions of the people, help in the diversification of revenues sources, increase the standards of living, and improve the education system and conditions, mainly in the villages and where rural communities could benefit from public lighting. The use of renewable energy will help solve energy issues in remote areas, increase the availability of energy in the region, and reduce the pressure on the national budget in terms of importing energy. Responses also talked about impact relating to improvements in health issues due to the reduction in the use of firewood and increase in water availability, as explained in RQ3.3.

SI participants mentioned that this would bring development at all levels, including providing a clean environment, economic development, and national balance as well as reducing youth delinquency and migration to urban areas.

In all, SI participants said the use of renewable energy would contribute to regional development, boost the national economy, boost entrepreneurship activities, reinforce economic development, reduce electric bills, and make people more comfortable.

RQ3.5: Do you think the use of renewable energy can reduce energy costs in the future?

As shown in the figure 5-4 below, 81% of the SI participants agreed that the use of renewable energy would reduce energy costs in the future. The respondents mentioned that there has been a slight reduction in solar kits/equipment costs compared to the past 5 years, and they believe that, despite the high initial cost of acquiring and installing them, with time, the running cost becomes cheaper, and there is more gain. One of the SI participants from the NGO group mentioned, *"The use of renewable energy will facilitate development and lead to a decrease in bills, as this will subsidise the use of petroleum products."* He added: *"The excess energy produced using renewable energy can be fed back into the grid, which will be an add to the energy sector in place."* One of the SI participants from the policymaker group mentioned, *"The cost of renewable energy is annihilated in the long run—for example, with hydroelectric dams, the cost is completely wiped out after 25 years."* Another SI participant from the policymaker group added, *"We will soon run out of fuel if we are not careful; we need to reduce dependence on fossil fuel by making use of our available potentials. By doing that, we could make use of the abundance of solar present in the country. Once solar kits have been installed, there will be no need to buy solar provided you have good batteries to run them. This will lead us to energy sufficient and even make possible exportation in the future."*

SI participants added that this, however, can only be possible if policies are put in place fiscally and financially to allow mixed energy to be developed and used.

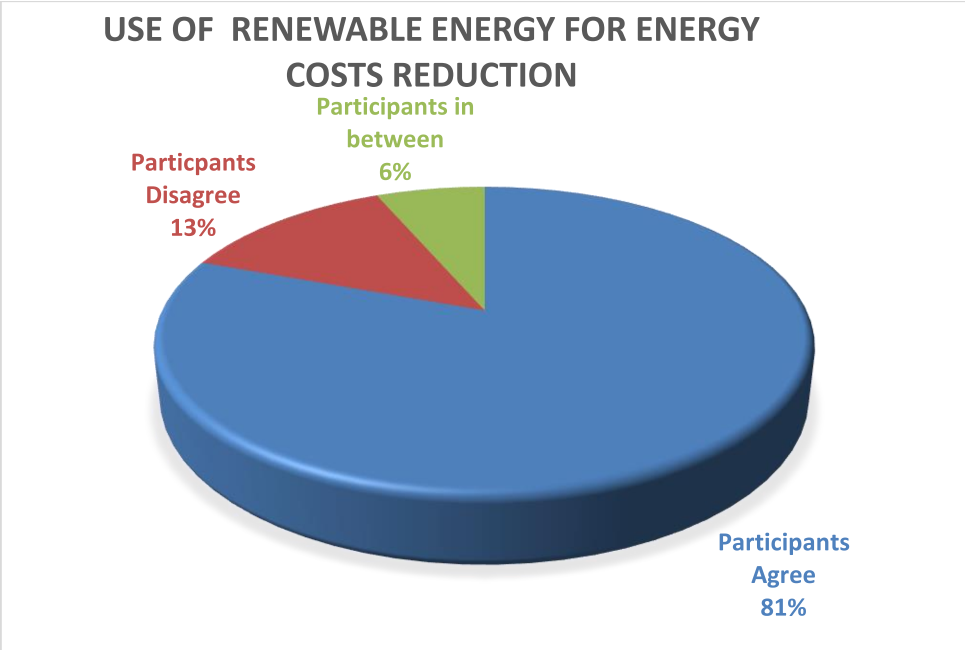

Figure 5-4: Use of Renewable Energy for Energy Cost Reduction

Of the SI participants, 13% disagreed with the idea that the use of renewable energy would reduce costs in the future and argued that renewable energy technologies are expensive and cost a lot of money to run and maintain. This is especially because most technologies are imported from the exterior at high cost, and in-house technicians and experts lack skills when it comes to maintenance.

They added that most solar panel installed in the country only last about 15 years, and batteries must be changed every 5 years.

Another 6% of the SI participants were undecisive. They argued that renewable energy remains very expensive, but it could only be made cheaper if the policies in place subsidised equipment costs even further. They added that a mixture of both renewable energy and non-renewable energy will be better and might reduce the cost, but there is no guarantee at this time to confirm that.

RQ3.6: What other impacts can the use of renewable energy have on sustainable development (environment, socio-economic development)?

Answers to this question from SI participants included reducing pollution, reducing bill costs, promoting employment, and creating economic activities. Additionally, they included protecting the environment, reducing tree cutting, increasing the success rate of businesses, sustainable energy, clean energy, balancing urban and rural areas, avoiding rural exodus, improving human life, and cultural development. In brief, renewable energy will provide economic and social development.

As an example of bill reduction, an SI respondent from the private sector said, *"An owner of a clinic with 30 to 40 rooms used to pay 1.2 million FCFA to CEET every year for bills. Once he got solar installed (which cost him about 12 million), within less than 3 years, he has been able to lower his expenses to 800,000 FCFA per year."*

Another SI respondent from the policymaker group stated: "*The use of solar lamps helps women sell their products without issues in the villages for longer periods, which will increase their source of income.*"

Finally, SI respondents mentioned that this would help rural communities with no access to the grid substantially and allow student development and access to technologies such as computers. Entertainment centres for broadcast of TV shows will help not only entertain the community and help it flourish but also generate income for the owners.

Task 4 of the research was **"To make recommendations on approaches to becoming self-sufficient"**. To address this task, the first phase of the research questions subdivided it into the following research questions:

- **RQ4.1:** What are the best practices that can be identified within the energy sector? (E.g., are there any adopted rules and regulations that help or favour the population? Is there any introduction of standardized power purchase agreements and power purchase tariffs to encourage development? Etc.)
- **RQ4.2:** What improvements can be recommended?
- **RQ4.3:** Who are the key policymakers, who are other important key players, and why?
- **RQ4.4:** What actions could be taken by policymakers to encourage wider adoption of renewable energy in Togo for sustainable development? What actions could be taken by other important key players?
- **RQ4.5:** Do you think the use of renewable energy technologies is cheaper or more expensive? Can you explain your answer?
- **RQ4.6:** Would you be happy to invest in renewable energy technologies?
- **RQ4.7:** What type of renewable energy would you recommend and why?
- **RQ4.8:** What payback period would you expect should you invest in renewable energy technologies?
- **RQ4.9:** What other suggestions could you recommend?

RQ4.1: What are the best practices that can be identified within the energy sector? (E.g., are there any adopted rules and regulations that help or favour the population? Is there any introduction of standardized power purchase agreements and power purchase tariffs to encourage development? Etc.)

Eighty percent of the SI participants answered none to this question; 20% said a few exist on paper or orally during campaign programs but none really in application. Participants added that CEB sells power at 58 FCFA to CEET, and in turn, CEET sells it for 63 FCFA/KWh for the first 40 KWh used and 84 FCFA for anything above that.

RQ4.2: What improvements can be recommended?

Lower customs duties on the import of renewable energy equipment, strengthening management, prioritizing renewable energy, promoting diversification and research, reviewing the energy policy in place while encouraging renewable energy, political will, raising awareness, and encouraging the population towards the use of renewable energy were some of the answers to this question from SI participants.

SI participants added that political will plays a huge role, and if the government is determined, the development of renewable energy will be much easier. Some participants spoke about the monopoly of the energy sector within the country by CEET, which does not help, and liberalisation of the sector is needed for investors to invest.

In addition, the introduction of standardised power purchase agreements and power purchase tariffs was recommended.

RQ4.3: Who are the key policymakers, and who are other important key players, and why?

Key policymakers were listed as the Ministry of Energy, Parliament, the government, CEB (unique buyer), CEET (unique distributor), IPP (ContourGlobal) the DGE (Direction Générale de L'Energie), and ARSE (Autorité de Réglementation du Secteur de Electricité).

SI participants added that, despite that the government being a key policymaker, it really does not have much authority over CEB, which is jointly owned by Togo and Benin. Initially, it was agreed that Benin would have 60% of what CEB generates and Togo 40%; however, due to the increase of industries in Togo, Togo faced a lot more energy crises, and since 2006 and 2007, they have had to find other source of energy. NGOs and private organisations were listed as secondary but do not have much control in decision-making.

RQ4.4: What actions could be taken by policymakers to encourage wider adoption of renewable energy in Togo for sustainable development?

Several suggestions were provided by the SI respondents, which included subsidizing equipment, introducing incentive measures in taxation, raising awareness, liberalization of the sector to enable people to invest, and implementation of renewable energy policy. One of the SI participants from the NGO group mentioned, *"Government should go in collaboration with NGOs to organise sensitization of the population to promote the use of renewable energy."*

Another SI participant from the NGO group suggested that it would be good for the *"government to partner with relevant countries that could help train experts for, e.g., product grant mechanisms and grant scholarships to university students to travel out for training in renewable energy."*

Finally, one the SI participants from the policymaker group suggested, *"If there was a possibility of providing loans to people to go for renewable energy and awareness was raised about it, many people would go for renewable energy."*

RQ4.5: Do you think the use of renewable energy technologies is cheaper or more expensive? Can you explain your answer?

Eighty percent of the SI participants said the use of renewable energy is very expensive especially due to the high cost of equipment compared to conventional power; for example, to get it installed in your house, you need about 3 million FCFA, which is huge (approx. $5,400), but they believe this will become cheaper with time.

Twenty percent of the SI participants answered cheaper, especially in areas that are not connected to the grid, as it cost a lot of money to extend the power grid.

RQ4.6: Would you be happy to invest in renewable energy technologies?

All SI participants were happy to invest in renewable energy and mentioned that the prospect exists. Even though it is expensive now, it will become cheaper and brings many benefits, such as reduction of greenhouse gases causing global warming and environmental issues, helping prevent some health issues, and assisting in the better functioning of health centres, as well as developing the economy.

RQ4.7: What type of renewable energy would you recommend and why?

SI participants recommended solar and hydropower as the first two types of energy that should be developed due to the abundance of solar resources and rivers within the country. Other recommendations from SI participants included biogas, biomass, onshore wind, offshore wind, geothermal, and tidal.

One of the SI participants from the policymaker group mentioned that *"22 sites of hydro have been identified since 1984 by Tractebel (Belgium-based consultancy company) but this has not been implemented due to the lack of funds and investment. This study might have to be redone because it's been more than 30 years."*

RQ4.8: What payback period would you expect should you invest in renewable energy technologies?

Four SI participants answered that they would expect a return in less than 5 years. Eleven participants said they would expect a return in 5 to 10 years. Ten participants answered 10 years, and six answered 15 years.

RQ4.9: What other suggestions could you recommend?

One of the SI participants from the NGO group said, *"Renewables energy is accessible to all; however, the cost is so expensive, and most villagers do not even have food to eat, not to talk of spending over $15 for lamps, which is far too much and impossible for them to do. The government must seek funding to develop the sector and subsidise equipment."*

Another SI participant from the academic institution group suggested, *"ECOWAS has to invest in building a big power station for West Africa instead of having power stations for each country separately."* There were also suggestions around the construction of dams and installation of about 100 ha of solar panels to help Togo generate enough energy for the people.

Finally, raising awareness, facilitating the arrival of investors for the development of renewable energy, increasing political will, sensitization of the population, and staff training will be key to developing the use of renewable energy within the country.

The second-round data collection targeted experts with knowledge in renewable energy for feedback on questionnaires which were sent as an online survey (this included participants with technical, research, policy management, and political expertise). These questionnaires were formulated based on the feedback from the first data collection. A total of 17 experts completed the questionnaires, as shown in Table 3-2 of Chapter 3. Questions were refined with the purpose of getting in-depth information from experts and were centred around:

- Discussing the potential issues behind the gaps found after analysis of the first-round interviews and finding potential solutions and recommendations for better approaches moving forwards.
- Finding out specific details regarding the type of energy used, power production, and installed generating capacity and what can be done to meet the Togolese government’s energy vision for 2030.
- Finding out details about the successes and drawbacks of recently implemented developments in terms of renewable energy resources, details regarding existing laws that promote the use of renewable energy, the management system, and how policymakers could best address the absence of framework regulations, which was one of the key findings in the second-round interviews.
- Finally, questions were asked about whether renewable energy should be prioritized, research promoted, and diversification in terms of renewable energy promoted.

The results of the second data collection per task and research question are discussed below. To answer task 1 of the research, **"To critically review the energy situation in Togo and outline factors resulting in high dependency on the international market"**, phase 2 of the data collection looked at the following questions:

RQ1: What type of energy is generally used:

- ***In urban areas of Togo?***

Responses from S1 participants included thermal energy, solar energy (PV) in small quantities, hydroelectric power, biomass energy (mainly firewood and charcoal), butane gas for cooking and in industries, hydrocarbons, as well as a very small quantity of wind energy produced at two locations.

- ***In rural areas of Togo?***

Responses from S1 participants included thermal energy, hydroelectric power, biomass energy (mainly firewood and charcoal), and solar energy (PV) in small quantities, especially a recent project providing solar installations in four villages with 100 kWp at Takpapiéni located in South Oti, in the Savanes region, 100 kWp at Kountoum, located in Bassar in the Kara region, 250 kWp in Assoukoko, located in Blitta in the Central region, and 150 kWp in Bavou located in Ogou in the Plateaux region. Battery torches and kerosene were listed as being frequently used in the villages for lighting.

RQ2: Do you know how much power is produced from the 230 MW installed generating capacity?

S1 participants answered approximately 1,600 GWh/year.

RQ5: In your opinion, why have the wind projects planned by Delta Wind failed to start? Please explain.

According to an S1 participant from the policymaker group, *"Togo does not have a good potential for wind energy development."* An S1 participant from the private organisation group said that, based on *"the study report presented in December during the ROGEP ECREEE workshop, the suggested proposed areas adapted for wind power development are few and most found around Lake Togo."* An S1 participant from the policymaker group mentioned that *"Togo does not have a good wind energy potential, and the selected site is a swampy area, with wind speed barely 3 m/s, while a minimum wind speed of at least 4 m/s is required to generate electricity. To achieve the required wind speed, the wind farms' masts must be raised around 100 m, and this will require important investment in terms of civil engineering."* Other S1 participants added that the energy potential for wind power plants in Togo is relatively low, with a wind speed of between 1 and 4 m/s, when it takes an average of 6 m/s to produce tangible electricity. Additionally, an S1 participant from the international organisation group mentioned that *"financial shortcomings are also one of the reasons, and the project leader is apparently still looking for technical and financial partners for a price proposal acceptable to all stakeholders."* Finally, other S1 participants mentioned that, based on some investigations, the project did not start because the price per kWh that CEB is offering will not ensure the profitability of the project.

RQ7: What are the existing laws that promote the use or development of renewable energy?

The answer to this question was Law n° 2018-010 of 8 August 2018 relating to the promotion of the production of electricity based on renewable energy sources.

RQ7.1: What are the benefits or disadvantage of these existing laws?

An S1 participant from the policymaker group stated, *"This law regulates the renewable energy sector and exempt taxes and customs duties on renewable energy equipment,"* and added, *"There is no disadvantage"*. According to an S1 participant from the private organisation group, *"This law gives priority to renewable energy development and allows an increase in the national electrification rate by opening up to the private sector under state supervision while guaranteeing the quality of the installations."* He added, *"In terms of* *disadvantages, there are a few restrictions that come into consideration, depending on the number of kWh consumed*." Other S1 participants mentioned that the tax exemption mainly benefits companies with public interest that have relevant projects. For individuals who purchase a solar lamp, for example, there is no benefit from the tax exemption; the same applies for companies that want to do business. Consumption of less than 32 kWh is considered to be tax-free; for consumption between 32 kWh and 100 kWh, a declaration has to be made, and for consumption above 100 kWh, an authorisation is needed in addition to obtaining a licence. Aside from marketing needs, with or without injection into the network, each actor in the private sector must have a licence obtained by Ministerial decree, which discourages SMIs (small and medium-size industries) and SMEs that are starting up. Finally, S1 participants mentioned that there are more operators in the energy sector to start up their business.

To address task 2, **"To critically review the knowledge on renewable energy penetration and investigate the potential of different renewable energy sources"**, phase 2 of the data collection sought answers to the research question below*:*

RQ6: What is the latest on the discovered oil in Togo? Has there been any progress in terms of exploitation? Assuming yes, what has been done? Otherwise, what has been the drawback?

To this question, about half of the S1 respondents answered that there were rumours, and there is no official news confirming the presence of oil. Other S1 participants answered that the offshore project in Togo is not profitable, and Togo does not produce oil.

To address task 3, **"To outline the potential impact of renewable energy usage on the environment and socio-economic development"**, the following question was asked in phase 2 of the data collection:

RQ4: Solar energy was installed in 22 villages from 2013 to 2016 with the aid of a WAEMU project named "PRODERE" ("Programme Régional de

Développement des Énergies Renouvelables et d'Efficacité Énergétique”). Do you know how those villages use the installed solar energy?

S1 responses showed that, in general, the use of this energy in rural areas is mainly for lighting and charging of electrical equipment, such as laptops, radios, TV, refrigeration systems, and fans for cooling. Participants also mentioned that it helps with water pumping and is used in the hospitals for vaccine and medication storage, schools, markets, and churches. Aside from that, part of this project helped with installation of mini solar photovoltaic power plants in four villages in rural areas, mainly Takpapiéni, Kountoum, Assoukoko, and Bavou, as detailed in the RQ1 answer of phase 2 above.

To address task 4 of the research, **“To make recommendations on approaches to becoming self-sufficient”**, phase 2 of the data collected sought answers to the questions below:

RQ3: Are you engaged in energy use/utilization, buying, or decision-making? How much estimated power is needed to meet the 2030 vision? What would you suggest in terms of percentage increase to the current electric power consumption?

S1 participants from the policymaker and academic institution groups answered yes to this question. S1 participants from renewable energy private organisations and NGOs mentioned that they participate in decision-making, but their contributions are just proposals, which are not necessarily considered in the final decision. The rest of the S1 participants answered no; however, they can provide suggestions, and it is up to the key stakeholders/policy makers to consider them.

To achieve 100% electrification by 2030, approximatively 202 MW of power will be required.

RQ7: What are the existing laws that promote the use or development of renewable energy?

As answered above, Law n° 2018-010 of 8 August 2018 relating to the promotion of the production of electricity based on renewable energy sources was named.

RQ7.2: Can you make suggestions for improvement, if any?

An S1 participant from the private organisation group suggested, *"It would be ideal for the obtaining of the license to be subjected to fewer requirements if the quality of the installations is guaranteed and if the royalties paid to various services of the state were lowered to facilitate access for all. In addition, as part of self-consumption, without ambitions of marketing, there should not be a need to obtain a license, but a simple declaration of ownership should be sufficient."* Another S1 participant from the academic institution suggested, *"There is a need to establish a real needs map based on zones to know what type of renewable energy is installed."* Furthermore, other S1 participants mentioned that this is the first law that favours renewable energy, and its implementation will hopefully allow lessons to be learned for its improvement. Finally, there were suggestions from S1 participants to make a law on energy efficiency and to review the tax exemption framework for solar products.

RQ8: How is the management system for renewable energy in terms of processes? Would you suggest something different?

According to one of the S1 participants from the policymaker group, *"The Ministry of Mines and Energy, along with the electricity regulatory authority and other ministries, such as the Ministry of Economy and Finance, deal with all processes related to renewable energy in the country."* Another S1 participant from the academic institution group mentioned*, "Currently, the AT2ER agency (The Togolese Agency for Rural Electrification and Renewable Energies) has been set up and has a large, ambitious program in the field."* Other S1 suggestions included putting in place laws to promote the use of these energies even if the state must initially waive taxes—and shouldn't taxes ultimately meet the general interests of countries? They added that currently, most of the energy is supplied by CEET. Most of the mini grids installed are state projects. Until recently, the private sector was not authorised to install mini power plants (off-grid or on-grid) and therefore had to limit itself to small solar kits. Thanks to the arrival of the new law, however, it is now possible to produce the energy to be injected into the network (after obtaining the license and paying royalties to the state)—and to market directly (under the same conditions), which thus makes it possible to decentralize and diversify the management mechanisms for renewable energies in terms of the processes.

RQ9: How can policymakers address the absence of framework regulations that govern the energy sector?

S1 participants answered by involving the *"real players in the sector"*. They mentioned that new regulations in the sector are already underway and will soon be effective with the assistance of ARSE (Regulatory Authority for the Energy Sector), AT2ER, and the National Direction of Energy. S1 participants added that texts and laws are being drafted with a view to create favourable conditions for local and international developers and investors. In all, S1 participants said regulations exist and there is just a need to improve them.

RQ10: Should renewable energy be prioritized? If so, why?

Eighty percent of the S1 participants answered yes. One said that *"Renewable energy offers a good opportunity to provide reliable access to electricity for the population due to their natural source while protecting the environment."* Additionally, one S1 respondent from a renewable energy private organisation mentioned, *"Renewable energy should be favoured due to its inexhaustible source and the fact that it is best positioned to facilitate access to energy even in remote areas and preserve the environment."* Furthermore, one of the S1 responses from the international organisation group stated that *"The promotion of renewable energies and the development of conventional (fossil) energies must go hand in hand to guarantee and support the economic development of the country."*

Twenty percent of the S1 participants answered no because, according to them, renewable energy are mostly intermittent sources, while the demand for electrical energy is continuously on the increase. In addition, they are expensive, given current technology, and, apart from hydroelectricity, it is impossible to store energy, at least to have high power in line with demand. One of the S1 participants from the policymaker group added, *"The mixing of renewable energies with conventional sources is technically limited given their instability in terms of frequency and voltage. Therefore, it would be dangerous to favour this type of energy."*

RQ11: Should diversification with regards to renewable energy be promoted? If so, why?

S1 participants believed this is important because, depending on the area, one type of renewable energy might be more suitable and efficient than another. They added that allowing diversification will allow greater access and reliability of energy, and different sources complement each other, giving an example of the sun, which does not shine at night. They added that diversification may help overcome the energy shortage. This could help maximize the use of energy sources available nationally. One of the S1 participants from the academic institution group mentioned, *"This should be done on a case-by-case basis, and a prior study should determine the final decision, and AT2ER is currently working on it."*

RQ12: Should renewable energy research be promoted? If so, why?

S1 participants supported argument that research needs to be promoted, particularly in Africa, to optimize the system for better performance, create manufacturing plants on-site, and produce materials that are accessible but efficient and adapted to our populations. One of the S1 participants from the academic institution group added that this is essential because *"it is not certain that all renewable energy technologies can implement climate-adapted products."* Additionally, *"research will make it possible to discover the best formulas for using proven technologies in the field of renewable energy."*

RQ13: Do you have any other suggestions to recommend?

S1 participants suggested that renewable energy should be promoted by raising awareness due to their many advantages and by encouraging innovation and research as well as staff training for a qualified workforce. They said that a field survey will guide the search for sustainable solutions in the use of renewable energy. S1 participants also mentioned that the lack of research is a real problem for development, coupled with the lack of funds to support research and development projects. Finally, S1 participants suggested that it would be desirable for the state to become more involved in training young students to produce this energy at a lower cost and then to popularise its use for all.

A third round of data collection was organised in 2020 for the purpose of validating information previously gathered. This round was based on the same questions that were used during the second data collection round. This was necessary due to a time interval between the interviews, considering developments that could have occurred. The third round consisted of face-to-face semi-structured interviews that targeted participants with knowledge in renewable energy with technical, research, policy management, and political expertise. In all, based on this data collection, several changes had occurred. These included the following.

There was an increase in the rate of access to electricity, which went from 80% of the population not having access to electricity at the start of the research in 2014 to 50% during data validation and 57.82% (CEET 2021). This is a major change due to Togolese government initiatives to work on increasing electricity access within the country. It is worth emphasising that the rate of access to electricity varies between urban and rural areas. For example, the current rate of access to electricity in urban areas is 88.8%, while rural areas' rate of access to electricity is 8%. This highlights the need to develop the use of renewable energy technology to supplement supply, especially in rural areas that are not connected to the national grid. The government launched a solar electrification project in 2017 as part of the initiatives taken to reduce the rural energy deficit. The details of these are discussed in Section 5.2.4 below. Recent installations include the installation of solar energy, such as the PRODERE project (which consisted of installing solar energy in 22 villages from 2013 to 2016 with the aid of WAEMU), are used for lighting purposes, phone charging, and powering radios and televisions. In some areas, these are used to help power hospitals for vaccine and medication storage.

Other uses include water pumping and lighting schools, markets, and churches. Other solar project included the construction of four mini solar plants from 2017 to 2019, namely 250 kW in Assoukoko in Blitta (Central region), 100 kW in Kountoum in Bassar (Kara), 100 kW in Takpapiéni in South Oti (Savanes), and 150 kW in Bavou in Ogou (Plateaux).

The solar plant located at Assoukoko is equipped with three water supply systems to help the population with potable water. The remaining three solar plants are mainly for electrification. Also, according to the quarterly activity report of solar kit distributors, from October 2019 to April 2020, Soleva distributed an estimated 1,385 solar kits, as detailed in the Table 5-2 below. These kits are used for electrifying homes, businesses, and equipment.

Table 5-2: Solar Kits Distributed per Region from October 2019 to April 2020 (Source: SOLEVA Quarterly Report 2020)

Region	Clients Home60	Clients Home120+	Clients Home400	Total
Maritime	441	207	73	721
Plateaux	144	75	21	240
Central	20	28	12	60
Kara	88	14	5	107
Savanes	208	20	29	257
Total	901	344	140	1,385

In addition, a solar power plant of 50 MW financed by the Abu Dhabi Development Fund and the West African Development Bank (BOAD) is being built in Blitta by AMEA Power. Other projects included the installation of 10,000 PUDC lampposts: The first phase of installing 2,000 solar streetlights as part of the project to install

10,000 streetlights was completed with provisional acceptance of the work in early December 2019. No current news exists on the progress. Furthermore, there have been some developments in terms of training, which are detailed in Section 5.2.4 below, and some developments in terms of renewable energy laws. These are discussed in Section2.3.8 Other developments planned by the government include the increase of hydropower capacity through the development of three projects, namely Sarakawa, Tetetou, and Titira. More details are provided in Section 5.2.4.

5.2 Discussion

5.2.1 Overview of Participants and Key Points on Types of Potential Energy for the Future

The interviews and questionnaires in all rounds targeted keys stakeholders with knowledge in the energy field. The respondents were people between the ages of 25 and 60 who had lived in their specific community for 6 years or longer. In terms of expertise, 5% of the participants had limited levels of experience in renewable energy, 10% had an intermediate level of expertise, about 45% had advanced knowledge, and 40% were leading experts in renewable energy. Their expertise included technical, research, policy management, political, and more, such as head of a laboratory/research centre. The non-expert responses were eliminated, and the analysis focused on the expert and advanced knowledge participants' responses. Based on the responses, about 70% to 80% believed there was significant potential in renewable energy, primarily solar and hydropower. The solar potential is in alignment with meteorological data showing that the high and over the year relatively constant solar radiation results in a high value of available solar energy, as illustrated in Figure 2-1. The hydropower potential is supported by the fact that there are small rivers which could be exploited for small (less than 10 MW) hydroelectric projects. According to PANER (2015), there is certainly an urgent need to develop small hydropower plants for the supply of electricity to rural areas and remote communities.

In comparison to solar energy, for example, wind energy has only been used to pump groundwater; however, initial exploration has shown that Togolese wind resources are not competitive compared to other sources on a utility scale (PANER 2015). According to the Global Wind Atlas (2019), Togo is in an area with very low winds. The wind speed is higher on the coast in the south, as shown in the Figure 5-5 below, and the speed is also higher in mountainous areas.

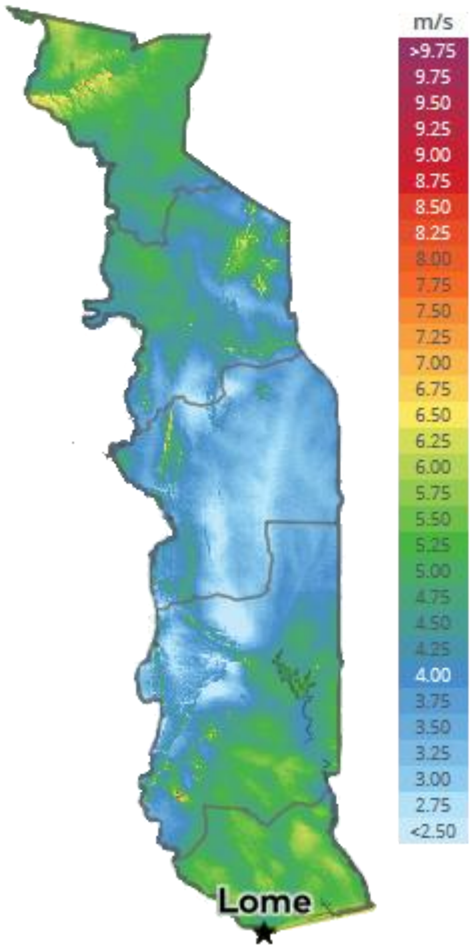

Figure 5-5: Wind Map of Togo (Source: Global Wind Atlas 2019)

In addition, the results illustrated that Togo has a widely used approach to study key resources in biomass energy and petroleum as well as the solar, thermal, onshore wind, offshore wind, geothermal, tidal, and wave resources available. However, according to expert responses, these will involve significant capital and technical expertise to develop in the currently challenging Togo economy. Figure 5-6 summarizes the key views in relations to renewable energy potentials.

Currently, Togo has 230 MW installed generating capacity, which produces 1,600 GWh of power annually, of which 65 MW of Nangbeto hydroelectric power is operated by the Benin Electricity Community (CEB, a jointly operated public entity between Togo and Benin in charge of generation) installation in Lomé. Furthermore, 1.6 MW of hydropower operated by the Electric Power Company of Togo (CEET) is installed in Kpime (Kpalime), and 100 MW of thermal energy operated by ContourGlobal Togo (CGT), an international power company, is installed in Lomé as well. There is 12 MW of thermal energy installed in Lomé (Sulzer), 11.9 MW of thermal power installed in Lomé B (CTLB), 4 MW of thermal power in Kara, and 1.5 MW of thermal power in Sokode. There are isolated thermal power stations that are not interconnected, the installed power is between 40 KVA and 1,280 KVA (CEET 2020).

Currently, Togo relies mainly on biomass energy, such as firewood, charcoal, and vegetable waste, which account for about 71% of energy used and contribute to deforestation and serious health issues due to firewood pollution, for example. Based on a literature review, Togo also relies on petroleum products (26%) and electricity (3%), which are imported as indicated in Section 1. To reach the 2030 vision set by the government, experts suggest a percentage increase of 202 MW to the current electric power.

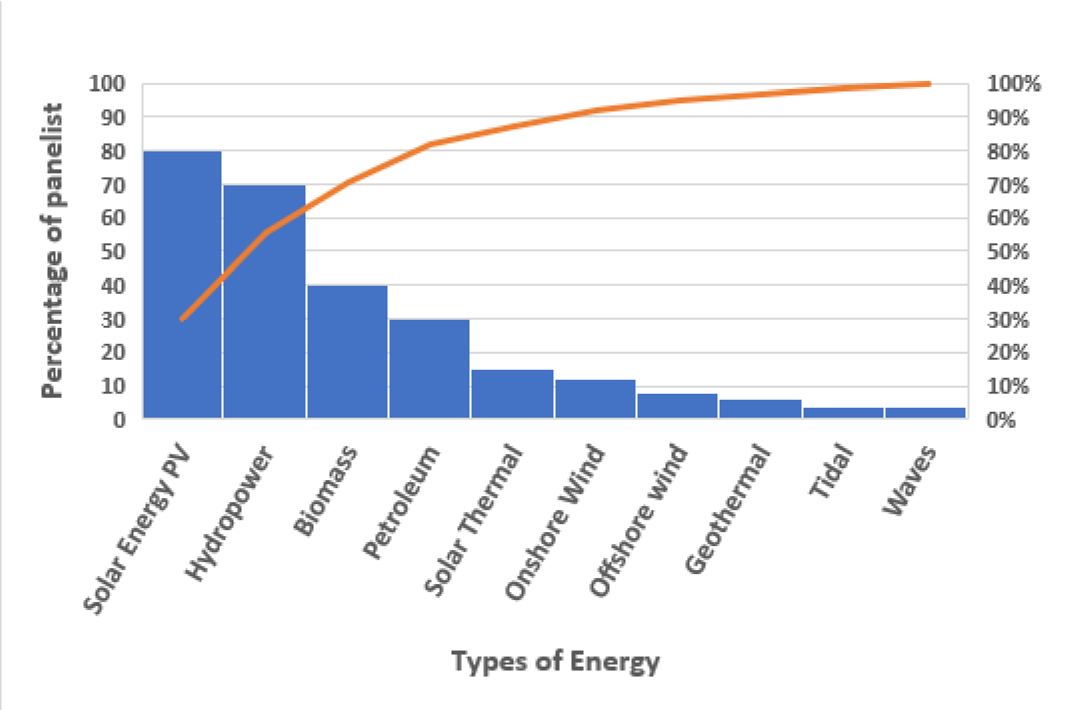

Figure 5-6: Views in Relation to Renewable Energy Potentials for the Future

5.2.2 Drawback Factors for Renewable Energy Development

Speaking with a broad range of stakeholders to find out their in-depth views in relation to renewable energy development led to identifying several drawbacks. For example, S1 and DVSI responses illustrated that some of the challenges faced by the Togolese government relate to determining the generation potential of various renewable energy sources, such as hydropower and wind. To emphasize that, one of the S1 responses from the academic institution group stated, *"There is a need for real mapping of potential based on different zones to know the type of renewable energy to install."* Other challenges include seeking external funding available to support the establishment of networks and sustainability of projects via integrated management provided by the mandated operator CEET (Togo PND 2018).

The results also showed that there are few adopted rules and regulations within the energy sector, such as standardized power purchase agreements and power purchase tariffs. In addition, few incentive measures in taxation exist, which only favour companies with public interest and not private organisations. Furthermore, the non-liberalization of the energy sector does not encourage investment from private investors. CEET remains the sole entity that can market electricity generated, and there is no competition in the electricity market that would reduce the price per unit. Looking at the abundance of renewable energy resources in Togo and the financial constraints facing the country, the government needs to collaborate a lot more with private organisations to attract more investment in the renewable energy sector. In addition, energy policies with incentives for investment in renewable energy should be developed to allow an increase of renewable energy in the energy mix of Togo.

5.2.3 Factors in the Promotion of Renewable Energy Development

To determine the factors in the promotion of renewable energy, the study focused on gathering key points from different groups of stakeholders (as illustrated in Figure 3-10 above) using interview questionnaires. Amongst these, "Should renewable energy be prioritized?" was one of the questions, to which 80% of the S1 and DVSI respondents answered yes, explaining, for example, that *"Renewable energy offers a good opportunity to provide reliable access to electricity for the population due to its natural source while protecting the environment."* Additionally, one S1 respondent from the private organisation group mentioned, *"Renewable energy should be favoured due to its inexhaustible source and the fact that it is best positioned to facilitate access to energy even in remote areas and preserve the environment."* Moreover, as mentioned in Section 5.2, one of the S1 participants from the international organisation group stated that *"The promotion of renewable energies and the development of conventional (fossil) energies must go hand in hand to guarantee and support the economic development of the country*." This is in line with Acheampong (2021), who stated that increasing the share of renewable energy in the energy portfolio will not only boost economic growth and mitigate CO_2 emissions but also help sub-Saharan Africa to achieve the Sustainable Energy for All (SEE4ALL) goal as well as Sustainable Development Goal 7 (SDG7). Despites these arguments, about 20% of participants within the expert group disagreed with the prioritization of renewable energy, saying, for example, that *"Renewable energy are mostly intermittent sources, while the demand for electrical energy is continuously on the increase. In addition, they are expensive, given current technology, and, apart from hydroelectricity, it is impossible to store energy, at least to have high power in line with demand."* Moreover, they added, *"The mixing of renewable energies with conventional sources is technically limited given their instability in terms of frequency and voltage. Therefore, it would be dangerous to favour this type of energy."*

Promoting diversification was another discussion point which experts believed to be essential because, depending on the area, one type of renewable energy might be more suitable and efficient than another. Moreover, they stated that allowing diversification will allow greater access and reliability of energy, and different sources complement each other, giving an example of the sun, which does not shine at night. They added that diversification could possibly help overcome the energy shortage. Furthermore, an S1 participant from the international organisation group stated, *"Diversification is necessary to maximize the use of energy sources available nationally."* Finally, an expert from the academic institution group added, *"This should be done on a case-by-case basis, and a prior study should determine the final decision, and AT2ER is currently working on it."*

Another point for discussion was based around promoting research. All experts from S1 and DVSI were in support of this. Some argued that research needs to be promoted particularly in Africa to optimize the system for better performance, create manufacturing plants on-site, and produce materials that are accessible but efficient and adapted to its populations. They added that this is essential because *"It is not certain that all renewable energy technologies can implement climate-adapted products."* Additionally, *"Research will make it possible to discover the best formulas for using proven technologies in the field of renewable energy."*

Moreover, suggestions were made for renewable energy to be promoted both by raising awareness due to its many advantages and by encouraging innovation and research as well as staff training for a qualified workforce. A DSVI participant from the international organisation group suggested, *"A field survey will really guide* *the search for sustainable solutions in the use of renewable energy."* Additionally, S1 and DVSI participants stated that the lack of research is a real problem for development, coupled with the lack of funds to support research and development projects. Finally, experts suggested it would be desirable for the state to become more involved in training young students to produce this energy at a lower cost and then popularize its use to all.

5.2.4 Recent Approaches to Renewable Energy Development Taken in Togo to Achieve Universal Electrification

Several approaches have been taken to increase energy access in Togo in the past several years. For example, to reduce the rural energy deficit, the Togolese government launched a solar electrification project in 2017. This was supported by the African Development Bank (AfDB) with an amount of $975,000 in partnership with a private company called Bboxx. The aim of the project was to bring light to 2 million Togolese (approximatively 300,000 households) by 2022. Based on experts' responses and a literature search, the Togolese government's ambition is to (Togo PND 2018):

- Bring the rate of access to electricity to 60% by 2022 on a national level
- Reduce the rate of losses on the network from 16.8% to 10% by 2022
- Reduce CO_2 emissions

The above ambitions can be achieved by strengthening the institutional, political, and legal framework for the energy sector, strengthening the production and distribution capacities of electrical energy, and increasing storage and distribution capacities for hydrocarbons (Togo PND 2018). Currently, the monopoly of the energy sector does not help, and liberalization is needed to enhance security and the political environment to attract investors. Other universal government plans include:

- Reducing the share of biomass energy (such as firewood and charcoal) consumption in households from 65% to 40% by 2022

- Increasing the share of renewable energy in the national energy mix by increasing solar electricity to 50 MWp and that of micro-hydroelectric dams to 64.1 MW (using Titira, Sarakawa, and Kpessi)
- Adopting energy efficiency standards

This can be achieved with the abundance of renewable energy resources present in Togo. However, clear goals must be set by the government to attract more investment in the renewable energy sector and improve energy efficiency standards.

Going forward, as part of the Togolese government's policy to achieve these ambitious goals, the government plans to develop, within the framework of the PND, an energy program which will help to exploit the hydroelectric potential with the construction of hydroelectric dams such as Tetetou (50 MW), Danyi-Konda (10 MW), Baghan (6 MW), and Landa-Pozanda (4 MW) (Togo PND 2018; Togo First 2018). Many rivers exist, such as Kpendjal, Ouale, and Sansargou in Madouri, Oti in Mango, and Mono in Kaboli, amongst others, and full commitment from the government is needed to achieve these plans for development.

Another addition will be the planned coal-fired thermal power plant, the international and regional connection program with two transmission lines of 330 KV and four transmission lines of 161 KV, and the construction of a 10 MW solar plant in Mango and 5 MW in Kara (Togo PND 2018). The coal-fired thermal power plant remains a question mark because Togo does not produce enough coal, and the plan is to import this resource to achieve this. Achieving sustainable development is key for a nation to be self-sufficient, and this plan, though it could help, will not be the best based on recommendations from discussions with a few energy personnel.

Working towards this ambitious plan, the Togolese government has taken some steps that will help in the planning and implementation of the set goals according to the experts' responses. Recent developments have been put in place on various levels:

- Institutionally, AT2ER was created in 2016 and started activities in 2017. This is a separate entity within the Ministry of Energy that will specifically take care of renewable energy projects and rural electrification programs.
- On the regulatory level, some renewable energy laws have been put in place to favour private organisations that have the public interest in mind.
- On the organisational level, an electrification strategy has been put in place with the goal of achieving 100% access to electricity by 2030.

In addition, there have been some recent developments, such as the construction of four mini solar plants started in 2017 and finalized in 2019 (see list in Table 5-3). The final acceptance of the last three solar mini power plants listed in Table 5-3 was done in 2019 as part of phase 2 of the Regional Program for Development of Renewable Energy and Energy Efficiency (PRODERE) in Togo. However, the Bavou solar mini plant of capacity 160 kWc has been provisionally completed but not commissioned yet.

Table 5-3: Construction of 4 Mini Solar Plants Detailing Installed Capacity in Various Cities per Region

Region	Locality	City	Installed Capacity
Plateaux	Ogou	Bavou	160 kWc
Central	Blitta	Assoukoko[1]	250 kWc
Kara	Bassar	Kountoum	100 kWc
Savanes	South Oti	Takpapiéni	100 kWc

[1] Power plant equipped with three water supply systems

The current efforts are on the network grid extension to allow power transmissions to target regions of the country. The first solar power plant of 50 MW is being built in Blitta by AMEA Power. This is financed by the Abu Dhabi Development Fund and the West African Development Bank (BOAD). The overall cost of the project is

$35.7 million for the first phase of 30 MW. Several future projects are being planned as well (Togo Ministry of Mines and Energy 2019):

- Access to Electricity—individual solar kit electrification project: The electricity strategy provides for the licensing of six operators for the distribution of kits. Two operators are in activity—Bboxx and Soleva. A call for tenders has been launched for additional licenses. Proposals were submitted on 3 December 2019. To date, three companies met the criteria and have been chosen to join BBoxx and Soleva for the execution of the rural electrification programme, called the CIZO project. These are Fenix International, Moon, and Solergie (AT2ER 2020).
- Moon, a French firm yielded by the crowdlending platform Solylend, will provide its Moon Kit, which is a solar system that provides lighting and charges USB devices. It comes with a Moonphone, which is a special smartphone through which beneficiaries are to pay back for the kit.
- Solergie, a Belgian firm that partnered with Total in 2018, will roll out its Solergie Box in Togo's rural areas. This is a solar system to which up to eight users can connect.
- Fenix International is a subsidiary of French multinational Engie (since 2017). Based in Uganda, where its main activity is located, it is a pioneer in the home solar systems market in Africa (Togo First 2020).
- Rehabilitation of 13,000 lampposts: The evaluation report of the invitation to tender issued for supply of equipment for the maintenance of 2,000 solar streetlights was validated by the DNCMP and was awarded to KYA-Energy in December 2019. There is no additional information on the progress.
- 10,000 PUDC lampposts: The first phase of installing 2,000 solar streetlights as part of the project to install 10,000 streetlights was completed with the provisional acceptance of the works early December 2019. No current news exists on the progress.

Further, the creation of an entity called Kekeli like ContourGlobal is at the planning stage for a natural gas plant of 65 MW capacity and hampered by equipment access delays. Negotiations are ongoing for construction materials needed for commissioning. This will be financed by Eranove, a French company.

In terms of training:

- With the help of Urbis Foundation 100, experts have been trained on solar technology and operations in the cities of Kpalime, Tsevie, and Anieh.
- For the upcoming CIZO project, 3,000 technicians were trained in 2019 (2 weeks of training per group). There were 600 technicians per region in all five regions of Togo. The training was done by KYA-Energy Group located in Lomé in partnership with the solar energy lab at the University of Lomé. The plan is to employ all those trained technicians in the future once the upcoming projects are executed. Additionally, 50 engineers (average of 10 per region) were trained at a master's level to oversee the CIZO project in due course.

5.3 Prospects for Developing Renewable Energy

The objective of this study is to evaluate the potential of renewable energy technologies and the impact of their development on the energy mix of Togo. Based on the literature, field work, and interviews, Togo relies most on biomass energy, petroleum, and electricity for its energy use (CEET 2018; CEET 2021) despite its potential in renewable energy that could be developed to implement a nationwide sustainable energy system (PANER 2015). As stated in Section 1, most of its energy is imported from the exterior to meet demand, and approximately 43% of its population still lacks access to energy (CEET 2021). This study used a three-round Delphi method to capture in-depth data. The first (2015) and second (2018) rounds of data collection targeted experts mostly in renewable energy, while the third round of interviews targeted the same groups of people in 2020, to validate data collected in the first and second rounds.

Figure 5-6 summarizes the percentage of experts who voted for the development of different types of renewable energy technology based on the interviews. From all listed renewable energy types, 80% of the participants strongly believed that developing solar energy PV is key to improving the energy situation due to its potential. This is not only based on participants' responses, but also on field visits, observations, and the literature. For example, Abusief, Caldon and Turri (2014) stated that solar energy is one of the most promising, non-polluting, free sources of energy. Their study reported the benefit of the high content of annual solar radiation in the Al Kufra area and the implementation of distributed generation technology using photovoltaic solar energy to improve the security of supply in this area. They concluded that, considering the advanced PV technology with decreasing cost and the high availability of solar energy in Al Kufra, it is strongly recommended to implement distributed generation technology using PV and battery energy storage systems to store the surplus PV energy produced or inject it into the grid or use it to supply part of the shed load, depending on the system mode.

Participants also argued that, compared to the other types of renewable energy, like onshore/offshore wind, wave, and tidal energy, the technology does not require a lot of money to develop, even though there is potential for these other sources as well (for example, wind power potential is estimated at 10–12 MW offshore and 3–4 MW onshore). Moreover, small-scale solar PV can be installed in remote areas that do not have access to the grid to provide electricity access to remote communities, which, according to Kizilcec and Parikh (2020), can provide technically and financially viable solutions for electrification to households located far from the electricity grids as well as those unable to afford a grid connection. Nerini et al. (2018) emphasised the need to explore off-grid solutions for electrification in sub-Saharan Africa, as this can lead to social and economic development and support the delivery of outcomes across all SDGs. This is supported by Olatomiwa, Mekhilef and Ohunakin (2016), who suggested a system of autonomous, off-grid power generation be established for rural communities in Nigeria using renewable energy technologies since improving rural access to electricity through grid extension does not look promising at present due to the associated costs. Furthermore, Siritoglou and Oriti’s (2020) study made use of tools such as design equations in compliance with IEEE standards for accurately sizing the distributed energy resources of a standalone microgrid to meet the critical load demands of a military, commercial, industrial, or residential facility when the utility power is not available. This microgrid combines renewable resources such as PV with an energy storage system to increase energy security for facilities with critical loads. This can also be applied to remote areas to provide the needed electricity using small-scale solar PV.

About 70% of the participants suggested the development of hydropower energy due to the presence of many rivers in the country. Based on this, the government is planning to increase hydropower capacity through the development of three projects, namely Sarakawa, Tetetou, and Titira.

- At Sarakawa, the government is planning the construction of a 24 MW hydroelectric dam on the Kara River with an annual output of approximately 105 GWh, the construction of an energy evacuation line, and rural electrification of 29 localities in the project area by extension of the electricity network. The French Development Agency (AFD) and the European Union are committed to developing this project due to the interesting characteristics (technical, economic, and environmental) it presents.
- At Tetetou, the government is planning to exploit the hydroelectricity potential using the Mono River to construct a hydroelectric dam of capacity 50 MW with the help of the European Union.
- At Titira, the government is planning the development of a hydroelectric project with a capacity of 24 MW. For this, a joint development agreement was signed in December 2019 between the Ministry of Mines and Energy and Globeleq. This agreement provides for the study of three variants, namely a hydroelectric plant, a hydroelectric plant coupled with a solar plant, and a solar plant with storage. Discussions are still ongoing.

Currently, Togo relies on biomass for most of its energy supply, with more than 60% of its needs filled by wood. According to the response biomass energy currently plays a big role in the country due to the country's level of poverty, as most of the indigenous cannot afford other types of energy (Kansongue, Njugana and Vertigans 2018). Some rely on cutting down trees for their use, destroying the environment. This also comes with many consequences due to the pollution from the use of firewood for cooking, often causing health issues, especially in women and children. Participants answered that, though this type of energy is harmful, most of the population will keep relying on it for energy use until the poverty level improves. Based on data from the second data collection round, since March 2019, the government has put in place some subsidies providing a grant of 2,000 FCFA per month (approximately $3.5) over 36 months to each house that owns a solar kit from the CIZO project providers. This is to encourage households to subscribe for the use of solar for their energy needs. This offer is conditional on payment of the monthly household fee. The kit's cost varies depending on the needs, with three tiers: Basic, $8.23; Basic Plus, $11.32; Premium, $19.29. Subscription is quite easy, and at least 40% of the clients subscribe to the Basic plan (capacity of 50 W), which is mostly used for lighting. However, the big issue comes with the monthly payment because, despite the grant, the farmer is left with a bill of approximately $6 per month to pay, and this is difficult for most farming communities.

Based on our study responses, other types of energy, such as solar thermal, offshore wind, onshore wind, geothermal, tidal, and wave, all have potential but will cost a lot more to develop.

Successes relating to recent installations of solar energy, such as the PRODERE project (which consisted of installing solar energy in 22 villages from 2013 to 2016 with the aid of WAEMU) include lighting purposes, phone charging, and powering radio and televisions. In some areas, these are used to help power hospitals for vaccine and medication storage. Other uses include water pumping and lighting schools, markets, and churches. Other solar projects have included the construction of four mini solar plants from 2017 to 2019. These are as shown in Table 2, namely 250 kW in Assoukoko in Blitta (Central region), 100 kW in Kountoum in Bassar (Kara), 100 kW in Takpapiéni in South Oti (Savanes), and 150 kW in Bavou in Ogou (Plateaux).

The solar plant located in Assoukoko is equipped with three water supply systems to help the population with potable water. The remaining three solar plants are mainly for electrification. Also, according to the quarterly activity report of solar kit distributors, from October 2019 to April 2020, Soleva distributed an estimated

1,385 solar kits (Table 4-3). This is part of the national plan which provides for the 55,000 kits by 2030 mentioned in Section 1. Everyone can benefit from it, especially in rural areas. The price varies from one operator to another according to the power requested. As mentioned above, the state offers a subsidy program of 2,000 FCFA per month per household to cushion the burden on the household. Most of these kits are used for electrifying homes, businesses, and equipment.

With regards to the planned offshore wind project, data gathered shows that this did not progress for several reasons:

- According to a study report presented in December 2017 during the ROGEP ECREEE workshop, potential development for wind energy is low within the country, with the exception of areas located around Lake Togo.
- The Delta Wind project has not progressed to date due to the selected areas, which are subject to wind instability and low capacity. Furthermore, experts mentioned that the wind turbine masts have to be raised to at least 100 m to reach the speed needed to produce energy. This will require a big investment, and project leaders are still looking for technical and financial partners to assist. There have been some rumours as well indicating that the Togolese company in charge of generation (CEB) offered to purchase the kWh at a price that will not ensure the profitability of the project.
- The average wind speed is said to be between 1 and 4 m/s when an average of 6 m/s is required.
- There is hearsay of personal interest issues that do not favour policymakers.

When asked if renewable energy should be promoted, 70% of the experts supported the idea mainly for solar energy and hydropower development due to their potential. Some of the arguments they listed included the following:

- They are good for the environment and will help protect the environment, curb pollution, and promote better health.
- They are natural sources of energy needed in a fast-developing world because demand is on the rise.

- They can be developed at a small scale, especially in remote areas that do not have access to the grid and can provide reliable access to electricity for the population at an affordable price with time.

Thirty percent of the expert disagreed. Reasons for supporting the non-promotion included:

- They are intermittent sources of energy and will be insufficient to meet demand, which is always on the rise.
- They are expensive given the current technology, and energy storage still causes an issue due to the lack of power storage technological equipment.

5.4 Conclusion

This study presented the views of key stakeholders in relation to renewable energy development (mainly solar and hydropower) in the energy mix of Togo, highlighting the current energy situation and actions planned for development to increase energy access in Togo. With a three-round Delphi method, the study captured the views of key stakeholders on the subject matter. It has been concluded that increasing the share of renewable energy, namely solar photovoltaics (PV) and hydropower, could significantly improve the energy situation in Togo. This could be done through the installation and development of small-scale solar plants and hydropower. Based on the discussions above, a lot of renewable energy development projects are taking place, and many others are being planned between now and the next 10 years. The study also found that, to date, there are few adopted rules and regulations within the energy sector and few incentive measures in taxation, and these only favour companies with public interest and not private organisations. Moreover, the non-liberalization of the energy sector does not encourage investment from private investors, as CEET remains the sole entity that can market any electricity generated. More than three-quarters of the expert panel also recognized the need to prioritize renewable energy due to its socio-economic and environmental benefits while promoting its diversification for better suitability depending on the location as well as greater access and reliability of energy. Finally, promoting research was suggested to help optimize the system for better performance, create manufacturing plants on-site, and produce materials that are accessible but efficient and adapted to each location. This should be done both by raising awareness of renewable energy many advantages and by incorporating staff training for a qualified workforce for development.

5.5 Limitations

An acknowledgement of the limitations of the Delphi method must be made. According to Bonaccorsi, Apreda and Fantoni (2020) and Chen et al. (2020), this method can mitigate overconfidence but cannot address the social desirability bias which is a form of bias that occurs when participants respond to questions with answers that they think would be acceptable to the researchers rather than based on their true views or experiences. This was overcome by guaranteeing participants confidentiality, ensuring anonymity, and assuring them that all personal information will be kept private. Therefore, we encourage further methodological, empirical, and theoretical studies on the improvement of the Delphi method in various research contexts.

Another limitation is tied to the data sampling when it comes to the gender and age implications of this study. As discussed earlier, only two or 6.4% of the participants with expertise in this study were female, as the energy sector staff was predominantly men, which caused a big gap, reflecting the gender inequality in the overall workforce in Togo. In addition, the age range of respondents was mostly between 25 years old and 60 years old, excluding younger and elderly people, whose voices could make a difference to the findings of the study. Research has shown that, historically, women have contributed to advancing technology in energy fields despite the gap caused by gender inequality.

More effort is needed from policymakers to address gender equity so that women are more involved in the decision-making process to ensure that better national energy policies and strategies are developed for the best benefit of all. Many studies support the idea that ensuring the inclusion of women in the design, planning, and implementation of energy access solutions as well as developing business models is essential to maximizing the development of energy solutions and ensuring a fair distribution of benefits of the projects (Tsagkari 2022; MacEwen and Evensen 2021; Bisaga 2018; Cecelski 2000). For example, MacEwen and Evensen (2021) stated that women's empowerment is a result of not only access to resources, like clean energy, but also involvement in decision-making and participation in deliberation processes.

In addition, Bisaga (2018) emphasised that gender mainstreaming in energy policy, planning and implementation is crucial to ensuring that all end-users' needs are met. This is the only way to make sure efficient and effective solutions are provided to the beneficiaries, as there could be consequences if gender inequality is not carefully considered when it comes to profits arising from investment in energy development as well as policy decisions. Cecelski's (2000) report showed that women have taken active roles in renewable energy projects that produce real benefits, such as improving their quality of life, reducing their workload, and proving them with opportunities to increase their income. Some examples include women's contributions to the design of household energy technologies and projects, such as improved stoves, which have been more effective and produced more benefits after receiving women's input on the product design. Another example is women's successful influence of energy policy decisions at the local, national, and international levels, which can be seen in their ability to determine the use and benefits of a project, managing arrangements, as well as receiving and controlling benefits (Cecelski, 2000).

Taking the case of Togo, the limited response of women who participated in this study prevented comparative analysis. Some of these results might have been different if more women and children were to take part in the study. It is very common to have more women in West Africa, including Togo, be the biggest users of energy for cooking and heating, which continue to expose them to harmful smoke every day due to the continuous use of firewood and charcoal as cooking fuels. Besides women, children and elderly people generally spend more time at home using the available systems than men, who mostly spend their time out working in the field or in offices and are mostly home in the evenings. In this case, the probability that men might not bring insightful suggestions into some of the problems that they rarely pay careful attention to or spend a lot of time with is high. Therefore, including women should not only be an option but rather a must to develop effective, efficient, and sustainable solutions to their energy needs and demand. This is demonstrated by Bisaga’s (2018) research, for example, which showed that men were on average more satisfied with solar home systems in Rwanda than women. This reflects the fact that these men have less interaction with the systems than women, who use them often enough to have a true understanding of their functionality, issues, and problems. The same goes for children and the elderly. Children, for example, help with household activities and use the available energy to study after school in the evenings. They also spend more time going to fetch potable water, which could have instead been allocated to their studies. Meanwhile, some elderly people spend more time at home after retirement, watching TV, if available, or listening to the radio, which can keep them engaged and less bored. Therefore, all gender and age groups should be included to ensure that better energy policies and strategies are developed.

6 CHAPTER 6 – A PESTEL APPROACH TO ANALYSING THE POTENTIAL IMPACT OF Renewable Energy DEVELOPMENT IN TOGO

6.1 Introduction

Like most developing countries, Togo continues to rely on the use of traditional forms of biomass energy, which causes tremendous socio-economic, environmental, and health hazards. In addition, the imbalanced distribution and use of electricity, petroleum, and liquid gas reflects the disproportion in income and quality of life. This disparity could be improved if steps are taken to develop Togo’s energy supply portfolio through the currently poorly valued and significant renewable energy potential, such as solar and hydropower.

This chapter will highlight the development of renewable energy in the past decade, providing a summary of the impact this has had so far on the environment and socio-economic development within the country. In addition, this chapter will discuss the challenges facing the Togolese government using a framework approach that will address the sustainability issues and provide solutions for the methods that will lead to the greatest impact and development based on the analysis. PESTEL and SWOT analyses are utilised to assess both the internal and external factors in relation to renewable energy development and its impact on Togo. The results show that renewable energy development in Togo has improved in the past decade and had some impact on the socio-economic development. However, better development will be achieved if approaches are introduced to provide a long-term solution to the high capital costs of the technologies, institutional sustainability is incorporated, the number of trained personnel and people with technical expertise is increased, and the government engagement with funding bodies to secure funds that will favour the off-grid and poorest communities is increased. There is also a need to include local participation in the design and operation of projects, introduce a cross-subsidization tariff scheme that covers the operation and maintenance costs of off-grid solar PV users and favours poor households, liberate the energy sector, and get government support to help private investment in rural electrification via build-own-operate arrangements.

6.2 Results

6.2.1 Impact Analysis Based on PESTEL Factors and SWOT Analysis

This section discusses the impact of renewables based on political, economic, social, technological, environmental, and legal factors. It also discusses the results of the SWOT analysis, highlighting factors (strengths, weaknesses, opportunities, and threats) that are affecting the development of renewable energy in Togo. By reviewing literature and analysing data collected, Table 6-1 below provides details of key items discussed for each PESTEL factor, and Table 6-2 provides details of key items discussed for the SWOT analysis. These are correlated as SWOT helps understand the results of the PESTEL to decide on strengths, weaknesses, opportunities, and threats. It also informs on internal factors while PESTEL identifies external factors that are outside of control. Brief PESTEL could be considered as a complementary tool to SWOT. The information provided in both Table 6-1 and Table 6-2 below are from the data collection results, which came from primary, secondary, and tertiary sources, as well as the analysis and recommendations derived from the results and literature. The status was decided based on the outcome of the study and how each factor of improvement or development in renewable energy affected the people and communities involved, which was established through engaging with them and learning from their experiences. Table 6-1 and 6-2 below provide a summary of the key items described in the PESTEL and SWOT results. The sections below provide comprehensive details with regards to the impact of renewable energy for each factor. It is worth noting that some of these factors can be cross cutting and it is necessary for them to be coordinated at all stages of development for efficiency. For example, economic issues can affect technological development, good technologies could increase production, contributing to a better economic situation, which in turn can affect the society and lead to sustainable development. Social and economic factors can reveal disparities among communities and impact their day-to-day.

Table 6-1: PESTEL Analysis Factors

Factors		**Details**	**Status of Impact**	**Criteria**
Political	Governmental Policy	Policy to distribute renewable energy at a subsided price for households as part of the electrification program, 2018. National Program for Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation (REDD+) 2010-2050, passed in 2015.	Positive	Data Collection
	Tax policy	Finance laws 2020 and 2021—tax exoneration on solar products to help companies. This law notably provides for exemptions or relief from the tax burden (customs duties and VAT) on the import of new electric and hybrid vehicles. It applies for a maximum duration of five years.	Positive	Literature and Data Collection
	Environmental policy	National Environmental Policy passed in 1998, which aims to define specific actions to protect the environment in Togo and ensure sustainable growth for the country in the medium to long term.	Positive	Literature
	Funding grant and initiative	Need for the government to help private investment and engage with different funding bodies that could help.	Neutral	Data Collection
Economical	Economic growth	Additional income generation for small business/farmers.	Positive	Literature and Data Collection
	Inflation	Financing capabilities are exceptionally low, but there are progressive increases in the prices of goods and services.	Negative	Literature and Data Collection

	Disposable income of consumers and businesses	People's disposable income is too low to afford expensive imported solar kits.	Neutral	Data Collection
	Wage rates	Extremely low wage rates.	Negative	Literature and Data Collection
	Financing capabilities	Need for innovative financing mechanisms to develop renewable energy.	Negative	Literature and Data Collection
	Economic Investment	Need to foster income-generating activities.	Negative	Literature and Data Collection
Social	Population Growth	High rate of population growth.	Neutral	Literature
	Age distribution	Population is unevenly distributed and mobile.	Negative	Literature
	Health	Improvement in health issues/health centres.	Neutral	Data Collection
	Career attitude	Better growth opportunities for students, public facilities, social benefits in increasing small business activities.	Positive	Literature and Data Collection
	Customer buying trends	Improvements in customer buying trends due to long sales.	Positive	Data Collection
Technological	Producing goods and services	Technology is central to renewable energy and increase in technology could help produce more goods.	Negative	Data Collection

	Increased training to use innovation	Low staff skill levels need to be improved.	Neutral	Data Collection
	Potential returns on investment	Cost of investing in solar products and potential return.	Neutral	Data Collection
	Cost and tax	Cost of equipment and reduction in taxation.	Positive	Data Collection
Environmental	Pollution and greenhouse gas emissions	Reduce pollution from thermal power stations and from cooking with firewood.	Negative	Literature and Data Collection
	Promoting positive business ethics and sustainability	Encourage the promotion of positive business ethics and sustainability.	Negative	Data Collection
	Reduction of carbon footprint	Reduce the amount of energy used; reduce waste.	Neutral	Literature and Data Collection
Legal	Renewable energy legislation	Law on the Promotion of Electricity Generation from Renewable Sources (2018). This law aims to enable the country to enjoy 50% renewable sources in its mix of electricity supply by 2030, in line with its electrification strategy spanning the period from 2018 to 2030 (Horizon 2030).	Positive	Literature and Data Collection
	Health and safety	Improve the health issues and safety of people. The 2018 renewable energy law also applies to the safety, operation, storage, marketing, and security of renewable energy sources.	Positive	Literature and Data Collection

	Equal opportunities	Need for transparency and equal opportunities for companies that enter the field.	Negative	Data Collection
	Future legislation	Introduce policies and legislation for better development. Togo has established a regulatory body, passed a public–private partnership (PPP) law and a public procurement decree, and established an agency to promote rural electrification in 2018.	Positive	Literature and Data Collection
	Competition law	Laws that protect the consumers. Mechanism to support low-volume consumers, such as social and lifeline tariffs.	Positive	Literature
	Environmental legislation	Law 2008-005 – Framework Law on the Environment. This law sets the general legal framework for environmental management in Togo. Togo is exploring a legal framework to promote renewable energy and a new off-grid rural electrification strategy. It is also currently in the planning stages of revising its national energy law to strengthen the role of the regulator.	Positive	Literature

Table 6-2: Summary of the SWOT Results

SWOT Factors	Results	Results
Strengths	What is been done well in Togo in terms of renewable energy development?	- A policy for tax exoneration has been put in place to help companies distribute renewable energy technologies at a subsidized price. - Some trained personnel: 50 engineers, 100 experts, and 3,000 technicians. - Institutionally, a separate entity called AT2ER was created within the Ministry of Energy that will specifically take care of renewable energy projects and rural electrification programs. - On the organisational level, an electrification strategy has been put in place with the goal of achieving 100% access to electricity by 2030.
	What unique resources does Togo have?	- Togo is endowed with a lot of potential for renewable energy, amongst which solar and small-scale hydropower are the most recommended. - Government plan to increase hydropower capacity through the development of three projects, namely Sarakawa (24 MW hydroelectric dam on the Kara River), Tetetou (use of the Mono River to construct a hydroelectric dam of 50 MW capacity), and Titira (plans to develop a hydroelectric project with 24 MW capacity). - High percentage of youth that could be used as a working force for development.

	What others see as strengths	- Renewable energy will bring about a cleaner environment and reduction in carbon emissions. - Renewable energy will create new jobs.
Weaknesses	What are the issues, and what can be improved?	- There is no approach to providing a long-term solution to the high capital costs of the technologies. Institutional sustainability is important when it comes to the sustainability of rural electrification programs. - Lack of funding. There is a need for the government to engage with different funding bodies that could assist in putting up in place policies that favour the off-grid and poorest communities.
	What resources are lower compared to others?	- Most of the in-house technicians have little knowledge, and the majority of experts come from the exterior, such China, Germany, Italy, and France. - Renewable energy resources such as solar thermal, onshore wind, offshore wind, and geothermal.
	What could be seen as weaknesses?	- Lack of capital and technical expertise to develop renewable energy in the current challenging Togo economy.
	What opportunities are open to Togo?	- Availability of lot of natural resources in renewable energy that could be utilised to achieve sustainable development. - The capital city is in a coastal area, which could be exploited to develop wave and tidal energy.

Opportunities	What trends can the Togolese take advantage of?	- Building on local capabilities could enhance irrigation and aquaculture management.
	How could the opportunities be turned into strengths?	- Ecotourism could be created by constructing a traditionally bult and locally resourced base structure (including use of renewable energy power) that will provide accommodation and leisure facilities for tourism, which could increase local employment, establish stronger retail for hotel need supplies, and highlight Togo's importance in wildlife conservation. - The design and construction of a multifunctional dam for managing the water supply and providing a suitable facility for fish production could be helpful in developing the assets of this city.
Threats	What are the possible threats?	- Long dry season coupled with climate change issues. The recent shortage of rain could have a big impact on hydropower plants' operation and energy production. - The season of harmattan, with strong wind, could end up destroying hydropower plants' infrastructure. - Energy storage could be a challenge.

	What are other countries doing that could be a threat if Togo copies it blindly?	- Adoption of least-cost analysis in implementing a rural electrification planning framework that first evaluates and assesses the cost-effectiveness of undertaking an off-grid project, compared to grid extension for other countries without looking into what could be suitable in Togo. - Introducing a cross-subsidization tariff scheme that covers the operation and maintenance costs of off-grid solar PV that will favour poor households basing on imported technologies without proper study. - Policymakers recognizing that renewable energy is much cheaper compared to conventional types of energy for the life cycle of the project without proper research to find the best adapted technologies that will be efficient for Togo. - Support from the government to help private investment in rural electrification via build-own-operate arrangements based on technologies that are more feasible in other countries.
	What types of threats are clearly shown?	- The monopoly and non-liberalization of the energy sector within the country by CEET, which does not help; liberalization of the sector is needed for investors to invest. - Renewable energy requires high starting costs but is more beneficial in the long run.

6.2.1.1 Political Factors

To reduce the rural energy deficit, the Togolese government put in place a separate entity called AT2ER within the Ministry of Energy that will specifically take care of renewable energy projects and rural electrification programs; it has an electrification strategy with the goal of achieving 100% access to electricity by 2030. In addition, it launched a solar electrification project in 2017 which was supported by the African Development Bank (AfDB) in partnership with private company Bboxx. The aim of the project is to bring light to 2 million Togolese (approximately 300,000 households) by 2022. Based on this, the government put a policy in place for tax exoneration on solar products to help companies like Bboxx distribute renewable energy technologies to households at a subsidized price as part of the electrification program. These subsidies as discussed in Table 6-1 have been introduced as part of the political framework by the party in power to get more people to sign up. As part of this program, Bboxx installs individual household solar kits for rural households, and each household in turn pays $8.23 per kit for the Basic tier, $11.32 per kit for Basic Plus, and $19.29 per kit for Premium, depending on their needs; all three are 50 W to facilitate upgrades. Bboxx uses a pay-as-you-go (PAYG) business model that has a payment plan of up to 36 months. This is a small-scale standalone system which provides electricity to customers who pay for it using mobile banking (Alstone, Gershenson and Kammen 2015; Baker 2023). In Togo, registration is quite easy, but monthly fees could sometimes be tricky, as these could be impacted by the unavailability of mobile charging points. Since 2019, the government has subsidized the cost by 2,000 FCFA (approximately $3.80) per month for each household with a solar kit. It plans to do that for a period of 36 months from the start date, under the condition that the household pays the monthly fee itself.

It is worth noting that, while this practice can lead to improved adoption and diffusion of renewable energy technologies, it is extremely difficult for registered individuals to sustain due to a lack of funds. Based on the data collected, only 4% of rural off-grid households subscribe, of which 40% go for Basic Plus. If the farmer cannot pay after registration, the kits are repossessed after a grace period of 120 days in a year. It should be noted that these subsidies for financing of renewable energy systems seek to address sustainability challenges by creating beneficial dependence on subsidies (Zalengera et al. 2014) when, in reality, the solution is not sustainable, as people do not have the means to keep up with their payments long-term. This results in the repossession of the kits, which makes the solution temporary and not sustainable. This approach fails to provide a long-term solution to the high capital costs of the technologies involved, as an average farmer will not be able to sustain payment of even $5 per month, and most beneficiaries would not be able to purchase the systems for a long period of time due to their economic situation. These issues could be remediated if the kits were not imported at high cost and were instead made locally at cheap prices that could be afforded by the community. However, more research needs to be done to implement this solution.

Institutional sustainability is a key reason for the development of renewable energy. This has been shown in Chile, where the rural electricity rate is nearly 100%. A key reason for this success is the Ministry of Energy recognizing that renewable energy is much cheaper compared to diesel generators for the life cycle of the project (Feron, Heinrichs and Cordero 2016; Feron, Cordero and Labbe 2017). This shows the importance of institutional sustainability when it comes to the sustainability of rural electrification programs (Feron, Cordero and Labbe 2017). Additionally, receiving support from the government helped private investment in rural electrification via build-own-operate arrangements, which is another key to their success. Furthermore, Chileans took into consideration local participation in the design and operation of projects.

Looking at the current issues in Togo, there is a need for government intervention, engagement, and complete support towards renewable energy projects and implementations. Furthermore, Togo could also learn from Kenya, which increased electricity access from 23% in 2013 to about 50% in 2016 (Lee et al. 2016). This success is owed to the formation of the Rural Electrification Authority (REA) in 2006, which played a key role in this development. There have been huge investments through subsidies and adequate planning. A GIS-based special least-cost analysis (Lee et al. 2016; Alao and Awodele 2018) has been adopted in implementing a rural electrification planning framework that first evaluates and assesses the cost-effectiveness of undertaking an off-grid project, compared to grid extension (Alao and Awodele 2018; World Bank 2008). In addition, the government of Kenya engaged with the World Bank, which influenced its recent policy that favours mini-grids as a least-cost off-grid electricity. This was done with the support of the Energy Sector Management Assistance Program (ESMAP). ESMAP also assisted the government in initiating an electricity access plan focusing on the most marginalized and poorest counties (ESMAP 2017; Alao and Awodele 2018). Just as Kenya's government did, the Togolese government needs to engage with different funding bodies as discussed in Table 6-1 and Table 6-2 that could assist in putting in place policies that favour the off-grid and poorest communities.

6.2.1.2 Economic Factors

There have been a few benefits from the installation of solar kits based on the rural electrification programme CIZO. A total of 40,199 solar kits have been installed by Bboxx within Togo. The Electricity Sector Regulatory Authority Activity Report (ARSE 2019) showed that 24,601 customers had installed the solar kits since 2017. It also showed that 20 shops were opened, and 10,225 customers had the Basic solar kits installed (comprising a solar panel, battery, and three bulbs) in 2019. In addition, approximately 6,511 customers had installed the Basic Plus kit (comprising a solar panel, battery, four bulbs, one loadable torch, and a radio). There was no Premium solar kit installed (comprising a solar panel, battery, one 24" television, four bulbs, one loadable torch, and a radio). A total of 1,158 solar kits were withdrawn for default on payment. Findings from the data collection showed that these installations have mostly been used for electrification and some basic needs. The same goes for the Soleva solar kits, which had a total of 1,003 customer installations by December 2019 and 1,385 by April 2020. According to the interview results, beneficiaries mentioned that these, coupled with the installed CEET streetlights and the solar photovoltaic mini grids, have helped children study, reducing the amount of money spent on kerosene for lamps. In some cases, public lighting has helped women have prolong sales of their products instead of having to stop selling once it becomes dark, a plus to the economic growth as discussed in Table 6-1. This has helped provide additional income to the users, thus improving the economic situation of the households. Furthermore, in the data collection results discussed in Chapter 5, participants mentioned that some of the installed solar kits have encouraged professional activities and helped small businesses increase their income in rural areas, as they can spend more time continuing their activities and improve productivity. Another tangible example of the impact highlighted by one of the private-sector participants during the interview had to do with bill reduction. As discussed in Chapter 5, an owner of a clinic with 30 to 40 rooms who used to pay 1.2 million FCFA in bills to CEET every year was able to lower his expenses to 800,000 FCFA per year in less than 3 years once he got solar installed. In addition, based on the responses received from participants during the interviews, the majority believe that the use of renewable energy will add value to produce, as farmers can take the opportunity to grow their products even in dry seasons, thereby generating more revenue.

Besides these benefits resulting from the recent installation of solar kits in Togo, it is worth noting that the estimated population of Togo according to World Bank Group (2023) is 8,848,700 (World Bank Group 2023), and Togo has a per capita gross domestic product (GDP) of $644.07 (Trading Economics 2022). In addition, Togo is classified as a Least Developed Country (LCD) and Low-Income Food Deficit Country (LIFDC) (United Nations WFP 2021) and remains among the poorest countries in sub-Saharan Africa. Over 50% of the population lives below the poverty line with extremely low wage rate and disposable income as discussed in Table 6-1 (under $1.25 per day). Findings from the interviews with various stakeholders, workshops conducted in rural areas, and observations during the field visits showed that the most affected by the lack of energy in Togo are those living in rural areas of Togo, which are the least developed. The poverty level was twice as high in rural areas (68.9%) as in urban areas (37.9%) and 34.8% in Lomé in 2015 (PND 2018). In 2021, the poverty level was estimated to be 58.8% in rural areas and 26.5% in urban areas according to the World Bank (2021). This is due in large measure to an annual population growth rate of 2.5% that is outpacing development progress, concentrated economic growth in the modern sectors, and limited access to quality services (World Bank 2021).

Based on gender, the poverty level is higher in households headed by women than those headed by men. This figure was estimated at 57.5% for women and 54.6% for men in 2015 (PND 2018). The poverty level has since decreased and is now estimated at 45.7% in female-headed households and 45.2% in male-headed households (World Bank 2021). Women remain more vulnerable, as they have less access to economic opportunities, education, health, and other basic socio-economic facilities (World Bank 2021). Social records indicate that self-employed farmers have the highest poverty rate despite the decrease in the level of poverty. The decline is mainly due to the significant investments made in the agriculture sector by the government. Employees in the public sector recorded the lowest poverty rate in 2015 (28.1%) according to PND (2018). Employees in the private sector and self-employed individuals are the socio-economic groups within which poverty rates increased between 2011 and 2015 (from 44.1% to 49% and from 39.7% to 46.2%, respectively) (PND 2018; Togo Embassy 2022). In addition to the poverty level being high in rural areas, the lack of access to the electricity grid is another issue. To improve the electrification rate, the government's policy put in place to subsidize solar products to help companies like Bboxx distribute renewable energy technologies at a subsidized price presents a significant barrier to sustainability. This is because, looking at people's financing capabilities, subsidizing the price is a plus; however, the majority of the population could not afford to pay over $5 per month emphasising the need for innovative financing mechanisms to be developed as discussed in Table 6-1. Furthermore, renewable energy technology kits in Togo are imported and mostly expensive, one of the weaknesses as discussed in Table 6-2 above. Based on the findings from the interviews, people's disposable income is generally too low to afford goods due to inflation issues within the country, not to talk about expensive imported solar kits. Table 6-3 shows the inflation evolution between 2009 and 2020.

Table 6-3: Inflation Rate Between 2009 and 2020

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Inflation rate (%)	3.71	1.45	3.56	2.58	1.83	0.19	2.58	1.29	−0.98	0.93	0.69	1.83

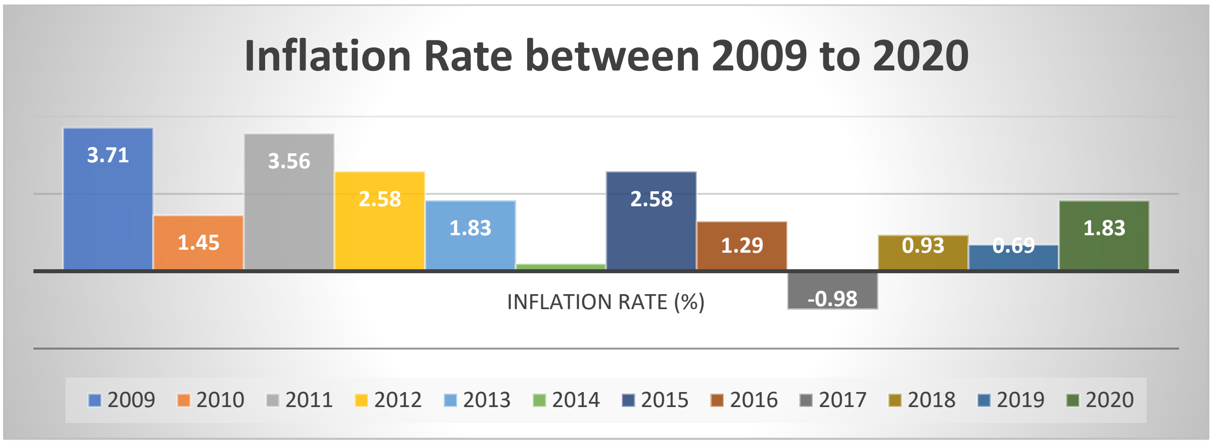

Figure 6-1: Togo Inflation Rate Between 2009 and 2020 (World Data 2021)

According to World Data (2021), the inflation rate was approximately 4.3% per year between 1979 and 2020. An item that cost 100 FCFA in 1979 cost 510.91 FCFA in the beginning of 2021, an increase of 410.91 FCFA. Between 2013 and 2016, inflation was brought under control to 1.4% on average due to the decline in food prices, which generally benefited from good weather conditions over the period, and a decrease in petroleum products (PND 2018). In 2019, the inflation began rising again from 0.69% in 2019 to 1.83% in 2020 due to higher food and oil prices (World Data 2021; World Bank 2021). In addition to these factors, the COVID-19 pandemic halted growth, which fell to 1.8% in 2020 compared to 5.5% in 2019 following a decline in investments and consumption. Travel restrictions have adversely affected the tourism and services sector, while the agriculture sector has remained resilient (World Bank 2021). A rebound in capital goods imports to combat COVID-19 and a reduction in exports widened the current account deficit from 0.8% of GDP in 2019 to 1.5% in 2019. Grants and concessional loans helped finance the current account deficit. Debt rose from

52.4% in 2019 to 60.3% in 2020, owing to the significant increase in the fiscal deficit from 0.9% in 2019 to 6.9% in 2020 and a slowdown in economic activity (World Bank 2021).

Thus, without innovative financing mechanisms (emphasising national constraints with limited capacity for individuals to be able to afford to buy technologies), the adoption of renewable energy technologies will remain low. This is because there is a need to come up with ideas that will foster income-generating activities that will facilitate paying for good-quality systems capable of meeting people's energy needs (Zalengera et al. 2014). For example, ecotourism could be created by constructing a traditionally built and locally resourced base structure (including the use of renewable energy power) that will provide accommodation and leisure facilities for tourism, which could increase local employment, establish stronger retail for hotel need supplies, and highlight Togo’s importance in wildlife conservation. In addition, the design and construction of a multifunctional dam for managing the water supply and providing a suitable facility for fish production could be helpful in developing the assets of this city. These are opportunities Togo possesses that could be turned into strength as discussed in Table 6-2 above.

6.2.1.3 Social Factors

Renewable energy development has had a few advantages for the society in Togo so far. Based on findings from interview questions 3.1–3.6 in the first data collection and RQ4 in the second and third data collection questionnaires, the installed solar panels at some locations provide electricity for health centres, which assists in the storage of products such as vaccines and medications for the best functionality of the hospitals. In addition, some of the respondents mentioned that solar installations have helped with food storage in some houses and the progress of work at offices during power outages.

Another benefit is the reduction of the use of firewood for lighting and cooking, which lowers the number of people affected by respiratory diseases due to inhaling smoke produced using burning wood for cooking. There has also been an improvement in water availability and access to potable water due to solar pumping for the communities. Moreover, the data collection findings showed that the use of renewable energy is helping students in their studies by providing more opportunities to study. Furthermore, the results showed that a few social events, such as TV projection shows and dance events, have been organised, allowing people to socialise due to the electrification access. In all, the use of renewable energy has helped a number of public facilities have light and has added substantial social benefits as discussed in Table 6-1, including increasing small business activities, thereby reducing the level of unemployment and contributing to better overall health.

With the benefits offered by the installation of renewable energy, the population growth rate in Togo is on the ascendency, with an average growth of 2.84% annually, which increases the demand in energy need as well. For example, between 1981 and 2010, the total population grew from 2,719,567 to 6,191,155 (International Monetary Fund 2014), and it is currently estimated at 8,848,700 (World Bank Group 2023). The population is unevenly distributed: 42% live in the Maritime region, which covers only 23.2% of Togo's total area (International Monetary Fund 2014). The disparity in population distribution and growth complicates development plans according to the International Monetary Fund (2014). Togo's population is also highly mobile; many people migrate in search of economic opportunities, with some moving from rural to urban areas and others leaving the country (International Monetary Fund 2014). Most urbanization has occurred in the Greater Lomé Metropolitan Area, where 23.9% of the population resides. However, urbanization is poorly regulated, with no urban planning or environmental policies. Rapid and uncontrolled urbanization causes housing and infrastructure problems (International Monetary Fund 2014). According to the latest census data on the age and sex of the population, the proportion of young people remains high, with 42% of the population being under age 15 and 60% under age 25 (International Monetary Fund 2014). This indicates that fertility and mortality are still high. Due to the lack of decent jobs, the youth are exposed to social scourges such as banditry, prostitution, delinquency, and alcoholism. Additionally, Togo experiences migratory movements, which are reflected by a rural exodus (especially to the capital Lomé) and longstanding and significant international migration (PND 2018).

According to the interviews, respondents believed that if there were better living standards in rural areas, less migration will be registered. Based on the literature, field visits, workshops, and interview questionnaires, Togo has unique resources as discussed in Table 6-2 above. It is endowed with much potential for renewable energy, amongst which solar and hydropower have been recommended based on the results of the data collections. Respondents believed that developing solar and hydropower in rural communities would help solve energy issues and socio-economic issues forcing the youth to migrate to urban cities.

Currently, several developmental projects are taking place in the country, such as the installation of solar kits to provide lighting and water pumps to help the communities. The research results from the non-governmental participants suggested that one of the issues associated with these installations is the lack of inclusion of local communities in developing their future energy needs. They recommended that proper planning for sustainability before implementation of each project and adequate monitoring after implementation be carried out to ensure good functionality of the projects. The inclusion of local communities in developing their future energy needs has been emphasised by Feron, Heinrichs and Cordero (2016). Their research findings demonstrate that, for a project to be successful, it must meet the specific local needs and consider the socio-cultural reality of each community. Moreover, major progress on cultural justice, equity, and environmental awareness is needed to ensure the sustainability of rural electrification efforts (Feron, Heinrichs and Cordero 2016). In addition, Zalengera et al. (2014) stated that technologies and their development methodologies, including financing mechanisms, should be adapted to the contexts in which they would operate. They added that this requires in-depth knowledge of several factors, such as energy needs and requirements, prioritisation of energy services, purchasing power, satisfaction with energy services and experiences with prevailing energy technologies, social practices and social set-up of communities, and available technical skills (Zalengera et al. 2014). Furthermore, in their approach to risk identification for the tidal industry in the United Kingdom, Kolios and Read (2013) emphasised the communication issues within the industry and its external stakeholders. They found that local fishing communities, as well as the general public and local communities, must be considered at an early stage in marine energy development to better plan for future. Kizilcec and Parikh (2020), who looked at SHSs in sub-Saharan Africa, also emphasised developing local corporations to understand the nuances of different country contexts and tailor their approach to customers, depending on their income, rural or urban setting, and prior SHS knowledge.

It is worth noting that the lack of energy in Togo, especially in rural areas, remains a big issue impacting people's lives. Most of these areas are endowed with resources such as solar potentials and many rivers, which could be developed, thus permitting the installation of solar power technologies and small-scale hydropower that could bring a lot of benefits. For example, based on responses from the data collection, participants in rural areas indicated that the installation of solar in some hospitals has helped with the storage of vaccines and drugs and improved access to vaccines, anti-venom, etc., thus saving many lives. As discussed in Chapter 5, the respondents also suggested that the use of renewable energy could improve health issues because this would help reduce the use of firewood, thereby decreasing the amount of smoke people are exposed to, which could lead to a reduction in respiratory diseases and reduction in pollution and green gas house emissions as discussed in Table 6-1 above. However, aside from the government subsidizing households' monthly payments for solar kits, financing is needed to develop community-installed solar plants for hospitals, schools, and solar water pumping, for example, to provide clean water to the communities.

Another key aspect of the society is the need for education. This could be a powerful force for advancing opportunity, prosperity, and growth. There are some trained personnel—50 engineers, 100 experts, and 3,000 technicians—who could help with future project plans in the development of renewable energy. However, in general, the domestic financing of education in Togo has steadily increased, in nominal terms, while the share of education spending has, for its part, fluctuated, representing, on average, 17.3% of total public expenditure. The total operating expenses absorbing the largest part of the public education budget limit the government's ability to invest in education sector reform. Indeed, from 2014 to 2017, an average 98.4% of expenditure on education was devoted to spending on operations, i.e., essentially the wages.

International funding increased slightly between 2009 and 2017. The share of the funding sector of development partners by ratio of total sector investments increased from 71% between 2009 and 2011 to 89% between 2014 and 2017. The proportion of bilateral aid was on average at 92% and that of multilateral aid at 8%. France and Germany are by far the two main funders of education in Togo. The volume predictability and quality of aid to the education sector have not changed much over the period examined. Partners' investment only materializes in the form of projects, which limits the predictability of aid and has probably contributed, at least in part, to restricting the capacity of the government of Togo to plan, properly implement, and monitor projects and ensure consistency with Education Sector Plan (PSE) 2014-2025 (Universalia 2019). Should the level of education improve this could impact people positively in a way that will help renewable energy development.

6.2.1.4 Technological Factors

From RQ7, the findings show that the Law n° 2018-010 of 8 August 2018 relating to the promotion of the production of electricity based on renewable energy sources was introduced, and based on RQ7.1, participants from the Ministry of Energy stated that this law regulates the renewable energy sector and exempts taxes and customs duties on renewable energy equipment. Based on conversations with participants from private organisations, this law gives priority to renewable energy development and allows an increase in the national electrification rate by opening up electrification to the private sector under state supervision while guaranteeing the quality of the installations. This is a plus that encourages organisations to purchase equipment. However, findings from the interviews with participants showed some restrictions depending on the number of kWh consumed. Participants mentioned that the tax exemption mainly benefits companies with public interest that have relevant projects, and there is no benefit for individual or private companies that want to do business. Responses from participants showed that for consumption above 100 kWh, an authorisation and a licence is needed for each actor in the private sector obtained by Ministerial decree, which discourages SMIs and SMEs that are starting up.

With the constant growth of the population and increase in energy needs, efforts must be made to increase energy production to solve basic energy needs like cooking and heating. As Kolios and Read (2013) stated, firewood is becoming scarcer, and renewable energy technologies for cooking and heating, such as solar cookers, solar water heaters, biomass briquettes, and biogas, could be more important than small-scale solar PV and /or wind energy technologies designed only for lighting, particularly for households (Zalengera et al. 2014). Policymakers must bear in mind sustainable development when deciding on priorities in terms of development. For now, the Togolese government is focused on increasing energy access for most Togolese and making plans to build mini solar grids and increase hydropower capacity through the development of three projects. These are namely Sarakawa (24 MW hydroelectric dam on the Kara River), Tetetou (use of the Mono River to construct a hydroelectric dam of 50 MW capacity), and Titira (plans to develop a hydroelectric project with 24 MW capacity) as discussed in Table 6-2, amongst others, to achieve its set target of 100% electricity for all in 2030. To date, the most common technologies put in place are more solar panels for streetlights. That is helpful in some ways but will not help communities with their basics needs of cooking, business, etc. For instance, making sure water pumps are installed in rural areas would be suitable for the community water supply. Based on findings from the interviews and field visit observations, the north of Togo has rivers that could potentially be used with solar-powered plants to develop irrigation. This could be of big help to the farmers to continue their farming activities even in dry seasons and not have to wait for rainy seasons to grow their produce, thereby producing goods in all seasons and reducing the threats as discussed in Table 6-2. In the same way, a solar-powered, value-added crop processing unit could also be put in place to help farmers grow, process, and store more agricultural products in all seasons of the year, thus reducing poverty. These could be based on examples such as the one shown in Reza and Sarkar (2015), where the idea of solar irrigation in real practice was implemented and showed the economic and technical viability of a directly coupled solar photovoltaic irrigation pump system operating in Gaibandha, Bangladesh.

Another important factor to consider is the production of technologies that are suitable for the environment in which they are being used for good functionality and reliability as discussed in Table 6-1. It is therefore essential to increase training to use available equipment and develop expertise that will help make people capable of producing techno-economically viable components and systems in-house. Doing this will reduce the risk of getting inappropriate technologies like the broken-down water pumps supplied by previous a project in Southern Togo, as shown in Figures 4-4 and 4-5 of Chapter 4.

6.2.1.5 Legal Factors

Most renewable energy technologies used in Togo are imported. In 2018, Togo approved another IPP for a 65 MW thermal power generation plant, and it has taken significant strides to reform its legal framework to attract private-sector investment (USAID 2021). The government put in place the following laws (LSE 2022):

- Finance laws 2020 and 2021: This law notably provides for exemptions or relief from the tax burden (customs duties and VAT) on the import of new electric and hybrid vehicles. It applies for a maximum duration of five years.
- Law on the Promotion of Electricity Generation from Renewable Sources (2018): This law aims to enable the country to enjoy 50% renewable sources in its mix of electricity supply by 2030, in line with its electrification strategy spanning the period of 2018 to 2030 (Horizon 2030) as discussed in Table 6-1 above.

- Law 2008-005 – Framework Law on the Environment: This law sets the general legal framework for environmental management in Togo. It aims to:
  - Preserve and sustainably manage the environment
  - Guarantee to all citizens an ecologically sound and balanced living environment
  - Create conditions for rational and sustainable management of natural resources for present and future generations
  - Establish the basic principles for managing and preserving the environment against all forms of degradation in order to develop natural resources to fight against all kinds of pollution and nuisances
  - Sustainably improve the living conditions of the population while respecting the balance with the surrounding environment (LSE 2022)

The 2018 Renewable energy law also applies to the safety, operation, storage, marketing, and security of renewable energy sources. Based on interviews with stakeholders, taxation is still expensive on imported solar kits as well as batteries as discussed in Table 6-2, causing the cost of energy to be high. In addition, based on discussions, tax exemption is only considered in some cases, such as in the case of companies with public interest, and does not benefit private organisations. This is because the government wants to be selective about the types of companies that start up their company. It was also revealed from the data collected that heavy consumers are charged an 18% tax. Lowering the tax on renewable energy technology equipment without being too selective about certain categories of companies or consumers would enhance the affordability of renewable energy systems and lead to better adoption and diffusion, as also observed by Zalengera et al. (2014). It is therefore necessary for a more transparent and equal legal framework to be put in place to regulate clear coordination among the Togolese tax service staff that oversee importation activities.

Another issue affecting most of the Togolese communities is being faced with health issues resulting from the lack of clean water and the use of firewood. Wood, for instance, is used for cooking, exposing villagers to smoke pollution (causing respiratory disease), cold, and wind during harmattan (because of the excess cutting of trees that are being used for firewood). If favourable policies are put in place to encourage communities to obtain part of their energy for cooking and water heating from renewable energy sources, this could reduce the use of firewood, thus reducing health issues and saving live. Similar policies have been key drivers of renewable energy technologies in Western countries whereby energy suppliers are obliged to source part of their energy from renewables (Zalengera et al. 2014).

6.2.1.6 Environmental Factors

Most of the renewable energy development outlined above is being used for electrification, water pumping, and basics needs, based on the findings from the data collections. The majority of households in rural areas especially continue to rely on the use of firewood for cooking, causing women especially to inhale a lot of smoke. This continues to cause respiratory issues, amongst other health issues as well as pollution to the environment as highlighted in Table 6-1. There is a need for governments to identify energy technologies that will be appropriate based on the local concept and communities as well as affordable. Currently, an important barrier is the high cost of solar equipment, which discourages its wide adoption. It is essential that, instead of importing the renewable energy technologies, critical evaluation and research is done in-house to identify the technologies that will be most appropriate for Togo and build appropriate knowledge to help manufacture these technologies in-house at reduced prices. Moreover, if strong policy regulations are put in place, such as the introduction of laws that protect air quality, water, and the environment, this will encourage people to switch to best practices for better results.

Togo is aware of the major environmental risks it faces, especially issues with coastal erosion, deforestation, desertification, and climate change (PND 2018). The energy sector has set ambitious goals to reduce greenhouse gas emissions by

2030. On the national level, for instance, Togo is committed to reducing its emissions by 11.14% by 2030 and 20% afterward (PND 2018). Based on the discussions with some participants from the electricity company, there is major pollution from the thermal power stations coupled with damage to the soil which are threats that need to be avoided. All these issues could be solved by increasing the share of renewable energy and reducing the amount of pollution from thermal power stations and reducing pollution resulting from cooking with firewood, deforestation, desertification, and climate change by switching to the use of solar cookers and water heaters. If all of these options are investigated carefully and environmental and legislations policies put in place, a better impact could be achieved. This is supported by Kolios and Read (2013), who stated that developers must consider the bigger picture and how their actions may have detrimental effects on the environment at any stage of the project.

6.3 Discussion

The energy sector does not contribute effectively to the economic development of Togo, particularly to the improvement of agricultural, industrial, and mining productivity as stated by PND (2018). Togo is weakly endowed with modern energy resources and still depends largely on traditional energies, mainly wood energy, which are constrained by population growth and climate change. In addition, the monopoly of the electricity sub-sector hinders the development of mini grids in rural areas (PND 2018).

To date, petroleum products are still the main modern energies accessible to rural areas. Togo’s dependence on these energies is worrying, as domestic and industrial demand is growing steadily. The following issues are noted (PND 2018):

- Instability of the prices of petroleum products due to insufficient security stock of petroleum products
- The weak national capacity to cover national gas needs
- The country’s 100% dependence on oil-producing countries, particularly on fluctuations in the price of a barrel of oil

- Low capacity and dilapidated hydrocarbon storage infrastructure

The PESTEL and SWOT analyses above provide details with regards to the benefits, motivation, barriers, and possible solutions for each factor. To summarise, in the past decade, the following development key points could be noted.

6.3.1 Increase in Energy Production and Decrease in Importation

The total energy produced and purchased in 2009 was estimated at 713.01 GWh according to CEET (2010), with only 3.2% production. This amount increased to a total of 1,094.0 GWh in 2015 (ARSE 2015) and 1,258.25 GWh in 2018 (energy purchased was 872.63 GWh; energy produced by CEET was estimated at 12.23 GWh and that of ContourGlobal at 373.39 GWh, for a total of 385.62 GWh) (CEET 2018). Energy purchase plus production further increased to a total of 1,350.35 GWh in 2019, with 64.52% and 35.48% of energy purchased and energy produced in the country, respectively. This further increased to a total of 1,543.13 GWh in 2021 (CEET 2021). This breakdown is shown in Table 6-4. This variation shows some positive development, as mentioned by the PESTEL and SWOT factors.

Table 6-4: Estimation of Energy Purchased and Produced for the Years 2009, 2018, and 2019. Sources: Statistiques exploitation ContourGlobal Togo SA (2019); CEET (2019); CEET (2010); ARSE (2015); CEET (2018); CEET (2021).

	2009		**2015**		**2018**		**2019**		**2021**	
	Energy (GWh)	**Percen-tage (%)**	**Energy (GWh)**	**Percen-tage (%)**	**Energy (GWh)**	**Percen-tage (%)**	**Energy (GWh)**	**Percen-tage (%)**	**Energy (GWh)**	**Percen-tage (%)**
Energy purchased	690.21	96.8	1,073.09	98.09	872.63	69.35	871.25	64.52	845.76	54.8
Energy produced	22.81	3.2	20.91	1.91	385.62	30.65	479.1	35.48	697.37	45.19
Total	713.02	100	1,094.0	100	1,258.25	100	1,350.35	100	1,543.13	100

6.3.2 Increase in Total Customers or Number of Subscribers and Increase in Energy Access Rate

In 2009, the total number of customers was 161,654 (CEET 2010), and the access rate in 2010 was estimated at 25% according to Sustainable Energy for All (2012). This increased to 27.62% in 2013, with an estimated 233,036 electricity subscribers, which further increased to 438,911 in 2018 (CEET 2018). The national electrification rate increased to 45.09% in 2018, 53% at the end of 2020, and to 57.82% in 2021 (CEET 2021). This increase is due to the continued investment in the extension of the distribution network, which favours more access to electricity for the population (ARSE 2019). Table 6-5 shows the access rate per region in the years 2010, 2011, 2018, 2019, and 2021.

Table 6-5: Breakdown of the Electrification Rate by Region. Sources: ARSE (2019); ARSE (2011); SOFRECO (2010 pp. 54–56); CEET (2019); CEET (2020); CEET (2021).

Region	**Year 2010**	**Year 2011**	**Year 2018**	**Year 2019**	**Year 2020**	**Year 2021**
	Access Rate %	**Access Rate %**	**Access Rate**	**Access Rate %**	**Access Rate %**	**Access Rate %**
Lomé	86	63.99	93.37	94.77	96.70	98.55
Rest of Maritime		10	44.86	64.0	65.52	73.89
Plateaux Region	5	9.06	19.10	22.30	23.84	27.64
Central Region	2	17.67	24.69	28.51	31.61	38.95
Kara Region	5	12.58	27.49	31.33	33.91	36.65
Savanes Region	2	8.89	16.08	18.11	20.09	22.39

6.3.3 Increase in the Share of Renewable Energy

Renewable energy development in Togo has increased in the past decade. Details on recent developments of renewable energy in Togo are presented in Chapter 5. As discussed in Section 6.2.1.2, based on the CIZO project discussed in Chapter 5, the total numbers of recorded customers who had active solar kits installed by December 2019 were 40,199 and 1,003 for Bboxx and Soleva, respectively. These installations were done between 2017 and 2019. This number increased to 65, 784 active solar kits for BBoxx and 2, 306 for Soleva by the end of 2021. Two solar kits operators have been added namely Solergie (4, 124 active solar kits) and Moon (601 active solar kits). This brings the total number of active solar kits to 72 815 according to ARSE (2021). It is worth noting that the national capacity supply for the various energy needs in 2019 was 339.56 MW, 360.02 MW in 2020 and 489.22 MW in 2021, an increase of 35.89% from 2020 to 2021 (ARSE 2021). The share of renewable energy in 2021 was 18.85% versus 11.27% in 2020 (ARSE 2021).

In 2008 to 2010, the share of renewable energies (excluding biomass) was essentially made up of hydroelectricity of national origin, which represented 0.3% of the total supply or 1.57% of conventional energy supplies (electricity and petroleum products) (Sustainable Energy for All 2012; World Bank 2013). The share of renewable energy in the mix increased to 9.74% in 2021 against 6.04% in 2020 (ARSE 2021). This shows progress in the development of renewable energy within the country. A summary of the estimation of the electric power generation based on renewable energy sources in 2019 is shown in Table 6-6.

Table 6-6: National Estimation of Renewable Energy in 2019. Source: CEET (2019); AT2ER (2019); ARSE (2021).

Operator	Type of Renewable Energy Source	Site	Installed Capacity
CEB	Hydroelectricity	Nangbeto (Plateaux region)	65 MW
AMEA Togo solar SAU	Solar Photovoltaic	Blitta	50MW
CEET	Hydroelectricity	Kpime (Plateaux region)	1.6 MW
	Mini grids based on solar photovoltaic	- Bavou (160 kWc) - Assoukoko (250 kWc) - Takpapiéni (100 kWc) - Kountoum (100 kWc)	0.610 MW
	Public lighting based on solar photovoltaic	Throughout the entire national territory	3.87 MW
Bboxx-EDF	Solar kits Photovoltaic	Throughout the entire national territory	3.29 MW
Soleva	Solar kits Photovoltaic	Throughout the entire national territory	0.12MW
Solergie	Solar Photovoltaic kits	Throughout the entire national territory	0.21MW
Moon	Solar Photovoltaic kits	Throughout the entire national territory	0.03MW

6.3.4 Introduction of Renewable Energy Law

With regards to Law n° 2018-010 of 8 August 2018 relating to the promotion of the production of electricity based on renewable energy sources, the legal arsenal in Togo was strengthened in December 2019. This, as shown in the PESTEL discussion, is a plus and a good starting point to development. This law establishes the general legal framework for the implementation of electricity generation projects based on renewable energy sources, either for one's own consumption or for commercialization. It defines the legal regulation of the installations, equipment, materials, and movable and immovable goods necessary for the production, storage, transport, distribution, marketing, and consumption of electricity from renewable energy sources (Energypedia 2020). This law also applies to the safety, operation, storage, marketing, and security of renewable energy sources (Loi Energie, Republic Togolaise 2018). There are various decrees that specify the Renewable Energy Sources Act for individual measures. The decrees serve (Energypedia 2020):

- To determine the performance thresholds of the various legal regulations for electricity generation projects based on renewable energy sources (Decret n° 2019-019, 2019)
- To determine the conditions for concluding and terminating concession agreements for the generation and marketing of electricity from renewable energy sources (Decret n° 2019-018, 2019)
- To determine the conditions for granting and withdrawing the license for the generation, distribution, and marketing of electricity from renewable energy sources (Decret n° 2019-021, 2019)
- For the creation, allocation, organisation, and functioning of AT2ER (Decret n° 2016-064, 2016)

6.4 Chapter Summary

This chapter talked about the role development of renewable energy has played in Togo and its impact within the country. It also discussed the challenges facing the Togolese government. It showed that renewable energy development in Togo has improved in the past decade and has impacted Togo’s development socio-economically and otherwise. It also showed that more development could be achieved if approaches such as long-term solutions to the high capital costs of the technologies are introduced, institutional sustainability is incorporated, the number of trained personnel/technical expertise is increased, and government engagement with funding bodies is increased. Furthermore, the inclusion of local participation in the design and operation of projects is deemed necessary, and a cross-subsidization tariff scheme should be introduced. Finally, liberalisation of the energy sector is needed as well as government support to help private investment.

There are many advantages associated with the use of renewable energy technologies that should be critically considered in decision-making towards a pathway to achieve development of renewable energy technologies. Investors may want a quick return on their investment, and if regulations and laws do not help them, due the high cost of equipment and taxes, it will be difficult for them to invest. Developing the knowledge to design and manufacture equipment in-house could remediate these issues by putting in place renewable energy technology equipment that is affordable and efficient, thereby reducing kit importation at high costs as well as reducing the risk of receiving inappropriate technologies.

In addition, the Togolese government needs to engage with different funding bodies that could assist in putting in place policies that favour the off-grid and poorest communities. Without innovative financing mechanisms, the adoption of renewable energy technologies will remain low.

The community interest, for instance, will be focused on achieving socio-economic and environmental impacts to better their living conditions. It is therefore important to include the local communities in developing their future energy needs. Furthermore, if proper planning is done before implementation of each project, the right equipment will be put in place for the benefit of the communities.

There is a need to reexamine the Bboxx PAYG business model used. This might have worked better if the payment plan was done differently to prevent repossession of the equipment after the 120-day grace period for nonpayment. Some academic literature has examined the efficacy of PAYG solar home systems in alleviating energy poverty, especially in East Africa, where this model is more known (Bisaga, Parikh and Loggia 2019; Baker 2023). In most of these cases, if payment is not made, the consumer is disconnected (Barry and Creti 2020). However, in Guajardo’s (2021) study, only 5% of customers did not pay for the device in full. He added fewer than 30% of the customers followed a regular schedule of fixed instalments, which reflects the flexibility that consumers can have in PAYG models. More information on how this model might work for rural communities in Togo is provided in Chapter 7. Finally, aside from introducing subsidies for households, financing is needed to develop communities' installed power plants in a way that will be sustainable for the communities to meet their own needs without having to always seek the help of experts from outside their communities. This could be achieved by raising awareness and developing training programs for skills needed for personnel within each community. It is worth mentioning that Togo took steps in providing a 2-week training for 3,000 technicians (600 technicians per region in all five regions of Togo) in collaboration with KYA-Energy Group and the University of Lomé in 2019 for the CIZO project. The hope is to be able to employ all those trained technicians in the future once the upcoming projects are executed. However, the training provided was based on imported equipment, and to date, none of the trained staff are employed.

7 CHAPTER 7 – OVERALL DISCUSSION

This chapter brings together key findings arising from this research work and discusses the implications of the results relating to the research questions. The chapter is divided into four parts: (1) the energy situation and factors that lead to high dependence on the international market; (2) the needs and issues relating to energy access in rural areas; (3) the factors that could facilitate renewable energy growth as a mechanism to improve energy access within Togo; (4) the key learning points of this research and suggestions on ways to improve energy access within the country.

7.1 Energy Situation

The literature on Togo indicates that it is still heavily dependent on its neighbours for its energy supply. According CEET's (2021) annual report, approximately 845.76 GWh of electric energy was purchased from neighbouring countries such as Ghana, Benin, and Nigeria. This showed a slight decrease of 3.48% compared to the 2020 importation, with a gross output in house energy generation of 8.37 GWh from CEET, 619.85 GWh from the international power company ContourGlobal, 14.08 GWh from the Kékéli Efficient Power Station, and 55 GWh from the new AMEA solar plant (CEET 2021). The overall rate of access to electricity within the country is estimated at 57.82% (CEET 2021), compared to 25% in 2010 (Sustainable Energy for All 2012). This increase has been possible due to many factors, including the maturation of several extension and reinforcement projects for the distribution network, as discussed in this thesis.

This study shows that, despites this progress, many people across the country still lack access to energy for their daily needs, and rural areas are most affected, with an estimated national rural access rate of approximately 8% and the majority relying on the use of biomass, such as firewood, charcoal, and vegetable waste products, as their source of energy supply. This rate is even lower in many remote rural areas, such as Kpendjal and West Kpendjal (1.86%), Tandjoare (2.29%), Akebou (3.74%), and East Mono (5.26%), as discussed in Chapter 2 (CEET 2021). There is little generation (for example, 697.3 MW in 2021 from all power plants), while population growth is on the ascendency at 2.33% per year based on World Bank (2022) data, which leads to an increase in energy demand.

Furthermore, the high cost involved in generating from some power plants (the cost of production of 1 kWh in 2020 was 177.86 FCFA, and that of importing was 53 FCFA) has led to some broken power plants in Lomé, such as Sulzer (Sulzer No. 1 and Sulzer No. 2, nominal power of 8,000 kW each), SDMO GE1A of 985 kW, and SDMO GE2A of 985 kW, being left unrepaired and the closing of many small power plants, such as in Mango (GAY 138, 1024 kW), Kpekpleme (180 kVA and GE 311 kVA and 144 kW and 248.8 kW, respectively), Kougnohou (Cummins 311 kVA, 248.8 kW), Kabole (Cummins 400 kVA, 320 kW) and Guerin-Kouka (Perkins 400 kVA and Cummins 400 kVA, 320 kW each). This forces the country to import energy from its neighbouring countries to meet demand. Based on results from the data collected, the studied communities showed 100% interest in developing other forms of energy, such as solar PV, biogas, hydropower, and wind energy, to increase their energy autonomy and provide socio-economic benefits, with more focus on solar PV and small-scale hydropower plants.

This thesis shows that energy access has significantly improved in comparable GDP countries (Pokharel and Rijal 2021), and Togo should target significantly improving energy mix access through renewable energy streams. Comparable nations such as Nepal are now exploiting rivers and water resources for developing different micro-hydro plants (deviating from heavy dependence on fossil fuels) to provide electricity to rural areas that lack access to the grid (Shrestha et al. 2020). In Kenya, the government's heavy investment in solar coupled with funds that mobilize private investment, like the Emerging Africa Infrastructure Fund, helped the country clean up its electricity sector, increase energy access, and modernize payment systems for energy (Kleinman Center for Energy Policy, 2023; Borgen Magazine, 2019). Meanwhile, in Bangladesh, the use of solar PV arrays and solar home systems in isolated remote areas had a major impact on rural electrification (Sarker et al. 2020).

7.2 Energy Access Needs and Issues

Energy is a crucial necessity for all areas of society, including agriculture, businesses, households, and education. The electricity access in sub-Saharan Africa, including Togo, is the lowest of any world region, due partly to the lack of grids that distribute electricity to customers. In Togo, most rural areas are not connected to the electric grids, making it more difficult for consumers to use modern energy services. Investigation showed that barely 20 among the 80 participants in the workshops in rural areas have access to electricity. Additionally, barely 2% of the rural communities that are located farther away from the centre have access to electricity. Issues related to the lack of electricity include exposure to smoke due to the continuous use of firewood for cooking and heating purposes which causes respiratory disorders and other health issues (Awopeju 2020; Kyayesimira and Muheirwe 2021). The communities used in this research for the data collection in 2015, 2018, and 2020 are spread across Togo, mainly in Mango, Mandouri, Kamboli, Notse, and Agome Glozou, and have similar occupations, such as farmers, fishermen, and artisans. Their produce and needs are quite similar, with a little bit of variation from one community to another, depending on the types of resources available within the communities. Key issues include:

- Waste of produce due to the lack of equipment for storage, packaging, and distribution processes, which forces the communities to sell their produce at very low prices to buyers from urban areas, where access to energy is much higher. This leads to other issues, such as famine in most rural areas of the country located in the north, with one rainy season available in the year for farming. The southern area of the country experiences slightly better conditions, as it benefits from two rainy seasons in the year.
- Movements of the youth to urban areas in search of better living conditions causing a rural exodus within the country. This is due to the lack of power, which is crucial to economic development.
- A high birth rate caused by the lack of electricity and leisure centres and therefore a lack of entertainment activities in the evening for recreation.

- The lack of access to healthy markets and the lack of financial assistance available to support village producers. The lack of power causes businesses to close earlier than normal. Additionally, there are no refrigerators for food storage.
- The lack of a good healthcare system where people in the communities could get treated in case of illness. Even in some places where this exists, the healthcare centres are badly equipped due to the lack of refrigerators that could be used to store vaccines, drugs, and anti-venom products, amongst others.
- Lack of access to potable drinking water.
- Lack of access to good educational centres.
- Lack of energy resources for continued business activities.

Based on the issues listed above, the data collected revealed the following needs:

- The need to have access to electricity for people's daily lives and businesses, as its lack currently has an impact on people that includes health implications (for example, women and girls' exposure to indoor pollution, which caused 700,000 deaths in 2019 in Africa alone). Other issues include implications for education and business development. This is supported by UNCTAD (2023 p. 2), which stated that "low access to energy has implications for health, education, poverty reduction, and sustainable development." They added in their report: "Access to a reliable and quality energy supply is vital to the economic development of any country"; "it drives industrialization, boosts productivity and economic growth, spurs human development, and is crucial to achieve almost all of the United Nations SDGs" (UNCTAD 2023 p. 2).
- The need to have water pumping facilities to assist with water shortage issues and provide potable drinking water.
- The need for equipped hospitals, which will benefit from refrigerators for vaccine and medication storage.
- The need to have storage, packaging, and distribution process equipment. This will allow better management of excess produce to prevent it from being wasted, spoilt, or sold at cheaper prices.

- The financial need for water tank and soil preparation to assist with livestock products as well as aquaculture production, including fish and shrimp.
- The need for irrigation, food processing, and transformation units.
- The need for equipped schools and skilled staff.

Correlating these needs with the literature review findings, the improvement of living standards in remote rural areas of Senegal was achieved due to renewable energy (Thiam 2011). Likewise, the development of renewable energy in northwest China significantly improved the efficiency of energy consumption, the health status of the inhabitants, and their standard of living (Ding et al. 2014). In addition, micro hydropower plants in Rwanda, DRC, and Mozambique had remarkable impacts on these communities. In Rwanda, they provided electricity to over 800 households and many schools, health centres, and small businesses in rural areas. In DRC, they allowed a hospital to sell its surplus electricity to around 800 customers, including 400 households and 194 small businesses close to the hospital. In Mozambique, the power plant provided electricity to 200 household villages, a health centre, a school, two maize mills, and shops (Franco et al. 2017; Liu et al. 2013). Togo could solve some of its issues by learning from some of these countries.

7.3 Factors That Could Facilitate Renewable Energy Growth

The current state of the art shows that renewable energy growth can be facilitated by factors such as lowering customs duties on imported equipment, introducing incentive measures in taxation, introducing standardized power purchase agreements and power purchase tariffs, increasing political will, liberalizing the Togolese energy sector, implementing policies and regulations that are clear and transparent and outline key roles and responsibilities of stakeholders, real mapping of technologies and resource assessment, public–private sector partnership, implementing fair laws that favour all organisations, and an increase in capacity building and knowledge transfer. For instance, Shah and Solangi (2019) showed that policy implications are key to a swift transition to renewable energy systems in Pakistan, and without them, development will be difficult. They added that China, Brazil, India, South Africa, and Senegal made great developments in attaining energy access and sustainability in rural electrification programs because of political support and financing. This was further supported by Mugisha et al. (2021) after looking at the cases of Kenya, Rwanda, and Ethiopia in East Africa. Other researchers listed affordability and accessibility of good-quality products, which could be achieved by developing a stronger regulatory framework (Kizilcec and Parikh 2020), as has been done in Spain, France, and Germany, for example. Moreover, after evaluating different policies that support renewable energy, Xia, Lu and Song (2020) found that feed-in tariffs are considerably efficient in promoting the deployment of renewable energy. In addition to feed-in tariffs, they found that declining costs of equipment facilitated excess investment in renewable energy.

From the engagements with different stakeholders in Togo, similar suggestions were proposed to facilitate the development of renewable energy growth. These included suggestions to lower customs duties on imported renewable energy equipment and introduce incentive measures in taxation, subsidize renewable energy equipment, introduce standardised power purchase agreements and power purchase tariffs and increase political will. SI stakeholders mentioned that political will plays a huge role on renewable energy development, and if the government is determined, development will be much easier. Law n° 2018-010 introduced in 2018 relates to the promotion of the production of electricity based on renewable energy sources, but this favours organisations with public interest. Based on stakeholder feedback, if this law were favourable for many organisations, people would be encouraged to invest.

Additionally, stakeholders discussed the monopoly of the energy sector by the CEET, which discourages people from investing. They suggested that the liberalisation of the energy sector would be key to attracting more investments into developing the energy sector and to enabling people to invest in and implement renewable energy policies. Other factors include raising awareness about renewable energy products and how they can be useful to the country. An SI participant from the NGO group stated, *"Government should go in collaboration with NGOs to organise sensitization of the population to promote the use of* *renewable energy."* Developing knowledge in renewable energy is another factor that could speed up growth. Currently, some experts exist within the country with the required skills; however, they are still waiting to be integrated into the system. In total, 50 engineers, 100 experts, and 3,000 technicians were trained across the country to assist with the development, maintenance, and oversight of solar projects within their communities. As of now, all solar technologies are imported from China, Germany, Italy, and France, with trade agreement or dependencies from the providers regarding maintenance of the equipment. The interviews with stakeholders confirmed that most repairs are done by experts from the above countries, which creates an extra financial burden for the country. It is suggested that more resources be allocated to train Togolese to develop their own renewable energy technologies, as seen in Burkina Faso. Togo could as well manufacture solar PV modules domestically as Burkina Faso has been doing since the start of the construction of a 30 MW factory in Ouagadougou in 2017 (Spaes 2020). This on its own could be a big step not only to solve the issues of continuous importations but also to have skilled personnel in-house instead of the continuous reliance on exterior experts for repairs and maintenance. In addition, this would help renewable energy growth and usage within the country, which would contribute to solving the country's energy issues.

Finally, based on the discussions with different stakeholders, it is encouraged that the government consider feedback and suggestions from other groups or organisations. The results show that mainly policymakers are engaged in decision-making, with contributions from top professors in academia. Private renewable energy organisations and NGOs' contributions are seen as proposals and not necessarily considered in the decisions. Making use of suggested key points is deemed necessary to ensure that the best solutions are developed to help with renewable energy growth within the country.

7.4 Scaling up Renewable Energy Solutions to Improve Energy Access

According to Togo PND (2018) and AT2ER (2019), Togo plans to achieve universal energy access by 2030. Based on statistics, the government needs approximately

995 billion FCFA in investment. As an alternative, they will have to mobilize an average of approximately 83 billion FCFA per year over 12 years to achieve universal access by 2030. This is approximately $142 million per year or four times more than the average government investment in electrification development per year (AT2ER 2018; AT2ER 2019). Financial need represents a major barrier to scaling up renewable energy development unless measures are taken to ensure that different approaches or models are used to address this issue. During data collection, stakeholders spoke about the criticality of financial needs when it comes to scaling up renewable energy. Some suggest that the government partner with relevant countries for product grant mechanisms to seek financial help from relevant funding bodies. Other suggestions include providing loans to people to go for renewable energy while raising awareness about it to help more people buy into the idea. One of the issues listed from the engagement with the communities in Togo was the lack of micro-financing for initiating new ventures. Should these opportunities exist in Togo, certainly, many people could make use of them, provided that awareness is raised. An SI participant from the NGO group advised that *"government should go in collaboration with NGOs to organise sensitization of the population to promote the use of renewable energy"* as a solution.

In addition, many companies use a PAYG business model that allows customers to make incremental payments that enable product access for a long period, reducing the upfront costs of adoption and providing flexibility to consumers (Guajardo 2021). This is said to be the fastest business model, and only 5% of customers in Guajardo's (2021) research did not pay for the device in full. Moreover, according to Gabor (2020), this business model is an example of the incorporation of electricity systems and their users into global strategies of capital accumulation through digital footprints and the creation of new development and energy asset classes. Meanwhile, Baker (2023) stated that PAYG (for SHSs, for example) has both constructive and destructive potential for socio-economic and environmental outcomes. She argued that the potential contribution to increasing low-carbon energy access for those who have access to the grid would have been unobtainable, and it is necessary to increase mobile communications for those who are disconnected, for example. She added that this could be destructive in terms of increasing customers' debt and creation of new long-term financial dependencies, among other issues. This suggests that many PAYG SHSs are not aimed at households at the bottom of the energy pyramid (Baker 2023). Looking at the PAYG system used in Togo by Bboxx, the key issue remains that, despite getting their kits subsided by the government (2,000 FCFA per month), consumers are faced with financial challenges in affording their share of the cost every month for up to 36 months. Suggestions for how this model could work well in Togo, since most consumers still struggle to have the necessary funds for their daily needs, include the option of seeking external grants to help consumers or allowing micro-financing with the possibility of paying with crops after harvesting, which could go a long way in scaling up renewable energy solutions to improve energy access. This would also prevent the farmers from being forced to liquidate their crops due to the lack of storage, processing, and transformation units. Doing this would not only motivate customers to acquire kits but also ease customers' worries about monthly payments.

Though finance represents a big barrier to scaling up renewable energy development, it is necessary to note that financial models alone will not be enough to achieve universal access. Comparing the literature review findings to the findings of this research shows the below identified gaps in provision that need to be addressed to scale up development of renewable energy.

Identified Gaps in Provision from Literature	Values for Togo
Policy interest Investment levels Inadequate regulatory frameworks Lack of knowledge transfer High technical cost of renewable energy Technical barriers Lack of awareness Political risk	Policy interest Low investment level, financing needed Adoption of rules and regulations Liberalization of the energy sector is needed Incentive measures in taxation are needed Generation/need for real mapping of potential Need for energy policies with incentives for investment Lack of awareness Need for capacity building Developing financial models, including seeking funding

Figure 7-1: Knowledge Gap Highlights

As shown in Figure 7.1 above, scaling up renewable energy solutions to improve energy access faces far more than just financial barrier issues. Ensuring that the technologies deployed are affordable and acceptable to local communities and that local capacity and institutions are developed so that efforts are sustainable in the long term is required for success (Pachauri et al. 2013). Based on Bisaga (2018), World Bank (2017), Shell Foundation (2017), and World Bank (2014), achieving universal access will require a collaborative effort of various stakeholders, and this will include a mix of mini-grid/off-grid energy access as well as on-gird solutions. Our research has shown that scaling up renewable energy as a solution to improve energy access requires a combination of different factors to provide the best services that are suitable, effective, and efficient for their beneficiaries. This will require an increase in political will among key Togolese policymakers as well as developing in-house capabilities in renewable energy technologies by training personnel with the knowledge needed to oversee projects from start to completion as well as perform maintenance and repairs on these technologies. In addition, raising awareness and performing more studies to determine the suitability, effectiveness, and efficiency of these renewable energy technologies is crucial for best results.

As seen in Chapter 2, Shah and Solangi (2019) talked about major developments in attaining energy access and sustainability in rural electrification programs due to political support and financing. Additionally, Mugisha et al. (2021) showed that Cambodia's success story is due to good policies that focused on a standardized approach to mini-grids, appropriate tariff regulations that evaluated every power provider individually depending on their cost, and the availability of effective financing mechanisms to private investors. Looking at the abundance of renewable energy resources in Togo and the financial constraints facing the country, the government needs to collaborate a lot more with private organisations to attract more investment in the renewable energy sector. This is supported by Kizilcec and Parikh (2020), who argued that partnerships with the private sector (in their case, SHS companies) are crucial to improve energy access and foster local capacity building because these firms are highly influential in the off-grid market.

Furthermore, as Kizilcec and Parikh (2020) discussed, "Governments should raise the number of financing schemes, promote enabling taxes and impose VAT and import duty exemptions on SHS equipment, as this could reduce prices for companies and support scale-up of SHS adoption." In the present research, an S1 participant mentioned, *"The promotion of renewable energies and the development of conventional (fossil) energies must go hand in hand to guarantee and support the economic development of the country*." Guaranteeing economic development, along with reducing environmental concerns, should be a focus in the development of renewable energy, as they can help minimize environmental impacts and avoid dependency on fossil fuels but also contribute to economic growth and job creation (Yushchenko et al. 2018; Lee 2019). Acheampong's (2021) research goes even further to state that this will not only boost economic growth and mitigate CO_2 emissions but also help sub-Saharan Africa to achieve the SEE4ALL goal as well as SDG7.

Finally, scaling up renewable energy solutions to improve energy access requires real mapping of potential. Research is needed "*to discover the best formulas for using proven technologies in the field of renewable energy",* and *"a field survey will really guide the search for sustainable solutions in the use of renewable energy"* per S1 and DVSI participants. This is key to ensuring that the most accessible, efficient, effective, and well-adapted renewable energy technologies are developed for the communities.

8 CHAPTER 8 – CONCLUSIONS AND RECOMMENDATIONS

This chapter reviews the research objectives set out in Chapter 1. It provides a summary of the key points and answers the research questions while drawing conclusions regarding each objective. In addition, it underlines the main contributions and discusses the limitations of this research study while highlighting potential areas of improvement. Finally, the chapter provides recommendations and concludes with outlining the future scope of research.

8.1 Conclusions

The aim of this research was to undertake a critical investigation of the factors that facilitate renewable energy growth and mechanisms to improve energy security in Togo and its impact on the environment and socio-economic development. To achieve this aim, five objectives were set, and several research questions were developed based on four main tasks.

Chapter 1 presented the background of the study, the reasons for carrying out this research, as well as a brief on the methodology adopted for this research. In Chapter 2, we discussed the state of art relating to the energy situation in Togo, the potential of different renewable energy sources, as well as other countries' approach towards renewable energy development. Chapter 3 reviewed the research methodology and methods used in this study, explained the research paradigm that supported the study, and discussed it in relation to the research methods adopted. Chapter 4 explored the need for appropriate energy delivery and relevant solutions based on engagement with stakeholders from rural communities. In Chapter 5, the research engaged key stakeholders in energy, policymakers, private organisations, and academic institutions, amongst others, using a three-round Delphi method. Key viewpoints were captured in terms of renewable energy source preferences for the future and drawbacks to promotion. In Chapter 6, PESTEL and SWOT analyses were used to get an in-depth understanding of the internal and external factors in relation to renewable energy development and its impact on Togo. This chapter highlighted the development renewable energy has had in the past decade. Finally, Chapter 7 discussed key findings arising from this study and the implications of the results in relation to the research questions as well as the literature review. The conclusions regarding each objective of this research are discussed below.

8.1.1 Conclusions Regarding Objective 1

Objective 1: *To critically review the energy situation in Togo to examine factors resulting in high dependency on the international market.*

Energy access remains an issue in Togo. According to CEET (2021), the national rate of access is estimated at 57.82%. The rate of access is high in urban areas (for example, 98.55% in Lomé, the capital city of Togo) and very low in rural areas (for example, 1.86% in Kpendjal and West Kpendjal and 2.29% in Tandjoare) (CEET 2021). Literature review and engagement with stakeholders from rural communities as well as stakeholders with expertise in various fields helped achieve this objective. The results showed that most Togolese are still struggling with energy access for their daily lives and activities. According to CEET (2021), energy generation in Togo is 697.37 GWh. This figure resulted from a combination of generation between CEET (8.37 GWh), the independent thermal plant ContourGlobal (619.85 GWh), the new Kekeli power-efficient thermal plant (14.08 GWh), and the AMEA solar power plants (55.07 GWh) (CEET 2021). The current generation is far lower than the energy demand, causing Togo to import energy from its neighbouring countries as a solution to increase the total available power for customers (845.76 GWh was imported in 2021) (CEET 2021). Another factor causing Togo to import energy is related to the high costs associated with energy production in Togo. Low production of energy despite the continuous increase in population and the lack of investment to develop other sources of energy is a major challenge for the energy sector.

The current energy sources in Togo are mostly based on thermal energy sources and hydropower. Solar photovoltaics and wind are produced in small quantities. Aside the new AMEA solar power plants, installed solar is mostly for street lighting and water pumping services. Additionally, several solar kits have been distributed to clients by companies such as Bboxx and Soleva as part of the CIZO project. These are mostly used for basic household needs such as lighting, charging phones, and powering televisions. Most of the population still relies on imports and biomass for its energy needs. The biomass used includes firewood and charcoal, which causes many health issues due to inhaling smoke as well as contributing to climate change issues and pollution. Togo's energy situation has yet to improve and be sufficient to meet the needs of the people despite all the efforts made in the past few years by several actors within the energy sector, including CEB, CEET, the Ministry of Mines and Energy, DGE, ContourGlobal, private renewable energy companies, the government, NIOTO, ARSE, and ABREC. To date, load shedding techniques are still being utilised to balance electricity supply and demand for customers. The use of renewable energy remains very low and will be an important factor in increasing supply within the country.

8.1.2 Conclusions Regarding Objective 2

Objective 2: *To conduct a field study to evaluate the needs and issues relating to energy access in remote rural areas.*

The engagement with stakeholders from rural communities in Chapter 3 provided a clear picture of the needs and issues relating to energy access. Rural communities from Mango, Mandouri, Kamboli, Notse, and Agome Glozou with similar occupations (farmers, fishermen, artisans) took part in the study. Based on the results, lack of access to energy affects more people living in rural communities compared to urban areas. About 20 among 80 participants who took part in the workshops had access to electricity; however, they mentioned that barely 2% of the rural communities living farther away from the centre have access. The need relating to energy access in remote rural areas includes access to electricity for people's daily lives and businesses, which is crucial and impacts many areas of society, including health, education, and business, as discussed in Chapter 7; there is also a need to have potable drinking water by installing water pumping facilities. Additionally, there is a need to have equipped hospitals for treatment and storage of vaccines and medications as well as access to storage, packaging, and distribution process equipment to better manage produce and prevent it from being wasted, spoilt, or sold at cheaper prices. Moreover, financial aid is needed to help rural communities with water tank and soil preparation for livestock products and aquaculture. Furthermore, the communities indicated the need for irrigation, food processing, and transformation units as well as the need to have equipped schools and skilled staff.

All of the above have impacts on the economy and social life of the communities and hinder sustainable development goals. Some of the issues still facing most Togolese communities include the migration of the youth to urban areas in search of better living conditions; the lack of healthy markets and financial assistance to help rural communities' producers, as explained in Chapter 7; and the waste of produce resulting from the lack of equipment. Other issues include the lack to potable water, good educational centres, and energy resources for various business activities. An increase in energy resources will significantly help resolve the needs and issues listed above.

8.1.3 Conclusions Regarding Objective 3

Objective 3: *To evaluate the decision-makers' engagement in relation to factors that could facilitate renewable energy growth as a mechanism to improve energy access within the country.*

In Chapter 5, the research engaged with key stakeholders in energy, policymakers, private organisations, and academic institutions, amongst others, using a three-round Delphi method. Key viewpoints were captured, such as the drawbacks to renewable energy development and factors that could facilitate renewable energy growth within Togo as well as preferred renewable energy sources for the future. With regards to the drawbacks, several issues were listed relating to existing policies and regulations, which are complex, unclear, and lacking transparency in terms of key roles and responsibilities of stakeholders; other issues included the lack of readily available information for renewable energy technologies to encourage investors, as the risk of investment is considered high, the lack of public–private sector partnership, as well as the lack of engagement with private companies to have them contribute to decision-making relating to the production, sale, and adoption of renewable energy. In addition, the coordination among agencies and entities in the energy sector is weak, with a lack dedicated institutions and unclear responsibilities. Moreover, the lack of communication and cross-discipline coordination is a barrier to development. Other issues include the lack of awareness and research, the high cost of tariffs, customs duties on imported renewable energy equipment, and lack of standardised power purchase agreements and power purchase tariffs.

The study results showed that lowering customs duties on imported equipment, introducing incentive measures in taxation, and introducing standardized power purchase agreements and power purchase tariffs could facilitate renewable energy growth. In addition, an increase in political will coupled with liberalising the Togolese energy sector is crucial for renewable energy development. The current monopoly of the energy sector by CEET discourages people from investing. Furthermore, implementing policies and regulations that are clear and transparent, outlining the key roles and responsibilities of stakeholders, will help greatly.

This research also showed that real mapping of technologies and resource assessment are needed to provide trusted information for investors to use as guidelines. This will provide a clear idea on the viability, availability, and applicability of renewable energy technologies that could be used to supplement the energy mix. Additionally, raising awareness of renewable energy products could clarify how these can be beneficial for people and encourage people to opt for them. Furthermore, stakeholders mentioned that the lack of public–private sector partnership makes organisations reluctant to finance the increasing requirements of energy infrastructure. The study concludes that an increase in public–private sector partnership is needed, and contributions from renewable energy private organisations as well as NGOs should be welcomed and taken into consideration to ensure that the best solutions are developed.

Implementing fair laws that favour all organisations is another key factor for renewable energy development. The current Law n° 2018-010 discussed earlier favours organisations with public interest, and a change is needed to encourage people to buy in. Additionally, capacity building and knowledge transfer are key processes that contribute to the growth and development of organisations as well as individuals. This research showed that few experts exist within the country with the required knowledge, and Togo still relies on experts from China, Germany, Italy, and France, who are highly paid to perform maintenance and repairs on renewable energy technologies. Having skilled personnel in-house is essential for renewable energy development.

Finally, the study concludes that solar and hydropower are the most dominant, suitable, and favourable renewable energy sources for development in the country based on availability, affordability, and profitability. Availability exists for other sources of renewable energy, such as wind, wave, solar thermal, solar CSP, tidal, and marine energy; however, these require more financing to develop.

8.1.4 Conclusions Regarding Objective 4

Objective 4: *To analyse the potential impact of renewable energy.*

The study used the PESTEL and SWOT frameworks to analyze the impact of renewable energy. It concludes that developing the use of renewable energy (mainly solar and hydropower) in Togo will have a big impact on alleviating the country's energy issues. Engaging with the communities gave a clear picture of how the few installed renewable energy sources have impacted Togo. This includes impacts on people's daily lives, such as increases in business hours at locations where renewable energy has been installed, provision of potable water for the communities, and helping students with extended hours of study. The research concludes that renewable energy development could promote employment, boost entrepreneurship activities, increase the success rate of businesses, provide clean and sustainable energy, and balance city and rural areas, thereby reducing the rural exodus. In addition, it will contribute to professional activities, reduce poverty, improve productivity, contribute to industrialization development, and reduce energy bills, amongst other benefits. A good example from this study is the tremendous savings made by an owner of a clinic that experienced a bill reduction from 1.2 million FCFA per year to 800,000 FCFA per year by switching to solar energy. Within less than 3 years, the clinic lowered its energy bill by 400,000 FCFA per year. This shows that, despite the high initial cost associated with renewable energy, high returns can be made over time and provide development at all levels, as discussed in Chapter 6. These include a cleaner environment, social and economic development, national balance, contributions to regional development, and boosting entrepreneurship activities and the national economy. Additionally, it has impacts on increasing agricultural produce, enabling more revenue generation, improving work conditions, and developing energy autonomy. Moreover, it could help in the creation of new business opportunities, enhance the development of community centres, and provide activities around multifunctional platforms, thereby reducing the rural exodus in Togo. Furthermore, improvements could be seen in health centres' operations, making storage of pharmaceutical products easier and providing hospitals with the capability to better treat their patients.

Overall, energy plays a huge role in all areas of society, including health, education, business, households, and industry. Inadequate energy, water, and health services can result in several negative effects, such as inability to store vaccines in hospitals, leading to a high number of recorded deaths; decomposition of products due to the lack of refrigeration, transformation, and processing units; lack of clean water for the community causing health issues; and loss of equipment and work data because of power failure issues. In addition, renewable energy could protect the environment and prevent tree cutting as a source of energy used for cooking, as current sources not only expose villagers to pollution, cold, and wind during harmattan but also contribute to climate change issues, including global warming and CO_2 emissions. The study concludes that developing solar photovoltaic and hydroelectric power will contribute to regional development, improve living conditions, and boost the national economy.

8.1.5 Conclusions Regarding Objective 5

Objective 5: *To make policy recommendations on ways to improve energy access via renewable energy growth and its impact on sustainable development.*

The study concludes on the following best approaches to scaling up renewable energy solutions to improve energy access:

- Develop different financial models to scale up renewable energy development. This could be done via government partnership with relevant countries for product grant mechanisms to seek financial help from relevant funding bodies or providing loans/micro-financing to help people initiate new ventures. Especially in rural areas, micro-financing with an option to pay with crops after harvesting could go a long way towards scaling up renewable energy solutions to improve energy access.
- The need for the government to revisit existing policies and regulations in place to make them simple, clear, and transparent to define key elements, set objectives, and enable fair sharing of risks and benefits among all stakeholders.
- Conduct further research for real mapping of technology resources to determine the viability, availability, and applicability of renewable energy technologies as well as other sources of energy that could be used to supplement the energy mix. Collaboration with international businesses and experts is needed to provide readily available data as a guideline for investors to use.
- An increase in public–private sector partnership at all levels. There is a need to work collaboratively with key stakeholders throughout the stages of each project. Maintaining clear communication and cross-discipline coordination and allowing private companies' voices to be heard in relation to the production, sale, and adoption of renewable energy is crucial for development. Doing so will allow private companies' technologies and innovations coupled with public sector incentives to achieve better project results.
- Liberalise the energy sector. The current monopoly of the energy sector is a barrier to attracting investment and discourages people from investing in the development of the energy sector and the implementation of renewable energy.
- Introducing measures in taxation, lowering customs duties on imported renewable energy equipment, and introducing standardized power purchase agreements and power purchase tariffs is needed for development.

Lowering taxes on renewable energy should be fair and benefit a broader range of companies rather than mostly those with public interest.

- Raising awareness is required to educate people about renewable energy technologies to enable people to make decisions on their use. Additionally, capacity building and knowledge transfer are crucial to develop the in-house capability and skills needed for renewable energy development and implementation.

8.2 Original Contribution to Knowledge

Based on Cryer's (2006, p.199) list of examples of an original contribution to knowledge defined in Appendix D1, the originality of this research meets the following conditions:

- An in-depth study
- An exploration of a topic
- A critical analysis
- A portfolio of work based on research
- A fact or conclusion or a collection of facts or conclusions

8.2.1 Contribution to Knowledge

This research involved an in-depth study related to the development of renewable energy in Togo and its capacity. As part of this study, a critical analysis of the potential use of renewable energy technologies in Togo with a focus on rural areas has been done. The research featured a thorough investigation and analysis of the current energy situation in Togo, an exploration of Togo's renewable energy development, as well as current and potential impacts on socio-economic development. These, to the researcher's best knowledge, have never been done and very few research data and publications exist in this field in Togo. Therefore, the outcome of this research provides additional data to the existing literature on renewable energy development based on Togo with potential application to other countries. This research also identified crucial factors that will help renewable energy development in Togo to supplement the energy mix and reduce the current energy dependency. In addition, applying the Delphi method in this research helped analyse possibilities, barriers, and solutions for growth, identified the driving forces for renewable energy development, and made the selection process more effective by involving experts in three rounds of data collection. Moreover, the use of PESTEL and SWOT frameworks helped understand necessary principles that need to be considered as well as to identify factors that could change or mitigate risks for renewable energy development in Togo.

As part of this research, four articles have been published, providing a broader view and impact to the energy sector for practitioners and policy makers offering a novel method for understanding the needs, practices, problems, and possible solutions to renewable energy development.

8.2.2 Contribution to Practice

This research contributes to a growing work of renewable energy development in developing nations that will support experts in the field with useful information (Osu, 2017) that could help development specifically in West Africa. The study provides valuable information to various categories of stakeholders that include policy makers, key experts within the field, and academics/research institutions amongst others on the pathway for development. In addition, bringing together policy makers, key experts within the energy field, academic institutions and various private, public, governmental, non-governmental, international, and financial institutions to participate in this study is a strategy that has not been previously employed and could serve as a pathway for identifying best strategies or solutions in a variety of project types. This is applicable and scalable to a growing work of renewable energy development in developing nations.

8.2.3 Contribution to Policy

This research provides recommendations for addressing the sustainability challenges facing Togo and identifies the internal/external strengths as well as weaknesses using strategic frameworks such as Delphi, PESTEL and SWOT for analysis. The study was based on a critical review of the literature to evaluate performance using evidence from existing theories and thereby constructing the research in a way that will add value to Togo beyond cross-national comparison.

In addition, the research builds up on current work, picking up on Togo's policy strategy and contributes towards a theoretical context that has been existing. The research also presents the views of policy makers and practitioners with regards to existing policies and makes recommendations on best approaches. Finally, the research offers recommendations on policies that will help facilitate the development of suitable renewable energy technologies in Togo.

8.2.4 Contribution to Methodology

The research combined action research with a traditional data collection method that will support real life analysis of renewable energy development and implementation in sub-Saharan Africa, specifically in Togo. This is done by a combination of existing knowledge and practice, an approach that has not been previously done in Togo. In addition, within this study, the use of the bottom-up approach which considers the integration of the community to policy makers and encourages cross-sector cooperation was utilised. The research engaged with different communities across Togo from the south to the north to better understand needs and issues and proposed reliable solutions for community resilience.

8.3 Limitations of the study

There were several limitations faced during this research. These include:

- The nature of the interview: Given the interview questions were semi-structured and open-ended, some of the interviews were time consuming and the time allocated was surpassed where the researcher had face-to-face interview discussions with respondents.

- The analysis and interpretation of the data collected were difficult in some cases due to the broad range of information provided by the participants, which in some cases were irrelevant. Besides, the use of self-reported data (primary data collected from interviews) is limited by memory of the participants, exaggeration, and individual bias (Akinsete, 2012; University of Southern California, 2012). Due to this limitation, cross-checking the data with the participants to make sure the information gathered from the interview discussion was correctly written and there was no miss-interpretation or change in the content was key.

- Issues of interpersonal relationship among the participants: During the meetings held with key stakeholders (4 to 8 participants), it was noted that people had difficulty expressing their feelings freely. This was overcome by conducting further individual meetings with key participants to discuss the questionnaire for data collection.

- Generalisation issues: Most data gathered resulted primarily from the input of respondents across various stakeholder groups. This suggests that the data gathered from the participants might limit applicability of some of the results of the study. The selected group of participants reflected a sample of the Togolese population. Findings and conclusions in this research were based on the responses from the sample selected to participate in this study and may be generalised to the entire population. Targeting a wider group might result in a slight variation of the result.

- Time constraint and culture impact: One of the limitations of participatory observation was the length of time and the resources invested in becoming immersed with the community that was studied. This was due to the differences in culture, language, and practices; some of the participants among the selected communities did not speak French and an interpreter had to be used for better understanding.

- Long-term engagement with individual respondents from the first data collection in 2015 to the data validation stage in 2020 continue to pose a challenge due to changes in personnel at some workplaces and relocation of participants amongst others. This must be acknowledged as a limitation in the field and was mitigated by the researcher keeping in constant contact with the participants from time to time. This long-term engagement was due to a break in research because of personal circumstances. A third-round data collection was conducted to validate the result leading to a few changes in the analysis and results in terms of development, planning, and training.

- Bias issues: Even though the researcher strived to maintain an objective standpoint, given the nature of action research, it is important to acknowledge issues related to subjectivity and perspective, as well as the role the reflexivity of the researcher plays in addressing these within the research process. To reduce this effect, the researcher maintained open dialogue and discussion with the participants throughout the studies. It is worth highlighting that bias due to being an overseas researcher could have also played a role in this research. Linguistic bias resulting from speaking multiple languages could have impacted the study in the form of how the result was translated back into the study language. This was crosschecked during data validation to prevent inaccurate assessment. In addition, given that the researcher was an overseas student, bias could have arisen from how participants welcomed the researcher as well as engaged with the researcher to provide accurate answers. This leads to wondering if the responses would have been different if the researcher was to be a home student and if she might have been treated differently. Obviously, this played a part in this research because the participants were more relaxed to discuss their views especially since data protection and confidentiality were discussed prior to engaging in open dialogue and discussion with the participants.

Overall, the limitations encountered can be classified into the methodological approach limitations and those encountered by the researcher. From Chapters 4, 5, and 6, methodological limitations arose because the answers to the research questions were self-recorded, and data gathered were noted by the researcher. This implies that the data gathered from the meetings are limited by the memory of the participants and could be subject to overstatement and individual prejudice (University of Southern California, 2015). This is addressed by using multiple data sources including secondary data to cross-check findings in addition to careful selection of reliable participants.

Looking at the exploratory, descriptive, and explanatory nature of this research, the limited time allotted to this study did not allow more investigations to take place. In fact, the length of time taken in this study due to a study interruption became useful in helping the researcher track developments and respondent views over a longer period to highlight longevity of the issues. The researcher also encountered difficulties in accessing the participants all through the organisation of various meetings which was due to the lack of availability and scheduling conflicts of the participants. In addition, there were issues associated with data collection, in relation to the type of questions that were described in Chapters 4, 5, and 6. These were related to the researcher's carefulness about the formulation of the questions to avoid invasive questions. Other issues experienced were associated with the subjectivity and the viewpoints of many personnel including the researcher. Finally, being focused and paying attention to conversations to derive key points from the discussions and the need for flexibility to accommodate changes in meeting times and venues were other issues to note. These were addressed by being flexible, determined, and quick to adapt to changes.

8.4 Recommendations

There is a clear rural energy gap in the agriculture sector, which needs to be bridged to increase the economic development in Togo. A mere increase in food production will not be enough to resolve issues but providing a much more social and environmentally friendly way of increasing food production, storage, processing, and distribution would be the best approach. The development of renewable energy in Togo has the potential to benefit human health, the environment, and socio-economic development. This will have massive impact on the day-to-day life of the population and help indigenous people run small or medium enterprises and micro businesses in their communities to generate income. So what theories are available to further analyse the strengths and weaknesses of the country? Is a human element the problem? Is it an actor's issues or implementation issues? What are the exact reasons even though there are some few policies and strategies? From the study we realised that even though few policies and strategies exist, they are more like statements and have mostly not been implemented. The 2017 World Bank "State of electricity access report" mentioned the growing role for the private sector to finance interventions, assuming the incentives are in place for investors to earn returns on their investments. This implies that if adequate policies and regulations are to be put in place facilitating the promotion of renewable energy, private investors might develop the will to invest in renewable energy businesses. It was good to get a hands-on practice to see what drives theory and incorporate it into sustainable practice. At a point, one begins to wonder if policies that have been set by the government could be factors limiting development? In Chapters 4 and 5, we took a critical review of the policies and strategies and in Chapter 2, we compared it to existing literature to make conclusions on why renewable energy development is not working. The following recommendations stem from this research:

- Policy recommendations: Based on Chapters 2, 4, and 5, it is noted that a few policies and regulations exist but most of them are merely on paper and lack clarity and transparency. This study recommends that the existing policies and regulations in Togo are reviewed for clarity, transparency, and simplicity. This is necessary to highlight important elements and set clear objectives to enable fair sharing of risks and benefits between various stakeholders. Additionally, the existing incentives are more beneficial to companies with public interest. The study recommends the introduction of incentive measures in taxation, reduction in customs duties, and standardization of power purchase agreements and power purchase tariffs in a way that is fair and beneficial to all for effectiveness.
- Financial recommendations: The plan for the Togolese government to achieve 100% electrification by 2030 requires the completion of many goals. These includes the installation of 555,000 solar kits, installation of at least 315 mini solar grids, the connection of 960 new localities to the network, the provision of electrification to 400,000 households currently living on the network that are not electrified, and the installation of at least 108MW of additional generation on the network as discussed in Chapter 2 (Togo PND, 2018; AT2ER, 2019). This calls for approximatively 995 bn in investment or approximately $142 million per year which is four times

greater than the average annual government expenditure on electrification development (AT2ER, 2018). Therefore, it is recommended that the government develop different financial models through government partnership with different countries in the form of grants to seek financial help from relevant funding bodies. These can be used to develop some of the above listed energy projects in a view to solve the energy deficiency issues. It is also recommended that the government works with different banks to provide loans to help small/medium businesses initiate new ventures. In addition, this research showed the current PAYGO business model used by BBOXX is not sustainable and leads to repossession of the kits after a grace period of 120 days following non-payment. The communities are poor and data collection from this research showed that due to the lack of storage and processing equipment's, many farmers for example end up liquidating their produce at cheap prices to avoid it being wasted. Therefore, it is recommended that a micro financing model with a possibility to pay with crops after harvesting be made available especially in rural areas for better results.

- Academic and research recommendations: The results from this research show that the lack of viable information regarding available technology resources is a major challenge for development. It is therefore recommended that the government work with academic and research institutions to conduct further research for real mapping of the technology resources. This is needed to provide readily available data that can be used as a guideline for investors. It should clearly state the viability, applicability, and availability of different energy sources that could be used to supplement the energy mix. A collaboration with international businesses and experts could help facilitate this.
- Public-private sector partnership recommendations: The study recommends an increase in stakeholders' participation at all stages of the project from evaluation till completion instead of involving them at the stage of execution. Clear communication and cross discipline coordination amongst entities is needed to achieve better project results. The

government could organize several workshops to bring stakeholders together to allow their participation prior to implementation.

- The importance of raising awareness and educating everyone about renewable energy including illiterates is highly recommended. Partnering with relevant countries that could help train experts (through product grant mechanisms, grants and scholarships to university students to travel out for training in renewable energy) could help the development of renewable energy. The government could encourage tree planting as well to boost environmental protection by putting in place some sort of reward (e.g., if a village plants 100 trees, they will be rewarded by the installation of a water pump).
- Liberalization of energy sector: Based on the findings of this study, the current monopoly of the energy sector by the electricity company is a barrier to development. This is because investors do not have the possibility to sell the energy generated at competitive prices since the electricity company is the sole seller within the country. This makes investors reluctant to invest into the energy sector. Additionally, due to the lack of storage for solar energy, it is recommended that some form of credit be given to owners and their bills lowered.
- Gender and age inequalities: During this research, very few women participated in the study which prevented comparative analysis. However, we noted that women in Togo are the most frequent users of energy for cooking and heating and they spend more time at home with children and elderly people compared to men as discussed in Chapter 5. For this reason, the study recommends that women should not be excluded from energy policy development, planning, and implementation so that all end users' needs are met.
- Technology recommendations: The study makes recommendation on developing renewable energy, mainly solar and small-scale hydro power to supplement the energy mix. It recommends better engagement with the communities to identify best solutions, create manufacturing plants, and produce materials that are accessible, efficient, effective and adapted to Togo. In addition, strengthening management, prioritizing renewable

energy, promoting diversification and research for system optimization and better performance are crucial.

Furthermore, suggestions to resolve this issue in Africa calls for the integration of renewable energy to be facilitated through the formation of power pools to balance electrical load over a larger network than a single utility. This could benefit a lot of countries within Africa and provide a framework for regional and cross-national planning (IRENA, 2022). A good power pool infrastructure could make investments in renewable energy projects more attractive as well as lower the cost of grid integration. Few things might be required:

- The need for better technology, as a power pool might need a large-scale transmission and adapted operation of various power plants. Flexibility provision and storage-based technology may be needed to accommodate variable renewable energy in Africa's power pool.
- Enabling a tariff structure for electricity use such as time of use tariff and other innovative solutions to support demand-side management (IRENA, 2021e) would be great, and this could as well help Togo's renewable energy development.

In Central and Southern Africa, dedicated mini-grid regulations have been less accepted (SNV, 2021a; IRENA, 2022). Mozambique approved its off-grid energy regulation to encourage the private sector to invest in distributed solutions that include mini-grids by providing explicit guidance on permitting processes and tariff settings among other aspects. Togo could as well learn from them.

Finally, legal and licensing provisions are necessary to attract long-term investment in renewable energy. This might need a simpler licensing for some mini grids, for example, in Nigeria mini grids under 100kW are excepted from licensing requirements though developers can apply if they wish to reduce operational risks.

In all, key measures are required to be seriously taken into consideration for the scale up of renewable energy development including national policies on renewable energy, rural electrification strategy and master plan, mini grid policies, regulations, as well as quality standards (IRENA, 2022). Looking into environmental and health protection measures, reviewing taxations, incorporating company formation, deeply investigating capacity building, and the provision of technical assistance among other measures could drastically help development.

8.5 Future Work

Future work suggestions based on this study are as follows:

There is a need for in-depth studies to be carried out in terms of the transferability of practices relating to renewable energy development in other developing nations compared to Togo. Each society is different and what worked for others might not necessarily work for Togo; therefore, further research has to be done taking into consideration the resources that are available, the technology, and the need of the people. An example of this situation is the broken-down water pumps supplied by previous projects and the disused tractors on irrigation project sites in Southern Togo that were discussed in Chapter 4. These were from an EU financial aid project that was meant to support the local community.

In addition, based on Appendix B3, the study found that there are many delays after the funding stage of projects. This implies that there is a need to explore the reasons behind the delays of many projects to make sure all components are met prior to grant approval and commencement of the projects.

Moreover, despite efforts in developing a better energy situation, the fact that current infrastructure is being shut down (examples include power plants in some areas as discussed in Chapters 2 and 7) due to the high cost associated with running them for energy generation, could have further implications for the country. Therefore, it is equally important that the Togolese carry out an in-depth study to find means to exploit the current infrastructure at cheaper prices instead of shutting them down. It would be even better to make sure all risk of non-exploitation is excepted prior to the construction of new infrastructure. Furthermore, there is a need for an in-depth study of the components needed to provide appropriate training and capacity building within the country. This will allow Togo to have experts in house instead of having to bring them from outside the country at very high cost for the maintenance of some of the technologies.

Finally, energy justice is a key component that needs consideration when planning towards energy transitions. It seeks to apply justice principles to energy policy, energy production and systems, energy consumption, energy activism, energy security, and climate change (Jenkins, et al., 2016). From this research, there is a need for an in-depth study to be carried on in Togo to understand how the non-inclusion of the three components of energy justice namely distributional justice, recognition justice, and procedural justice are impacting the energy system and socio-economic development. Based on this study, it is noted that most Togolese are not receiving a fair share of benefits and cost and how the unequal benefit of energy distribution and production burden impact the community. Many communities do not have access to the electrical grid to date. The electricity access rate in the capital town Lome is about 98% compared to 1.86% for Kpendjal and West Kpendjal as an example. Besides, rural communities for example will need to work harder to afford the utility bill compared to urban areas. Moreover, many of the indigenous populations are exposed to pollution from the use of firewood as a source of energy for cooking and heating which leads to the question of whether energy democracy is for all. One of the concerns highlighted in this study is the fact that people are not equally represented within the energy system or free from physical threats but are often misrepresented and ignored in decision making. Further research is strongly encouraged to ensure fairness in resource allocation and provision of inclusive protocols in energy system decision making. This will ensure an equitable engagement of all stakeholders irrespective of background, age, gender, and character for best solutions to be developed to address the energy issues. In all, energy justice is a broad topic that could form the basis for better energy solutions being developed for Togo in the future.

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APPENDICES

Appendix A – Chapter 1 Appendices

Appendix A1: Objectives and Expected Deliverables

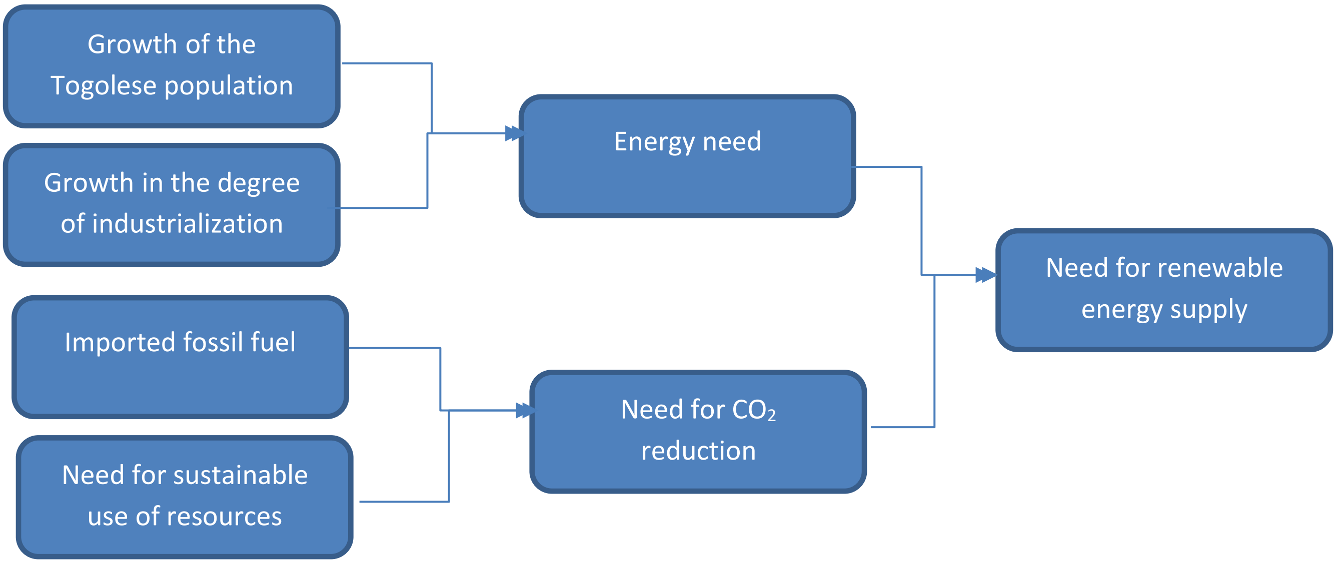
Task	Action Plan	Expected Outcomes
1	- Outline the current energy situation - Identify gaps - Identify current issues and barriers facing the energy sector - Identify the reasons for high dependency - Identify current stakeholders and actors within the energy sector and their key roles and functions	Outline the shortcomings in the energy sector
2	- Identification of in-house capabilities/skills in renewable energy technologies - Raise awareness of renewable energy technologies - Provide a clear understanding of available resources and outline the most favourable renewable energy technology	Outline the most suitable renewable energy technologies
3	- Examine social impact of renewable energy usage - Examine economic impact of renewable energy usage - Examine environmental impact of renewable energy usage - Analyze renewable energy development through a PESTEL analysis approach	Outline the impact on the environment and socio-economic development through a SWOT and PESTEL analysis
4	- Recommendations on approaches to becoming self-sufficient	Provide recommendations

Appendix A2: Research Questions per Task

Task	Questions
1	• What is the current energy situation in Togo? • Why is Togo so dependent on imported energy? • What factors lead to high dependency on the international market? • Who are the current actors? • Who generates power, and who is the owner? • Who provides the equipment? • Are there any dependencies from the providers?
2	• What is the potential for renewable energy sources? • What is the level of knowledge in renewable energy in terms of skills? • Why is renewable energy technology not widely used? • What are the current existing components of renewable energy? • What developments have been made, and what went wrong? • What enabling factors will help encourage the uptake of renewable energy technologies? • Who are the key policymakers?
3	• Why is the use of renewable energy necessary? • Can the use of renewable energy improve the social life of the people? • Can the use of renewable energy improve any health issues?

	• What impact can the use of renewable energy have on the economy? • What other impacts can the use of renewable energy have?
4	• What are the best practices that can be identified? • What improvements can be recommended?

Appendix A3: Need for Renewable Energy



Need for Renewable Energy Supply (Adapted and Modified from Kruijsen)

Appendix A4: Research Sub-Question Generation Process

Based on the research questions, a question arises: **What are the factors that will encourage the development of renewable energy technologies in Togo?**

The research focuses on the potential use of renewable energy technologies to improve the energy security in Togo and its impact on sustainable development. Special emphasis is made on rural areas, as they are the most affected by the energy issues and find themselves in remote parts of the country with no access to the power grid.

Developing the use of renewable energy to improve the current energy situation in Togo has been identified as the main topic of this study. The progression of the research question has therefore evolved from this background. The initial research question that originated with scoping of the study related to finding out the reasons behind the crucial lack of energy and, therefore, the question: **Why do 3/4 of Togolese lack access to energy?** The identified gaps, such as the deficit in energy production in Togo leading to high dependency on imported energy from the international market, led to reformulating the research question as: **Does Togo have the potential to develop renewable energy resources?**

Literature review, field visits, and various discussions with a wide range of professionals—including supervisory teams, externals, and the public—revealed that Togo has significant potential for renewable energy development, which, if harnessed, could help achieve sustainable growth. Based on this, the key point to consider was then redefined to: **What is preventing the development of renewable energy technologies in Togo despite the potential impact this could have?**

Further improvement of this research question led to refining the research question to: **What are the factors that will encourage the development of renewable energy technologies in Togo?**

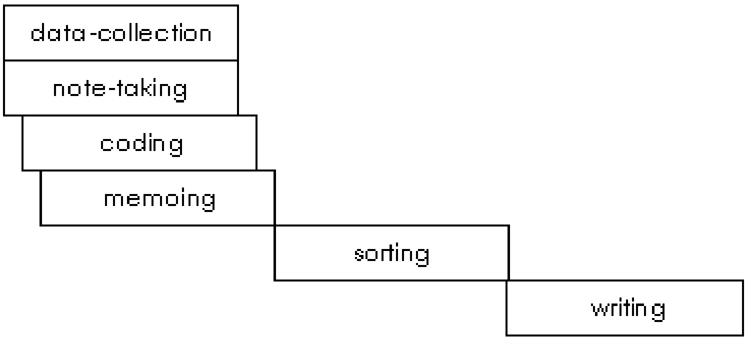
The generated sub-questions from the above are as follows:

- What are the potential drivers that will promote the development of renewable energy technologies in Togo?
- What actions could be taken by policymakers to encourage wider adoption of renewable energy in Togo for sustainable development?

Appendix A5: Data Collection Methods

Nature of Data	Source	Mode of Collection
Primary	Interview notes Field work notes Illustrations Equipment/data loggers	Interview Questionnaires Field work notes
Secondary	Journal publications Conference proceedings National and international standards Governmental and non-governmental reports	Desktop study Literature review Conferences workshops
Tertiary	Database	Archival

Appendix A6 – Steps Showing the Progress of the Grounded Theory Method (Source: Dick 2005)



Appendix B: Chapter 2 Appendices

Appendix B1: Types of Renewable Energy Available in Togo

Appendix B1-1: Solar Energy

Togo has a lot of solar radiation, which increases from south to north and reaches 2,045 kWh/m^2 yearly in the north of the country (Global Solar 2019). It has mainly been utilised for lighting and the operation of simple solar-powered appliances (HELIO International team and EERA-Togo team 2014; personal communication 2022). A decade ago, a few non-governmental agencies working in Togo, such as Solar Without Borders (2010), SunPower Afrique (2010), Scatec Solar (All Africa 2012b), NNV, and Jeunes Volontaires pour l'Environnement (JVE) (NNV 2009), were actively involved in promoting the use of sustainable energy resources. These organisations encouraged the use of small-scale solar-powered systems and solar energy generation facilities in both rural and urban areas through the installation of photovoltaic modules and solar-powered lighting to alleviate the increase in poverty and environmental issues (Solar Cookers International Network 2013).

Previous developments include the introduction of a 5-kW solar electric system on the roof of non-profit microcredit bank FECECAV's headquarters in Kpalime. This was done in 2010 by SunPower Afrique, a small non-profit organisation based in Collegeville, with the help of locals (Montgomery News 2015). Other developments include the free design and installation of solar energy systems in 2012, which led three hospitals to receive secure hot water systems in addition to the one hospital in the north that had one since 2011 (Wagner Solar 2015). A few efforts have included the introduction of photovoltaic solar lanterns with LED lamps in rural area of the Vo district (southern Togo) and the promotion of the use of solar cookers through organised workshops as well as providing training to the youth on its design (Oseni 2015; JVE 2010). Some of these have had minimal impact on solving the energy issues, and others have been unsuccessful due to the lack of skilled people to deliver appropriate training, poor cooperation among the communities, and the high financial cost implications of imported equipment (JVE 2010). This could have been addressed if indigenous capacity for design was built and the communities were more educated on the use and benefits of renewable energy technologies. Other plans include projects on a solar-assisted backup system for a youth training centre in Sokode (central Togo), with the aim of securing a stable power supply to the education centre with library and internet access.

Between 2017 and 2019, four mini solar plants were constructed in Blitta (250 kW), Bassar (100 kW), Takpapieni (100 kW), and Bavou (150 kW). Today, several projects are being executed that use renewable energy, especially solar. A solar plant owned by Emirati independent power producer AMEA Power with full capacity of 50 MW has been installed in Blitta (Central region of Togo), the largest solar PV plant in West Africa. Based on personal communication with electrical company staff (2022), this plant started operating in 2021, producing about 33 MW daily. The energy produced from it is fed back into the grid. This is the first utility-scale renewable energy project developed by an independent power producer (IRENA 2021; Global Law Group 2022; Afrik 21 2021; Energypedia 2020). According to IRENA (2021), it will have the ability to provide electricity to about 160,000 homes and small businesses and greatly reduce the country's dependence on firewood, charcoal, and fuel imports for energy consumption. In addition, it will help increase the share of renewables in electrification to 100% by 2030. Based on discussions with key energy personnel, so far, the impact of this solar power plant in the Central region coupled with the extension of the power grid to some areas (IRENA 2021; Togo Local Electrification Program 2018, CEET 2020) has brought the number of electricity subscribers from 294,639 in 2015 to 634,926 in 2022 (personal communications 2022). More recently, according to the International Maize and Wheat Improvement Center (2023), solar-powered dryers are now being used for the production and preservation of crops (such as peanuts) in Koumonde, a village located in the Kara region.

Appendix B1-2: Hydropower

Togo possesses a great potential for hydropower development. It has numerous rivers and waterfalls, such as Kpendjal, Ouale, and Sansargou passing through Mandouri (at the North), Oti River of length 520 km passing through Mango, and Mono River of length 400 km in eastern Togo passing through Kaboli and draining a basin of about 20,000 km^2. Currently, hydropower serves as one of the main sources of base load electricity generation, though its potential depends on the season, differing from region to region. Mono River is seen as the main current use of hydropower potential; however, it is underused, as the Nangbeto power plant proved it has a triple degree of variability—event-driven, seasonal, and multi-year (Energypedia 2020)—which could be utilised for more prospects.

Several projects are being planned for the development of hydropower, including the construction of dams such as Tetetou (50 MW), Danyi-Konda (10 MW), Baghan (6 MW), and Landa-Pozanda (4 MW) as well as the construction of 24 MW hydropower plant in Sarakawa (Togo First 2018). Electricity from hydroelectric plants accounts for 29% of total installed capacity (CIA 2017). Regardless of its potential for hydropower generation, Togo currently has a hydroelectric power plant of 65 MW composed of two turbines of 32.5 MW each located in Nangbeto, accounting for 6.39% of production and 1.6 MW installed at Kpime, which accounts to 0.24% of energy production (ARSE 2019) due to the lack of exploitation.

Appendix B1-3: Wind Energy

In addition to the available sunshine, Togo experiences considerable wind speeds, which are estimated at 3–10 m/s (Ajayi 2013) compared to an average of 7.9 knots (4.06 m/s) in the UK (Statista 2022), for example. This potential has not been fully explored and exploited for power generation due to the high cost of equipment and maintenance and lack of experienced technical staff; additionally, the existing installed capacity is very small (Both Ends 2012). In 2012, the Togolese government signed a contract with Eco Delta for the construction of a wind farm which will generate 25.2 MW of electrical power that will supply about 7% of Togo's electricity. Some feasibility studies have been conducted (REN21 2014), but discussions with key energy staff in Togo revealed that this project was put on hold due to political issues. According to PND (2015), wind is making a tentative start and has only been used to pump groundwater.

Appendix B1-4: Biomass Energy

Togo is endowed with biomass resources such as wood, charcoal, and agricultural waste. Currently, biomass energy accounts for 76% of Togo's national final consumption (Energypedia 2020). Most of it is unclean and used as direct forms of energy in households, which produce a lot of pollution and respiratory diseases, amongst other issues. A lack of technical expertise in biogas technology has render Togo deficient in the generation of power from biogas. Biogas and biofuels production accounts for only 1% of the electrical energy production. According to the national development plan (PND 2018-2022), the goal is to increase the share of biogas and biofuels in the national energy mix from 1% in 2015 to more than 2% by the end of 2022 (PND 2018). The capital cost involved in this technology has also been a factor in its development even though the government offers significant resources for the development of this technology (REEGLE 2013).

In all, there is a huge potential for renewable energy in Togo, particularly solar energy and hydropower, which can be developed to fill the energy gap.

Appendix B2: Current Supply and Demand

Togo's energy consumption comes from three sources—biomass (76%), petroleum products (20%), and electricity (4%)—as shown in Figure B2-1 (Energypedia 2020). Importation consists of about 744 GWh of electricity and 6,265 GWh of petroleum products (composed of petrol gas, gasoline, jet fuel, lamp oil, diesel, heavy fuel oil, and others). Biomass (31,788 GWh made of firewood and vegetable waste), hydropower (209 GWh), and renewable energy (2 GWh) are produced in Togo. Figure 2-2 below shows the details of Togo's energy supply from production and import to consumption (SIE 2017; Energypedia 2020).

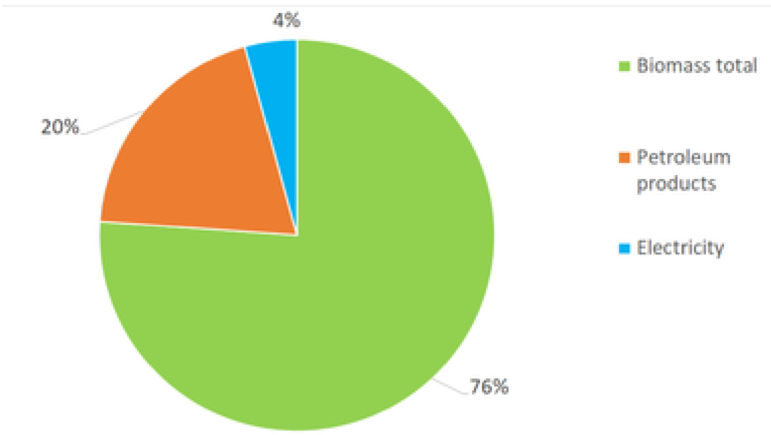


Figure B2-1: Togo's Energy Consumption (SIE 2017)

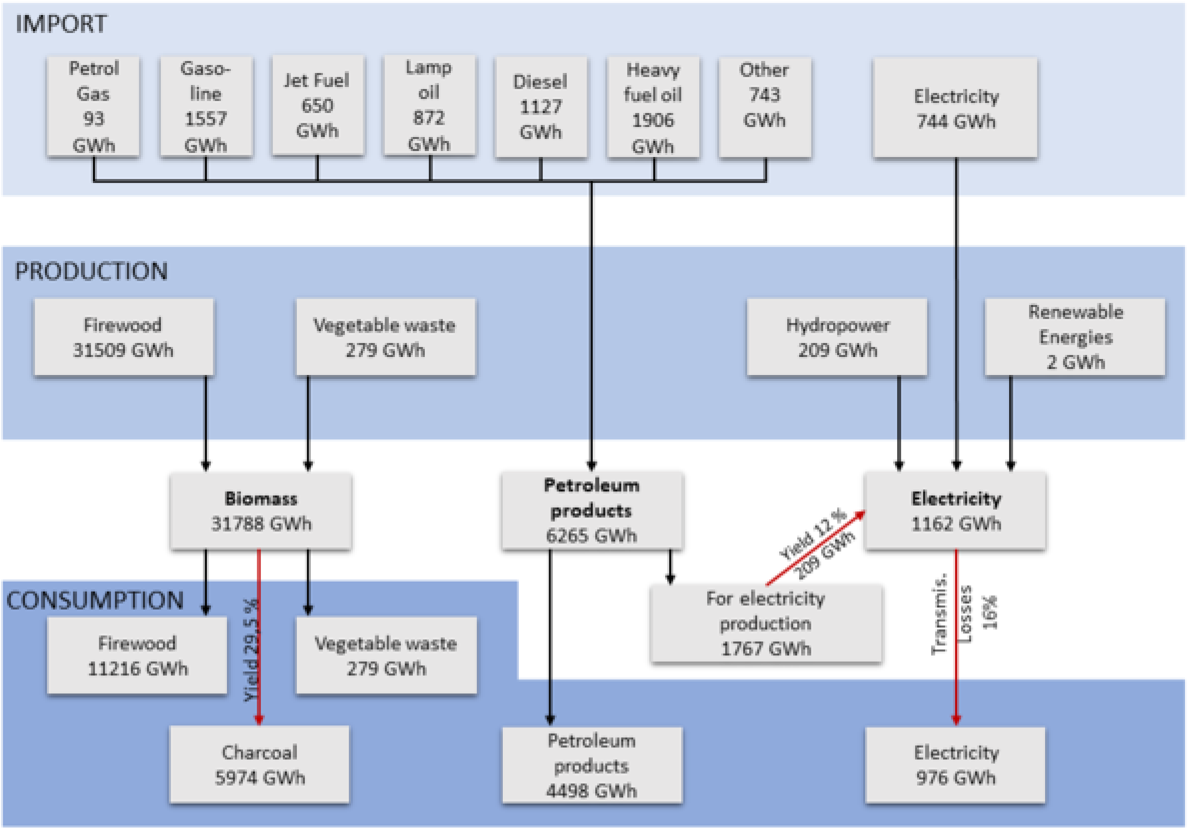


Figure B2-2: Togo Energy Supply from production and import to Consumption. Source: SIE (2017).

Of the imported oil, 72% is used for direct consumption, with most of it serving in the transport sector, and the remainder is used for electricity generation, with productivity of 12% for public power stations. Biomass consumption results from domestic sources, mostly firewood, which is used by households (35%), and nearly all the rest is converted into charcoal. There is also 279 GWh of vegetable waste of that is used unchanged as an energy form (Energypedia 2020).

The total electricity production in 2020 was 540.44 GWh between CEET and CGT, as shown in Figure B2-3 below, with transmission and distribution losses accounting for 16.04% of the electricity generated (CEET 2020).

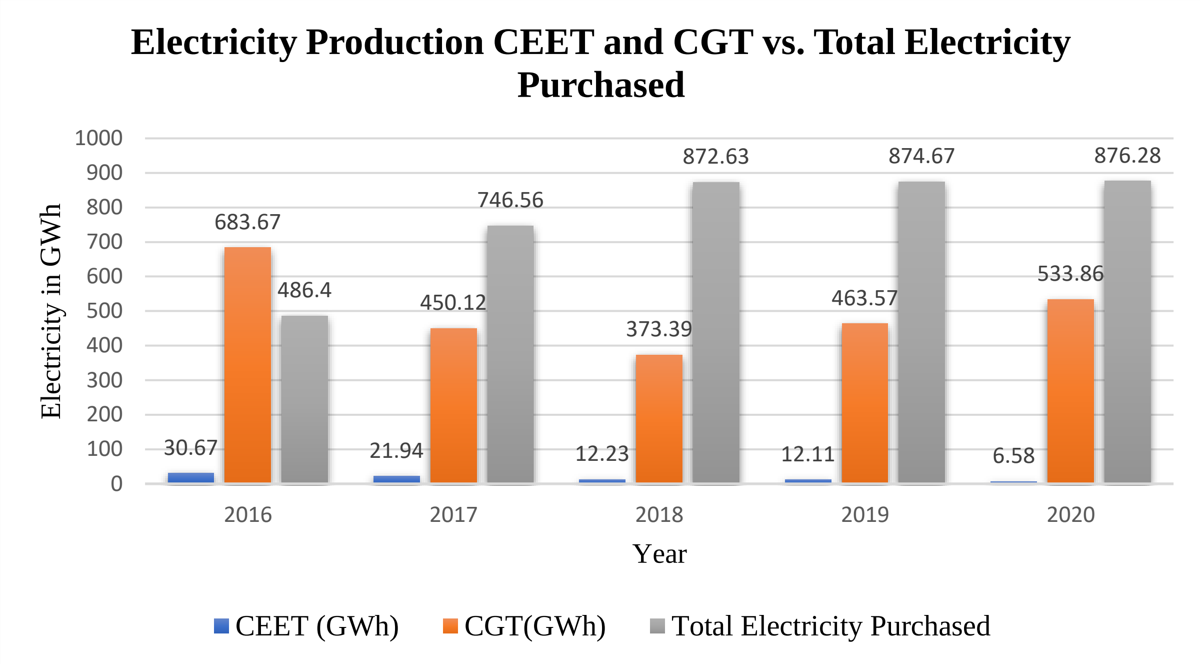


Figure B2-3: Electricity Production of CEET and CGT vs. Total Electricity Purchased (Adopted and Modified from CEET 2018; CEET 2019; CEET 2020)

As seen in Figure B2-3 above, energy production in Togo is done through CEET and CGT. The production from CGT comes from thermal energy, while that of CEET comes from an energy mix that includes thermal, hydropower, and solar. The share of thermal power produced was approximately 3.1 GWh in 2020, that of hydropower was 3.2 GWh, and that of renewable energy, specifically solar, was 0.276 GWh (0.175 GWh in 2019, and none in 2018) (CEET 2020). There are two reasons for the decrease in electricity production over the years: the extension of the electrical grid and the closure of some isolated plants. The closing of some power plants has been due to the higher cost of producing electricity compared to importing. A few examples include power plants in Mango (GAY 138, a power plants of nominal power of 1,024 kW), Kpekpleme (180 kVA and GE 311 kVA, 144 kW and 248.8 kW, respectively), Kougnohou (Cummins 311 kVA, 248.8 kW), Kabole (Cummins 400 kVA, 320 kW), and Guerrin-Kouka (Perkins 400 kVA and Cummins 400 kVA, 320 kW each). In addition, several broken power plants have been left without repairing them, such as Sulzer (Sulzer No. 1 and Sulzer No. 2, nominal power of 8,000 kW each), SDMO GE1A of 985 kW, and SDMO GE2A of 985 kW. The cost of production of 1 kWh in 2020 was estimated at 177.86 FCFA, while that of import was about 53 FCFA/kWh. The increase in demand is on the ascendency, as with the extension of the grid, new clients get energy, and a few industrial big consumers have also been set up, such as Steel Cube in Kara, ATP in Davie, Manumetal in Davie, and CIMCO in Lomé. To meet demand, Togo is forced to import most of its energy from the top three West African countries in total primary energy supply, as shown in Figure B2-4 below, namely Ghana, Côte D'Ivoire, and Nigeria (CEET 2018; CEET 2020).

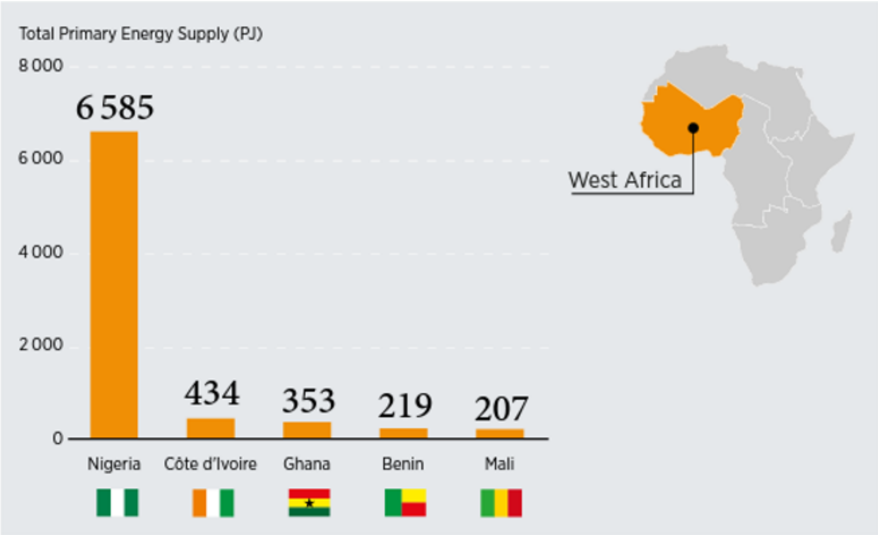


Figure B2-4: Top Five West African Countries in Total Primary Energy Supply in Petajoules (PJ). Source: UNSD (2018).

In 2020, there was no importation from Côte d'Ivoire. The importation from Ghana was mostly from hydropower, but in recent years, this has been a mix of hydropower and thermal. The importation from Nigeria is purely thermal. A total of 872.63 GWh was imported in 2018, 874.67 GWh in 2019, and 876.28 in 2020. Table 2-1 summarises this, even though Togo has significant renewable energy resources potential (PANER 2015), such as the solar, wind, and hydroelectric power resources discussed above, that could be developed to implement a nationwide sustainable energy system.

Table B2-1: Summary of Electricity Purchased in GWh (CEET 2020)

HEADINGS		2020 Electricity (GWh)	2019 Electricity (GWh)	2018 Electricity (GWh)	2017 Electricity (GWh)	2016 Electricity (GWh)
Electricity Purchased (GWh)	**VRA-TCN- SBEE-NANGBETO**	868,59	867.42	865.51	741.75	482.08
	SBEE Bénin (Cross-Border)	1.92	1.78	1.88	-	-
	ECG Ghana (Cross-Border)	5.3	5.07	4.95	4.58	4.11
	SNPT Togo	0.47	0.4	0.3	0.23	0.21
Total Purchased (GWh)		**876.28**	**874.67**	**872.63**	**746.56**	**486.4**

Currently, the rate of access to electricity in Togo is increasing, as shown in Figure B2-5 below (from 35.81% in 2016 to 53% in 2020), but with large disparities between regions, as shown in Figure 2-6, as well as between urban and rural areas (the urban access rate is 88.8%, and the rural access rate is 8%) (CEET 2020; CEET 2018; Energypedia 2020). Cape Verde and Ghana had the highest electricity access rates in West Africa in 2019 at 96% and 84%, respectively, according to IRENA (2022).

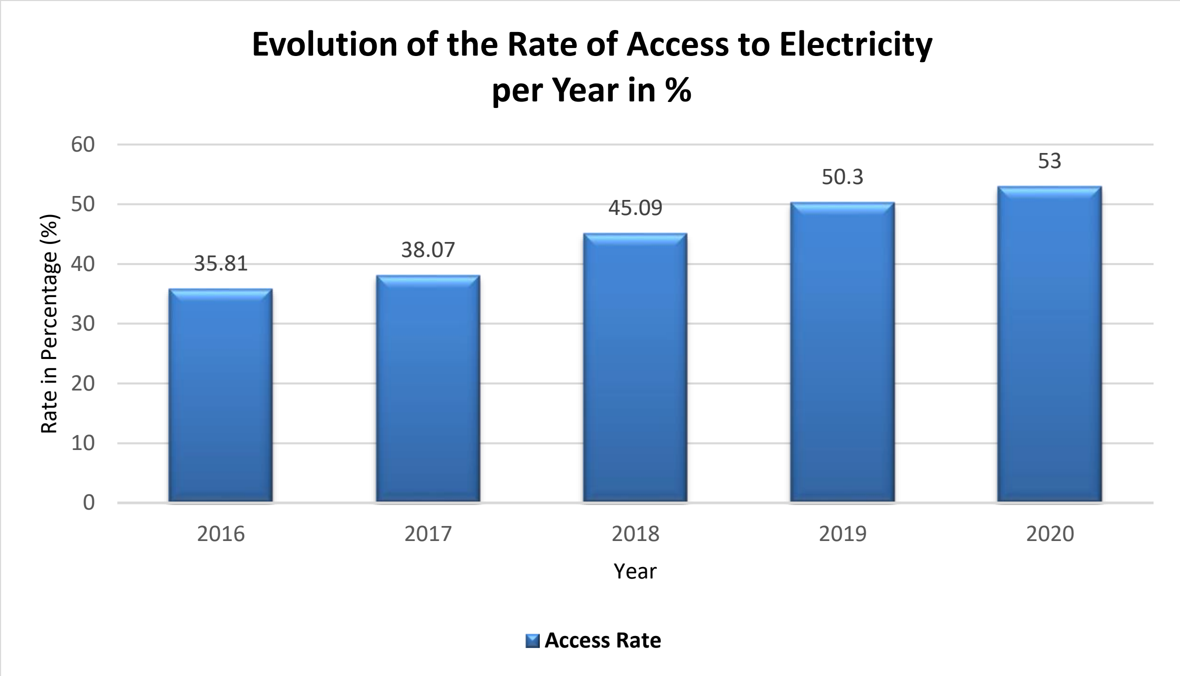


Figure B2-5: Evolution of the Rate of Access to Electricity per Year in Percentage (Adopted and Modified from CEET 2018; CEET 2019; CEET 2020)

Figure B2-5 shows that the rate of access to electricity has increased since 2016. In 2020, the access rate was 53%. Comparing this to the energy produced in 2020, production has decreased, while the access rate has increased. The increase in the access rate is due to more importation (876.28 GWh in 2020) and the extension of the electrical grid.

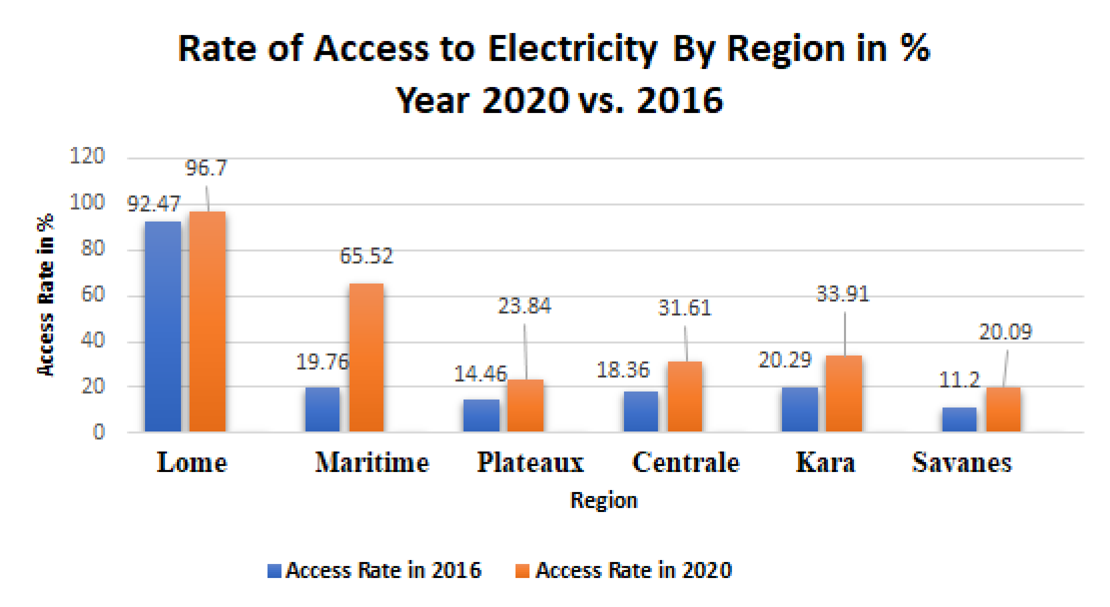


Figure B2-6: Rate of Access to Electricity by Region in Percentage – Year 2020 vs. 2016 (Adopted and Modified from CEET 2016; CEET 2020)

As shown in Figure B2-6, the rate of access to electricity in Lomé (capital city of Togo located in the south in the Maritime region) was about 96.70% in 2020, while the rest of the Maritime region had an access rate of 65.52%. Compare this to 2016, when the access rate in Lomé was about 92.47% and that in the rest of the Maritime region was 19.76%. This implies a 4.23% increase from 2016 to 2020 in Lomé and a 45.76% increase in the Maritime region. The high access rate in Lomé is due to three factors: Lomé is the capital city of Togo, it is the most populated city in Togo, and its infrastructure is more developed. The increase of the rate of electricity access has been possible due to the extension of the power grid, resulting in an increase in the number of people who have access to electricity. The rate of access to electricity in Sokode, the second most populated city of Togo located in the Central region, is slightly lower than that of Kara, situated in the Kara region. This is because Kara is considered the second city of Togo in terms of infrastructure after Lomé. The second national public university is also based in Kara. This city represents the region of the current president, who has been in power since 2005, taking over after the death of his father, who was in power for

38 years. The increase in the rate of access to electricity is mostly due to the extension of the power grid and a few solar installations. The Savanes region, located in the north, has the lowest rate of access to electricity (20.09% in 2020 and only 11.2% in 2016). Most of the people leaving in this region do not have access to the electrical grid, and the rural access rate is about 8%. The increase in the rate of access from 2016 to 2020 was possible due to the increase in solar kit installations for homes. The state has promised the construction of a new power line of 240 km that will improve electricity supply in the north. This power line will connect the localities of Kara, Mango, and Dapaong, located in the northern part of the country, with an expected capacity of 161 kV/20. Construction is to be financed through a loan of $52 million from Exim Bank of India. The Togolese government launched the work in December 2020 for a period of 20 months, and the work is being done by KEC International, Transrail Lighting, and Techno Electric & Engineering, all Indian companies (Magoum 2020).

Appendix B3: Previous Investments in Togo (Adopted and Modified from AfD, CEET, KfW, press; AT2ER 2018)

S Subsidies; TA Technical assistance; P Loans

No.	Financial backer		Total term	Total (CFA bn)	Projects financed	Current Status	Performed on Schedule?	Project Impact
1	AFD	P, S, TA	2013-	20	• Extension of **Lome's electricity grid** (cofinanced with the EU, €30 M) • Research to harness **hydroelectric potential** • Technical assistance to **CEET**	. In Progress . Finalised . In Progress	. No . Yes . Yes	. 100% Access to electricity in Lome, Dismantling of anarchic network . Evaluation of Hydroelectric potential of the Sarakawa River . Capacity building and support in the implementation of projects
2		S, TA	2015-	20	• Extension of **Lome's grid** (€7.8 M) • Review of the **legal and regulatory framework** of the energy sector • **Transborder** electrification of rural communities in Southern Togo from Ghana (12 locations) and Benin (8 locations)	. In Progress . In Progress . Finalised	. No . Yes . Yes	. 100% Access to electricity in Lome, Dismantling of anarchic networks . Improvement of business climate . Improvement of the rate of access to electricity in rural areas
3		P	08-16	15	• Upgraded generation/distribution capacity for **CEET** (phases I and II) • Dismantling of **"spider web"** grids in Lome (Detsicope and Djagble)	. In Progress . Abandoned	. No . Abandoned	. Improvement of the rate of access to electricity in the six largest cities of Togo after Lome, Dismantling of anarchic networks . Abandoned
4	KfW	S, TA	14-16	30	• Extension of **Lome's grid** (€10 M) and **transformer sub-station at Davie/Lome** (€12 M) • Renovation of the **hydro-electric plant** at Nangbeto (€11.5 M) • Construction of a West African Power Pool (WAPP) **power transmission line** - (€13 M) • Technical assistance to **CEET**	. In Progress . In Progress . In Progress . In Progress	. No . No . Yes . Yes	. 100% Access to electricity in Lome, Dismantling of anarchic networks . Improve plant performance, secure production . Contribute to the establishement of the regional energy market . Capacity building and support in the implementation of Projects
5	CHINA EXIMBANK	P	13-16	11	• Upgrade and **extension of the** CEET power distribution **network** phase 2 – zones targeted: Lome, Tsevie, Tabligbo, Vogan, Notse, Anie, Blitta, Bassar, Tchamba, Mango, Cinkasse	. Finalised	. Yes	. Increase in the rate of access to electricity and improvement in the quality of the electricity distribution service
6	EXIM INDIA	P	13-	15	• Electrification project for **150 rural locations** (rural electrification phase 4)	. In Progress	. No	. Increase in the rate of access to electricity in rural areas
7		P	13-16	9	• Access to power for **rural communities** in Togo (ER3) - CFA 8.5 bn • Project for a **transmission line** Dapaong-Mango -CFA 9.6 M	. Finalised . In Progress	. Yes . No	. Increase in the rate of access to electricity in rural areas . Development of socio-economic infrastructure in the Savana region
8	WORLD BANK	P, TA	2009-	46	• **Emergency power** infrastructure upgrade project - CFA 26 bn (09-13) • Project to improve **operating performance in the sector and provide access to electricity** in the Lome region - CFA 20 bn (2017-)	. Finalised . In Progress	. Yes . Yes	. Improve the living conditions of vulnerable populations living in urban and peri-urban areas of Lome . Improve the quality of electrical energy distribution service in the city of Lome

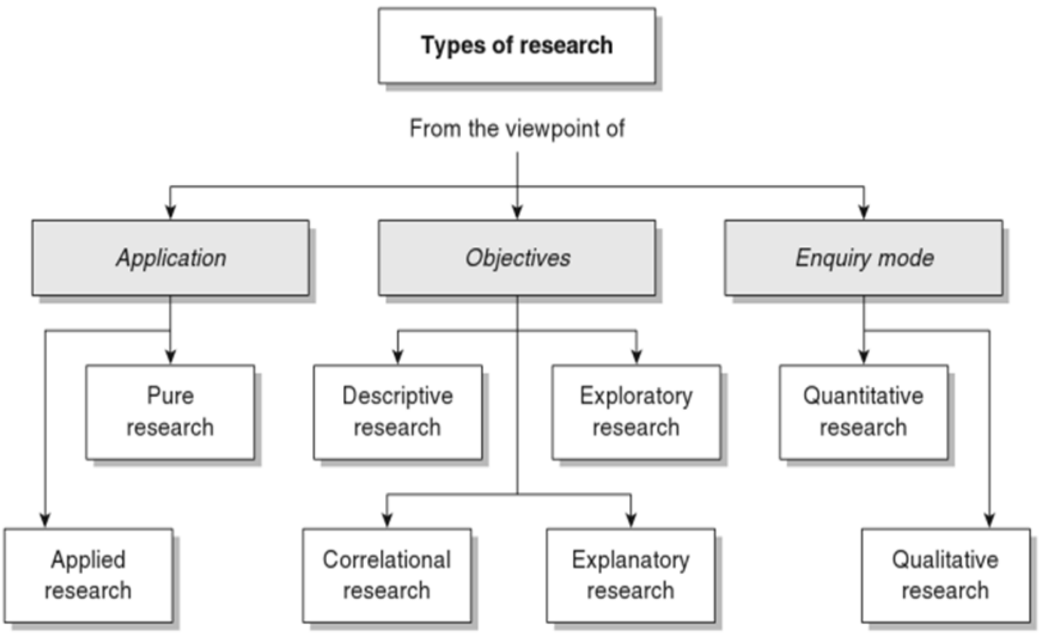
Based on the table above, there have been a few financed projects since 2008. The financial backer for each project is listed in the second column. These backers either subsidised the project, provided some loans, or offered technical assistance for the execution of the project. This represents the term of the project and is shown in the third column. The fourth column represents the year, the fifth column the amount in billion CFA for the project, and the sixth column the details of the financed project. Columns seven, eight, and nine represent the project status as of June 2022, the timeline, and the impact/potential impact, respectively, based on personal communication (2022). As seen in the table, some of the projects are still ongoing, while others have ended. The latter is the case with Project No. 5, the upgrade and extension of the CEET power distribution network phase 2, targeting zones Lomé, Tsevie, Tabligbo, Vogan, Notse, Anie, Blitta, Bassar, Tchamba, Mango, and Cinkasse between 2013 and 2016 (AT2ER 2018). This project helped increase the rate of access to electricity and improve the quality of the electricity distribution service. A few of them show a range of dates insinuating that they have ended; however, this is not the case based on discussions with key energy personnel (personal communication 2022). Examples:

- Project No. 3, the upgrade of the generation/distribution capacity for CEET (phases I and II) and the dismantling of “spider web” grids in Lomé (Detsicope and Djagble) (AT2ER 2018), which shows a date range between 2008 and 2016. In reality, the upgrade of the generation/distribution capacity is still in progress, and the dismantling of the spider web grids in Lomé has been abandoned. This part of the project has been abandoned because its objective has been considered within the framework of the implementation of another program.
- Project No. 4, the extension of Lomé’s grid (€10 million) and the transformer sub-station at Davie/Lomé (€12 million); the renovation of the hydroelectric plant at Nangbeto (€11.5 million); the construction of a West African Power Pool (WAPP) power transmission line (€13 million); and the technical assistance to CEET between 2014 and 2016 (AT2ER 2018). All of these are still in progress, and the reasons for the delay are not clear yet.

- Project No. 7: The access to power for rural communities in Togo (ER3) of approximately CFA 8.5 billion has been finalised, while the transmission line Dapaong-Mango project of approximatively CFA 9.6 million is still in progress. According to Magoum (2020), the government launched the work for the project for a Dapaong-Mango transmission line in December 2020 for a period of 20 months. This has been confirmed through discussion with energy personnel, who stated that the work only started in 2021 (personal communication 2022). The delay in commencing this project was due to the service fees that had to be taken care of by the Togolese government, such as payment to landowners for the lands this will occupy and payments that needed to be made with regards to the cutting of trees in the country.

Appendix C: Chapter 3 Appendices

Appendix C1 – Types of Research (Source: Kumar 2011)



Appendix C2: First Round Data Collection

Appendix C2-1: Research Information Sheet

RESEARCH INFORMATION SHEET

Research Title: An assessment of the role of renewable energy development in Togo

Investigator: Leontine N Kansongue (Under the supervision of Prof James Njuguna & Prof Stephen Vertigans).

Invitation: You are being invited to take part in this research study, as your knowledge in relation to the field of research will be invaluable to the study. Before you decide on whether you would like to take part or not, please read the following information carefully to understand the reasons for doing this research and what it will involve.

Voluntary participation: Please be advised that taking part in this interview is voluntary and you are free to withdraw at any point in time.

Purpose of the research: Togo relies on biomass for most of its energy supply; it has no proven oil or natural gas reserves and is forced to import all its petroleum from Ghana, Côte d'Ivoire and Nigeria. Currently, approximately 60 percent of its inhabitants lack access to energy, one of the key resources for development in today's world. This deficit in power slows down economic activities and hinders the economic development of the country. Despite this lack of energy, literature and empirical observation reveal that Togo has significant potential for renewable energy. Hence, the aim of this research is to undertake a critical investigation of the factors that facilitate renewable energy growth and mechanisms to improve energy security in Togo and its impact on the environment and socio-economic development. The study is ongoing and will run for a total period of 3.5 years. The recommendations of the study might help improve the energy sector in Togo and facilitate the development of renewable energy technologies for sustainable development in the country.

Process of the interview: Open-ended questions will be asked by the researcher using the formulated interview questions. Questions will be asked one after the other to allow the participants to answer each question as it is being asked. The time scale for the interview per participant is about 45min (be reminded that you can request to stop the interview at any time).

Data storage arrangements: Handwritten notes will be taken as the interview progresses to summarize the minutes of the meeting. At the end of each meeting, the researcher will go over the notes taken with the participant to confirm the accuracy of discussions. The interview will be recorded on a digital voice recorder. A copy of this recording will be saved on an external hard drive for a duration of 3 years. Any personal data will be subject to the UK 1998 Data Protection Act and will be stored securely.

Participants: Participants are selected based on their ability to provide information in their different fields of work. Information sought is not confidential and will be used in the production of a research thesis and possibly in future publications. Responses by the interviewees will be anonymized.

Benefits and Risk: The result of this research will have no direct benefit to you immediately, but your participation is likely to help us come up with good recommendations for policymakers. The implementation of these recommendations in the future will help improve the energy sector and assist in the sustainable development of the country. Your participation in this study does not put you at any risk.

Contact: For further information, please contact:

Leontine N. Kansongue	Prof James Njuguna	Prof Stephen Vertigans
E:n.kansongue@rgu.ac.uk	E:j.njuguna@rgu.ac.uk	E:s.vertigans@rgu.ac.uk
Phone: +22893787945	Phone: +441224262304	Phone: +441224263229

Thank you for reading the information sheet.

Appendix C2-2: Informed Consent Form

<u>Informed Consent Form</u>

Please answer yes or no to indicate you consent to the following:

I have read the foregoing information, or it has been read to me
Yes ☐ No ☐

I have been given time to consider whether or not to participate in this interview Yes ☐ No ☐

I have been given opportunity to ask questions, and I am satisfied with the answers I have been given regarding the study Yes ☐ No ☐

I understand that I am under no obligation to take part in this interview, that I do not have to answer all questions, and that I am free to withdraw at any time Yes ☐ No ☐

I agree for the interview to be recorded Yes ☐ No ☐

I would like my responses to be treated anonymously Yes ☐ No ☐

I agree that the data that I have provided can be used in the research output (Thesis and publications) Yes ☐ No ☐

I know who to contact if I have any questions about the study Yes ☐ No ☐

I hereby consent to take part in this study.

Participant's name ……………………………………………………

Signature ………………………………………………………….

Date …..…………………………………………………………….

Appendix C2-3: First Data Collection Questions

Name of Company/Community/Participant:

(Note: information sought will be used in the production of the research thesis and possibly in future publications).

Location:

Participant's gender:

1	Male	
2	Female	

Age group:

1	Less than 16 years	
2	16-24 years	
3	25-39 years	
4	40-60 years	
5	61 years and above	

Level of education:

1	No Formal Education	
2	Primary	
3	Secondary	
4	Technical	
5	Tertiary	

Employment status:

1	Homemaker	
2	Labourer	
3	Farmer	
4	Retired	
5	Student	
6	Unemployed	
7	Self-employed:	
	• Type of business	
	• Size of business	
8	Employed:	
	• Public sector	
	• Private sector	
	• NGOs	
9	Others	

Number of years in this community:

1	Less than 5 years	
2	6-10 years	
3	11-15 years	
4	16-20 years	
5	Above 20 years	

<table>
<tr><th>Question Number</th><th>Community Questions</th><th>NGOs and Private Organisation Questions</th><th>Policymaker Questions</th></tr>
<tr><td colspan="4">Task 1: To critically review the energy situation in Togo and outline factors resulting in high dependency on the international market.</td></tr>
<tr><td>1.1</td><td colspan="2">Do you have access to energy for your daily life and activities?
Yes ☐ No ☐
*If yes:
• What type?
• How and what do you use it for?
• Is it sufficient?
• Do you require more energy for your daily uses?
• Are there any issues caused by potential energy shortage?
*If no:
• Would you like to have access or greater access to energy?
• Any preference for type of energy?</td><td>n/a</td></tr>
<tr><td rowspan="2">1.2</td><td colspan="3">Do you know what form of renewable energy is produced/generated in Togo itself?
Yes ☐ No ☐
*If yes,
• What form?
*If no,
• Who generates the energy?
• Who is the owner?</td></tr>
<tr><td>n/a</td><td colspan="2">• Who provides the equipment?
• Are there any dependencies from the providers? Does this generation</td></tr>
</table>

		depend on any long-term import arrangements? Yes ☐ No ☐ ▪ If yes, can you elaborate further?
1.3	n/a	Who are the current actors within the energy sector in Togo?
1.4	Could you see other forms of renewable energy being produced/generated in Togo in the future? Yes ☐ No ☐ *If yes, • Could you give details? • Do you know why this type of energy is not currently produced? *If no, • Do you know why?	
1.5	Are there any issues caused by the current energy in place, such as pollution, health issues, etc.?	
1.6	In your opinion, what are the issues facing the energy sector in general?	
Task 2: To critically review the available knowledge on renewable energy penetration and investigate the potential of different renewable energy sources.		
2.1	What are the potential renewable energy sources in Togo? • Could you provide more details?	
2.2	Have there been any renewable energy developments within the country? Yes ☐ No ☐ *If yes, • Which ones? • Have they been successful? Yes ☐ No ☐ ▪ If yes, what drove their success? ▪ If no, what went wrong? • Could there be greater development of renewable energy technologies in Togo? Yes ☐ No ☐	

	▪ If yes, what is needed? And what type would you recommend? ▪ If no, why not? And what are the reasons for the lack of development?	
2.3	Are there types of renewable energy that are currently used within your area? Yes ☐ No ☐ *If yes: • What types? • Do you make use of it? • What do you use it for?	
2.4	n/a	What is the level of knowledge in renewable energy in terms of skills? For example, are there experts in the field of renewable energy technologies in Togo to take care of installations, operations, and maintenance? Yes ☐ No ☐ Can you give more details?
Task 3: To outline the potential impact of renewable energy usage on the environment and socio-economic development in Togo.		
3.1	Would you advise the use of renewable energy in Togo? Yes ☐ No ☐ *If yes, what are your reasons? *If no, why not?	
3.2	Can the use of renewable energy contribute to your daily life and activities? E.g., improve living conditions, generate income, enable education, and help in your field of work? Yes ☐ No ☐ *If yes: • How can it help you?	n/a

	• What impact will it have on your field of work? *If no, why not?	
3.3	How can the use of renewable energy improve any health issues (e.g., respiratory disease, product and vaccine storage in hospitals or clinics)? Yes ☐ No ☐ *If yes, how?	
3.4	What impact can the use of renewable energy have on the: • Community level? • Regional level? • National level?	
3.5	n/a	Do you think the use of renewable energy can reduce energy costs in future? Yes ☐ No ☐ *If yes why? *If no, why not? Can you explain your answer further?
3.6	What other impacts can the use of renewable energy produce on sustainable development (environment, socio-economic development)?	
Task 4: To make recommendations on approaches to becoming self-sufficient.		
4.1	What are the best practices that can be identified within the energy sector? (E.g., are there any adopted rules and regulations that help or favour the population? Is there any introduction of standardized power purchase agreements and power purchase tariffs to encourage development? Etc.)	
4.2	What improvements can be recommended?	
4.3	Who are the key policymakers***? Who are other important key players, and why?	
4.4	What actions could be taken by policymakers to encourage wider adoption of renewable energy in Togo for sustainable development? What actions could be taken by other important key players?	

4.5	n/a	Do you think the use of renewable energy technologies is cheaper or more expensive? Can you explain your answer?
4.6	n/a	Would you be happy to invest in renewable energy technologies? Yes ☐ No ☐ *If yes, why? *If no, why not?
4.7	n/a	What type of renewable energy would you recommend and why?
4.8	n/a	What payback period would you expect should you invest in renewable energy technologies?
4.9	What other suggestions could you recommend?	

*****(Policymakers refer to politicians; electricity company representatives; Togolese ministry representatives)*

Appendix C3 – Second and third Round Data Collection

Appendix C3-1: The research information sheet and questions refined

<u>RESEARCH INFORMATION SHEET</u>

Research Title: An assessment of the role of renewable energy development in Togo

Investigator: Leontine N Kansongue (Under the supervision of Prof James Njuguna & Prof Stephen Vertigans).

Invitation: You are being invited to take part in this research study, as your knowledge in relation to the field of research will be invaluable to the study. Before you decide on whether you would like to take part or not, please read the following information carefully to understand the reasons for doing this research and what it will involve.

Voluntary participation: Please be advised that taking part in this research is voluntary.

Purpose of the research: Togo relies on biomass for most of its energy supply; it has no proven oil or natural gas reserves and is forced to import all its petroleum from Ghana, Côte d'Ivoire, and Nigeria. Currently, approximately 60 percent of its inhabitants lack access to energy, one of the key resources for development in today's world. This deficit in power slows down economic activities and hinders the economic development of the country. Despite this lack of energy, literature and empirical observation reveal that Togo has significant potential for renewable energy. Hence, the aim of this research is to undertake a critical investigation of the factors that facilitate renewable energy growth and mechanisms to improve energy security in Togo and its impact on the environment and socio-economic development. The study is ongoing and will run for a total period of 5 years. The recommendations of the study might help improve the energy sector in Togo and facilitate the development of renewable energy technologies for sustainable development in the country.

Process of the interview: Open-ended questions will be distributed by the researcher using the formulated interview questions. Questions will be sent via email to participants to complete.

Data storage arrangements: A copy of the completed questionnaires will be saved securely for a duration of 4 years. Any personal data will be subject to the UK 1998 Data Protection Act and will be stored securely.

Participants: Participants are selected based on their ability to provide information in their different fields of work. Information sought is not confidential and will be used in the production of a research thesis and possibly in future publications. Responses by the interviewees will be anonymized.

Benefits and Risk: The result of this research will have no direct benefit to you immediately, but your participation is likely to help us come up with good recommendations for policymakers. The implementation of these recommendations in the future will help improve the energy sector and assist in the sustainable development of the country. Your participation in this study does not put you at any risk.

Contact: For further information, please contact:

Leontine N. Kansongue	Prof James Njuguna	Prof Stephen Vertigans
E:n.kansongue@rgu.ac.uk	E:j.njuguna@rgu.ac.uk	E:s.vertigans@rgu.ac.uk
Phone: +22893787945	Phone: +441224262304	Phone: +441224263229

Thank you for reading the information sheet.

Appendix C3-2: Questionnaire for Second and Third Data Collection

Name of Company/Community/Participant:

(Note: information sought will be used in the production of the research thesis and possibly in future publications).

Participant's gender and location:

1	Male	
2	Female	
3	Location/city	

Type of Organisation:

1	Governmental	
2	Non-governmental	
3	Private	
4	Others	

What is your Level of Expertise in Energy?

1	No experience	
2	Limited experience	
3	Intermediate	
4	Advanced	
5	Expert	

What role do you play in the organisation you work for?

1	Technical	
2	Research	
3	Policy/management	
4	Political	
5	Others	

Questions:

1. What type of energy is generally used?	
1.1	In urban areas of Togo? • Thermal energy (produced by burning fuels such as coal, oil, gas or wood. Can also be taken from steam from a geothermal field or created by nuclear reactions)? • Solar energy (PV, thermal)? • Any other type?
1.2	In rural areas of Togo? • Thermal energy? • Solar energy (PV, thermal)? • Any other type?
2. Do you know how much power is produced from the 230MW installed generating capacity?	
3. Are you engaged in energy use/utilisation, buying, or decision-making? How much estimated power is needed to meet the 2030 vision? What would you suggest in terms of percentage increase to the current electric power consumption?	
4. Solar energy was installed in 22 villages from 2013 to 2016 with the aid of a West African Economic and Monetary Union (WAEMU) project named "PRODERE" ("Programme Régional de Développement des Énergies Renouvelables et d'Efficacité Énergétique"). Do you know how those villages use the installed solar energy? • Lighting only? • Charging electrical equipment? Such as?	

• Powering Hospitals? • Others? • Can you give more details?
5. In your opinion, why have the wind projects planned by Delta Wind failed to start? Please explain.
6. What is the latest on the discovered oil in Togo? Has there been any progress in terms of exploitation? Assuming yes, what has been done? Otherwise, what has been the drawback?
7. What are the existing laws that promote the use or development of renewable energy?
7.1. What are the benefits or disadvantage of these existing laws?
7.2. Can you make suggestions for improvement, if any?
8. How is the management system in terms of renewable energy when referring to processes? Would you suggest something different?
9. How can policymakers address the absence of framework regulations that govern the energy sector?
10. Should renewable energy be prioritized? If so, why?
11. Should diversification with regards to renewable energy be promoted? If so, why?
12. Should renewable energy research be promoted? If so, why?
13. Do you have any other suggestions to recommend?

****(Policymakers refer to politicians; electricity company representatives; Togolese ministry representatives)*

Appendix C4: Description of Data Codes Used

Code (No. of Participants)	Organisation	Description
PFG1 – Focus Group 1 (9)	Electric Power Company of Togo (CEET)	In charge of energy distribution and sales
PFG2 – Focus Group 2 (9)	Ministry of Energy and Mines	Supervises Togo's energy sector activities and in particular the electricity sub-sector activities
PFG3 – Focus Group 3 (6)	Ministry of Environment and Forest Resources	Coordinates the development and implementation of policies in all that concerns environmental issues, forest resources, and wildlife
PFG4 – Focus Group 4 (8)	Ministry of Agriculture, Livestock Farming and Fisheries	Provides regulatory and technical advice, training, and support to farmers to effectively manage and use the potential in agriculture and fisheries
PFG5 – Focus Group 5 (7)	National Assembly House (Parliament/MPs)	Togo's legislatives body
IFG1 – Focus Group 6 (7)	ECOWAS office	Works to promote economic integration among its members
IFG2 – Focus Group 7 (7)	Food and Agriculture Organization (FAO)	Serves as a project facilitator but works/acts directly with ministries
IFG3 – Focus Group 8 (10)	African Biofuel and Renewable Energy Company (ABREC)	Works to promote renewable energy and energy efficiency technologies
AFG1- Focus Group 9 (7)	University of Lomé - Renewable Energy Centre	Provides research, training, and technical experience towards the development of solar PV
EFG1 – Focus Group 10 (5)	Energy, environment/ development NGOs	Deals with issues related to climate change and development
WG1 – Workshop Group 1	Private, public, international, financial, and non-governmental organisations, academics, public	Presentation on renewable energy development in Togo/attendees' opinions
WG 2- Workshop Group 2	Rural community (Kamboli)	Understand needs, practices, problems
WG 3 – Workshop Group 3	Rural community (Mango)	Understand needs, practices, problems
WG 4 – Workshop Group 4	Rural community (Mandouri)	Understand needs, practices, problems
WG 5 – Workshop Group 5	Rural community (Agome Glozou)	Understand needs, practices, problems
WG 6 – Workshop Group 6	Rural community (Notse)	Understand needs, practices, problems
WG 7 – Workshop Group 7	Rural community (Dapaong)	Observation
SI – Stakeholder Interview (1–31)	Stakeholders with expertise	Provide responses to face-to-face interview questions
S1 – Survey (1–17)	Stakeholders with expertise	Renewable energy key views

DVSI – Stakeholder Interview (1–16)	Stakeholders with expertise	Provide responses to face-to-face interview questions for data validation

Appendix D – Chapter 8 Appendix

Appendix D1: Defining the Research Originality

Several criteria exist to distinguish a Master of Philosophy-level dissertation and a doctorate-level thesis, the main one being the level of originality (Akinsete 2012). The key compliance for submissions is a 'significant contribution' to an existing body of knowledge in the field of study, which must be unique (Phillips and Pugh 2010). On this concept of originality, Cryer (1996) compares the research process to the journey of an explorer and suggests that originality can be considered from three perspectives: tools, procedures, and techniques (Akinsete 2012). Furthermore, Cryer (2006 p. 199) cites numerous examples of original contributions to knowledge, comprising:

a. A new or improved product

b. A new theory or reinterpretation of an existing one

c. A new or improved research tool or technique

d. An in-depth study

e. An exploration of a topic

f. A critical analysis

g. A portfolio of work based on research

h. A fact or conclusion or a collection of facts or conclusions

Based on the above, the originality of this research meets conditions stated in points d, e, f, g, and h.