AN INVESTIGATION INTO THE DRIVERS AND BARRIERS AFFECTING THE IMPLEMENTATION OF RENEWABLE ENERGY TECHNOLOGIES IN ZAMBIA

BY

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A Dissertation submitted to the University of Zambia in partial fulfilment of the requirements for the award of the Degree of Master of Business Administration General

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DECLARATION

I, **CHEWE MHANGO**, do hereby declare that this work is my original work achieved through personal reading and research. This work has never been submitted to the University of Zambia or any other Universities. All sources of data used and literature on related works previously done by others, used in the production of this Dissertation have been duly acknowledged. If any omission has been made, it is not by choice but by error.

Signature: .... Date: ....

APPROVAL

This Dissertation by Chewe Mhango is approved as a partial fulfilment of the requirements for the award of the Degree of Master of Business Administration General.

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ABSTRACT

Zambia, rich in its renewable energy potential, faces a complex matrix of challenges and opportunities in harnessing and optimizing this potential. This research sought to investigate the drivers and barriers to the implementation of renewable energy technologies beyond hydropower. The study, grounded in expert interviews and a comprehensive review of pertinent documents, unveils a multifaceted landscape of regulatory, financial, infrastructural, and societal challenges that intersect with immense opportunities presented by abundant alternative renewable energy resources. The research employed an interpretivist philosophy, acknowledging the dynamic construction of reality based on individual experiences and societal contexts. Following interpretive principles, the study sought a profound understanding of drivers and barriers in Zambia's renewable energy landscape. Utilizing an inductive approach, the research aimed at exploring new aspects, avoiding preconceived theories, and deriving insights from empirical data. A descriptive research design, specifically a qualitative survey, was adopted to capture the intricacies of the renewable energy sector. The target population included key entities in the electricity subsector, and a purposive sampling technique, with maximum variation sampling, ensured diverse perspectives. Data collection involved in-depth interviews and document review. The findings highlight the urgent need to diversify Zambia's energy mix due to vulnerabilities in hydropower exacerbated by climate change. Regulatory hurdles, financial barriers, and public acceptance issues are significant challenges. The research recommends a streamlined regulatory environment, innovative financing mechanisms, and comprehensive public awareness campaigns. It also advocates for international collaborations to leverage technical, policy, and financial synergies. Ultimately, the study provides a roadmap for Zambia's renewable energy future, offering actionable recommendations to guide its journey toward sustainability and prosperity.

Keywords: Renewable energy, hydropower, financial mechanisms, public awareness, international collaboration, energy diversification, bureaucratic bottlenecks, Zambia, drivers, barriers.

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DEDICATION

This Dissertation is dedicated to the loving memory of my late father, Mr. Oliver M'hango. His guidance, wisdom, and unwavering support have been my inspiration and strength. May his legacy continue to light my path and those of others he touched.

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LIST OF ACRONYMS

8NDP	Eighth National Development Plan
CO2	Carbon Dioxide
CSP	Concentrating Solar Power
DNSPs	Distribution Network Service Providers
EPACT05P.L.	Energy Policy Act of 2005 Public Law 109-58
ERB	Energy Regulation Board
FIT	Feed-in Tariff
GEF	Global Environment Facility
GHG	Greenhouse Gas
GGGI	Global Green Growth Institute
IPP	Independent Power Producer
IPPs	Independent Power Producers
ITPC	Itezhi Tezhi Power Company Limited
LHPC	Lunsemfwa Hydro Power Company
LSMFEZ	Lusaka South Multi-Facility Economic Zone
MCL	Maamba Collieries Limited
MoE	Ministry of Energy
MW	Megawatt
MWh	Megawatt-hour
NECL	Ndola Energy Company Limited
NEP	National Energy Policy
NGOs	Non-Governmental Organizations
NWEC	North Western Energy Corporation

PV	Photovoltaic
REA	Rural Electrification Authority
RECs	Renewable Energy Credits
REEMP	Rural Electrification Master Plan
REFiT	Renewable Energy Feed-in Tariff
REF	Rural Electrification Fund
REMP	Rural Electrification Master Plan
REPD	Renewable Energy Policy Division (assumed based on context)
REEEP	Renewable Energy & Energy Efficiency Partnership
RETs	Renewable Energy Technologies
RPS	Renewable Portfolio Standards
SAPP	Southern Africa Power Pool
SDG	Sustainable Development Goal
TNSPs	Transmission Network Service Providers
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
ZDA	Zambia Development Agency
ZPL	Zengamina Power Limited

CHAPTER 1

INTRODUCTION

1.0 Introduction

Energy plays a major role in the development and progress of a nation. According to Jamil et al., 2015, the two categories of energy are renewable energy and non-renewable energy. Renewable energy is the type of energy obtained from regenerative or virtually inexhaustible energy sources that occur in the natural environment. This type of energy includes solar, wind, geothermal, and wave power. On the other hand, non-renewable energy refers to energy obtained from static stores of energy, that is, sources that remain bound unless released by human interaction. Non-renewable energy sources include fossil fuels coal, oil, and natural gas. This Chapter provides an outlook of the research on the drivers and barriers to the implementation of renewable energy technologies in Zambia. The Chapter highlights the background to the study as well as the country profile. Additionally, the statement of the problem, objectives, aim, and significance of the study are outlined.

1.1 Background of the Research

The United Nation's 7th Sustainable Development Goal (SDG) aims to ensure access to affordable, reliable, sustainable, and modern energy for all by 2030. Whilst access to electricity in poor countries has begun accelerating and renewable energy is making impressive gains in the electricity sector, more focused attention is needed to expand the use of renewable energy and to increase the electrification rate in Sub-Sahara Africa (World Bank, 2017). According to the World Bank (2017), the global population with access to electricity rose from 83 percent in 2010 to 87 percent in 2015, then accelerated to 89 percent in 2017 (a gain of 1 percentage point annually in the past two years). However, despite this rise at the global level, 840 million people were without this essential service in 2017, mostly in sub-Saharan Africa. In that region, only 44 percent of the population had access, and an estimated 573 million people still lacked electricity. Additionally, the United Nations Report on Sustainable Development Goals (2021) reveals that despite progress in the past decade on improving access to electricity and increasing renewable energy use in the electricity sector, the world is still falling short of attaining the 7th SDG. Global access to electricity increased from 83 percent in 2010 to 90 percent in 2019, with an increase in average annual electrification of 0.876 percentage points. The global access deficit decreased from 1.22 billion in 2010 to 759 million in 2019 (World Bank, 2021). Despite the significant effort made, there may still be as many as 660 million people without access to electricity worldwide in 2030. Regarding the share of renewable energy in developing countries, the Report discloses that the said countries had a renewable energy capacity of 219 watts per capita at the end of 2019, an increase of 7 percent over the year but slightly less than the 8.8 percent expansion in per capita capacity for 2018. Further, the per capita hydropower capacity remained stable in 2019, as total capacity increased in line with population growth during the year at approximately 0.4 percent. On the other hand, solar and wind capacities both expanded much faster than population growth, leading to increases in per capita capacity of 22.2 and 11.3 percent, respectively.

The current power supply situation and landscape in the Southern Region of Africa comprises a generation mix that is dominated by thermal (coal) with 59% and the other available generation technologies are hydropower, solar, distillate, nuclear, wind, and gas (SAPP,2021). The installed generation mix for the Southern Africa Power Pool (SAPP) is depicted in Table 1.1 below.

Table 1.1: SAPP generation mix

No	Energy Source Type	Percentage (%)
1	Thermal	59
2	Hydro	24
3	Solar PV	4
4	Distillate	4
5	Nuclear	3
6	Wind	3
7	OCGT	2
8	Solar CSP	1

According to Munoz et al. (2020), the use of renewable energy which now accounts for one-third of the global power capacity has significantly increased in the last decade. With Africa’s low electrification rates, using renewable energy is one of the quickest and most cost-effective ways to improve access and contribute to economic development, greener energy consumption, and achieving the SDGs.

The region remains highly uneven regarding energy access, installed generation capacity, and plans for renewable energy expansion. As the commercial competitiveness of renewables has improved, interest in renewable energy technology has grown, partly due to the cost reductions in technologies such as wind and solar. The relative economic appeal of renewables concerning fossil fuels has also grown. Renewables are experiencing decreasing capital costs (and resultant lower tariffs) and do not carry the financial risk associated with fuel price volatility and potentially stranded assets from fossil fuel infrastructure (Hafner et.al, 2018). Increasing renewable energy generation capacity can also address power shortages and expand energy access in the region, particularly in rural areas where renewables can be efficiently linked to mini-grids in rural electrification initiatives. Renewable energy can be a powerful driver for development in the region. In addition, to providing electricity needed to power the economies of the Southern African Development Community (SADC) region, renewables also have the potential to deliver additional development co-benefits, including job creation, increased industrial activity through the expansion of supply chains, and development of local solutions, expansion of regional trade in services, market creation, the reduced balance of payments, and revitalization of geographical areas where the renewable energy resource is located (Munoz et.al, 2020).

Renewable energy technologies are considered clean energy resources and are critically important due to their environmental-friendly nature (GCF, 2018). With the increase in awareness of a clean environment, it is believed that traditional dependence on fossil fuels has led to carbon dioxide (CO2) emissions, greenhouse gas (GHG) problems, and environmental pollution. Therefore, national, and international energy policies have a very important role in regional and global power equilibrium and their importance is increasing (Foster V., 2020). Matching supply with this surging demand is a principal and critical challenge for countries around the world. In this respect, diversification of energy resources and their transportation routes, efficient use of local resources, and the use of existing energy resources with various technological and strategic practices in the most efficient way possible is necessary to improve energy security and reduce dependence on foreign energy sources.

Considering the above, the adaptation of Renewable energy has been enshrined in SDG number 7, which advocates for investing in clean energy sources such as solar, wind, and thermal to achieve universal access to affordable electricity by 2030 (UNDP, 2014). It is hoped that the adaptation of renewable sources of energy could positively influence climate change adaptation; gender mainstreaming and sustainable growth and development are also innumerable. It is against this background that this study aims at investigating the drivers and barriers to the implementation of renewable energy technologies in Zambia.

1.1.1 Zambian Context

Zambia’s energy sector structure comprises three sub-sectors: electricity, petroleum, and renewable energy. The renewable energy sub-sector consists of wholesalers and retailers of renewable energy generating equipment, producers of bioenergy, solar mini-grids, utility-scale solar power plants as well as small hydropower generators (ERB, 2020). Zambia is endowed with a range of energy resources, the primary sources of energy are hydro, biomass, coal, wind, geothermal, solar, uranium, waste (including municipal solid and agricultural waste), and petroleum. Zambia is confronted with increasing energy demand, resulting from demographic and socioeconomic factors, at an average of 6 percent or 150-200 MW per annum. The Country's total population is expected to grow from 17.9 million in 2019 to 26.9 million by 2035 leading to an increase in the demand for energy services (ERB, 2020).

The Country's electricity supply is predominantly based on hydropower. As of September 2019, the installed generation capacity stood at 2,976.3 MW, comprising 80.8 percent hydro, 10 percent of coal, 3.5 percent of heavy fuel oil, 2.7 percent of diesel, and 3 percent solar PV (NEP, 2019). In 2020, the installed electricity generation capacity was 3,011.28 MW compared to 2,981.28 MW in 2019. The increase in capacity was attributed to Dangote's connection of 30 MW to the national electricity grid. According to the Energy Regulation Board (2020), the generation mix slightly changed as the sector slowly began to have clean energy. Solar energy contributed 6.79 percent to the increase in installed capacity compared to 0.04 percent in 2018. On the other hand, hydropower continued to account for a higher proportion of the generation mix at 79.65 percent, whilst coal was at 10.96 percent, Heavy Fuel Oil at 3.65 percent, solar at 2.96 percent, and diesel at 2.78 percent (ERB, 2020).

Despite the increase in installed capacity in 2020 in comparison to 2019, the country is confronted with increasing energy demand and a low electrification rate, therefore, necessitating expansion and diversification of the existing available renewable energy and other energy resources (World Bank, 2020). The electrification rate stands at approximately 49 percent as of 2019 (World Bank, 2020). Despite the rapidly growing electricity demand by various consumers, there have been limited investments in expanding electricity generation capacity, with few efforts made to replace the aging electricity infrastructure. Without adaptation, the societal consequences of this general drying trend, with more frequent intense rainfall events, could be profound.

Further, as the country is in the short-term facing a diminishing electricity reserve margin, uncertain hydrology, and in the medium to long-term facing issues with energy supply security, there is a need to increase the generation mix. In 2020, the projected demand forecast was about 2,310 MW against an average generation of about 1,500 MW this translated into a power deficit of 810 MW. The deficit was attributed to reduced water levels in the main water reservoirs for power generation as the energy generation system is heavily dependent on the availability of water. The low water levels resulted in load management and thus the total load shed for Lusaka was a daily average of 213.83 MW, Copperbelt was at 120.57 MW whilst Northern and Southern regions had averages of 71.57 MW and 65.35 MW, respectively (ERB, 2020). Thus, the total daily national load shedding in 2020 was 461.31 MW (ERB, 2020).

The Government's overall energy objectives, in line with the National Energy Policy (NEP) 2019, Vision 2030, and National Development Plans, are to create conditions that will ensure the availability of an adequate supply of energy from various dependable sources at the lowest economic, financial, social and environmental cost consistent with national development goals. The Government intends to increase power generation and diversify the current energy mix by providing an appropriate policy and regulatory framework that is consistent with Vision 2030 (Ministerial Statement, 2022).

1.2 Problem Statement

The energy sector in Zambia has historically been dependent on hydroelectric power, which, as of 2021, still accounts for approximately 85% of the country's electricity generation (ZESCO, 2021). However, climate change's escalating impacts, such as fluctuating water levels in major rivers, have resulted in frequent power outages. These disruptions have had adverse effects on both the Zambian economy and social welfare (Mulenga, 2019). Recent studies suggest that the vulnerability of hydroelectric power to climate change is a growing concern not only in Zambia but globally (Miara et al., 2019). As a result, the Zambian government has recognized the urgent need to diversify its energy mix. The government has shown interest in deploying renewable energy technologies (RETs) other than hydro-based sources as part of its energy strategy (REPD, 2017). However, despite abundant solar, wind, and biomass resources, the deployment of these alternative RETs remains sluggish (Mwape & Guma, 2018; Mwanza & Ulgen, 2020).

The literature has identified several drivers that could potentially accelerate the deployment of RETs in Zambia, such as favorable policy frameworks, public-private partnerships, financial incentives, and capacity-building initiatives (Kapika & Eberhard, 2013; Chileshe & Syampungani, 2016). However, there is a research gap concerning the effectiveness of these drivers, given the slow pace of RET adoption in Zambia (Mwape & Guma, 2018). Moreover, Zambia's unique geographical, political, and socio-economic contexts pose additional challenges. For example, over 60% of the rural population lacks access to electricity (World Bank, 2020). This issue makes it even more critical to understand both the drivers and barriers to RET deployment in Zambia. Such understanding is necessary for informing policy and decision-making processes, thereby fostering sustainable development and energy security. By addressing these issues, this study seeks to provide insights that will be instrumental in guiding both policy and investment decisions in Zambia's energy sector.

1.3 Aim of the Study

This study aims to investigate the drivers and barriers to the implementation of renewable energy technologies other than hydro-based sources in Zambia.

1.4 Research Objectives

The research objectives were as follows:

1. To establish the drivers in the deployment of renewable energy technologies in Zambia.
2. To establish the barriers affecting the deployment of renewable energy technologies in Zambia.
3. To assess the effectiveness of the drivers in the deployment of renewable energy technologies.

1.5 Research Questions

The research questions were as follows:

1. What are the drivers in the deployment of renewable energy technologies in Zambia?
2. What factors affect renewable energy technologies' deployment in Zambia?
3. How effective are these drivers?

1.7 Significance of the Research

Rapid development over the past century has resulted in the pressing issue of global warming. These alarming trends have mobilized governments and Non-Governmental Organizations (NGOs) to support the research and implementation of renewable energy. Considering this, the present study unveiled various drivers and barriers to the implementation of renewable energy technologies in Zambia. Given Zambia's severe energy crisis, characterized by demand exceeding supply and leading to frequent electricity blackouts, this research created awareness about alternative means of energy production.

The research has provided a foundation for further analysis of determinants in the implementation of renewable energy sources. Consequently, the findings have been instrumental for policy formulators in implementing programs that facilitate the use and investment in renewable energy technologies. Policymakers are also better equipped to devise programs that minimize barriers to the implementation of such technologies. Moreover, the recommendations from this research serve as crucial resources for both regulated and regulatory entities, aiding in the creation of favorable regulatory and legal frameworks to support renewable energy implementation. While there has been considerable research on the adaptation of renewable energy sources in various developing countries, the Zambian context had been notably underrepresented in recent literature. Therefore, this research has contributed significantly to the body of knowledge by enhancing our understanding of the drivers and barriers to the implementation of renewable energy technologies in Zambia. Furthermore, the study adds to the growing corpus of literature focused on the utilization of renewable energy technologies.

1.8 Scope of the Research

The research focused on the drivers and barriers to the implementation of renewable energy technologies in Zambia, specifically excluding hydro-based sources. The study analyzed various sources, including wind, solar, biomass, and geothermal energy. It explored the impact of government policies, financial incentives, technical challenges, as well as cultural and social barriers on the implementation of these technologies. The study also examined the availability and impact of information and education about renewable energy technologies in Zambia.

The research was conducted in Lusaka and was aligned with the National Energy Policy of 2019. Key players in the electricity sector such as ZESCO Limited, the Energy Regulation Board, the Ministry of Energy, Independent Power Producers (IPPs) like Bangweulu Power Company and Ngonye Power Company, Kariba North Bank Extension Power Corporation Limited, and the Rural Electrification Authority were considered. These organizations play various roles in policy formulation and guidance, regulation, promotion of rural electrification, generation, and supply of electricity, and undertaking investment projects. Consequently, the study selected key personnel at the management level in these institutions, who provided reliable information on the current situation in Zambia concerning renewable energy technology.

1.9 Outline of the Dissertation

The study has six chapters, and the introduction is presented in this Chapter. Chapter Two on the other hand examines the relevant literature applicable to the study which aims to provide insight into the research questions and objectives. The theoretical and conceptual framework on the drivers and barriers to the implementation of renewable energy technologies is outlined in Chapter Three. Additionally, the methodology adopted for this research is presented in Chapter Four, and the same outlines the research design, study population, sampling procedures, and data collection. Chapter Five presents the research findings and Chapter Six draws the conclusion and recommendations that follow the research findings.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This Chapter provides a review of the literature that supports this study. In line with the research questions and objectives, drivers, and barriers to deploying renewable energy technologies in Zambia are discussed. Further, a review of the strategies that can facilitate the deployment of renewable energy technologies as well as their effectiveness is presented. Firstly, the Chapter presents an overview of renewable energy technologies, their importance, and their status quo in the Zambian context. The Chapter also highlights the literature on the drivers and barriers to the implementation of renewable energy technologies. Additionally, the strategies in place and their effectiveness in deploying renewable energy technologies are discussed. Lastly, the literature gap that supports this study is presented.

2.1 The Concept of RETs

The concept of Renewable Energy Technologies (RETs) is intrinsically tied to the broader notion of renewable energy. Renewable energy is often described as energy generated from sources that are not only readily available but also inexhaustible. In this vein, RETs serve as the technological apparatus that harness these sustainable energy sources. RETs offer an array of options that can be exploited to meet the diverse energy needs of both urban and rural communities, and their application can significantly impact social, economic, and environmental sectors (Khanal, Shakya, & Bajracharya, 2020). One of the most appealing aspects of RETs is their sustainability. Unlike conventional energy sources, which rely on finite resources like coal and oil, renewable energy is inexhaustible. Solar energy, for example, captures energy from the sun, which is expected to last for billions of years. This aspect of sustainability is not just an environmental boon but also offers a pathway to energy security. It reduces a country’s dependence on volatile global fossil fuel markets, a point also emphasized by Khanal et al. (2020). The environmental benefits of RETs are noteworthy. Solar and wind energy technologies, for instance, produce negligible greenhouse gas emissions once installed. According to a study by Persoon, Bekkers, and Alkemade (2020), these low emissions contribute to the global fight against climate change. Furthermore, renewable energy technologies like wind turbines and solar panels do not emit harmful pollutants into the air or water, which is beneficial for both public health and biodiversity.

Economically, RETs are increasingly showing promise. Technological innovations have significantly reduced the costs associated with wind and solar energy, making them competitive with, if not cheaper than, traditional forms of energy. The implications of this cost-competitiveness are profound for both developing and developed countries, potentially revolutionizing how societies approach energy generation and consumption. However, despite these advantages, RETs come with their set of challenges. The intermittent nature of wind and solar energy requires robust storage solutions, and there are still environmental concerns associated with the production and disposal of these technologies (Sun et al., 2019). These challenges are crucial for policymakers to consider, as they develop regulatory frameworks and incentives to promote RETs. Additionally, RETs have the potential to impact the social fabric of communities. For example, decentralized renewable energy systems can empower rural communities by providing them with access to electricity, thereby spurring local development. This is particularly relevant for countries with large rural populations that lack access to a central electricity grid. Besides, RETs are not just limited to well-known technologies like solar and wind energy. Other forms such as biomass and geothermal energy are equally promising but are often overlooked. Each form of RET has its own set of advantages and challenges, and their suitability can vary depending on geographical, climatic, and social factors (Xuan et al., 2022). While significant strides have been made in the field of RETs, there is still much to be explored. Recent research has begun to delve into the more nuanced aspects of RETs, such as their role in combating bacterial infections (Kaler, Nix, & Schubot, 2021). Although this may seem unrelated to energy production, it highlights the versatile nature of RETs and their potential to contribute to various sectors of society.

2.2 Importance of RETs

Renewable energy sources are an option to ensure both energy security and sustainable development. The energy produced from renewable energy sources plays an important role in decreasing energy insecurity, contributing to energy security, and diversifying energy consumption (Yadzi and Shakouri, 2017). Further, renewable energy sources are used principally by the electricity sector to decrease shortages and lack of access thus, a significant expansion in renewable energy has been encouraged by technological advances. There are many reasons why RETs are importance. Many studies have pointed out the following, response to climate change, addressing energy shortages and social benefits (Jamil et al.,2015, Twindell 2015 and Munoz et al., 2020). These are discussed below:

2.2.1 Response to climate change

Jamil et al (2015), argue that two factors, that is, climate change and impending fossil fuel depletion are the main reasons that have attracted recent attention to finding alternative energy resources. Thus, renewable energy is considered an obvious choice to reduce the carbon dioxide footprint which gives rise to global warming. The authors further argue that the deployment of renewable energy in any country has an impact on its sustainability as it provides a wide variety of socioeconomic benefits which include contributing to the diversification of energy supply, enhancing regional and rural development, as well as creating an opportunity for domestic industry and job creation potential.

2.2.2 Addressing energy shortages

According to Twindell (2015), the desirable benefits of RETs cannot be over-emphasized; with the most obvious being, wider access to energy supply for domestic use in both urban and rural communities. Conversely, the use of RETs for energy sources entails less negative global warming due to environmental degradation caused by the combustion of carbon-producing sources of energy such as coal-powered energy plants (Trimble, 2016).

2.2.3 Social benefits

Munoz et al (2020), argue that expanding renewable energy in Southern Africa can contribute to addressing power shortages and expanding energy access in the region, particularly in rural areas where renewables can be efficiently linked to mini-grids in rural electrification initiatives. Further, in addition to providing the additional electricity needed to power the economies of the region, renewables also have the potential to deliver additional development co-benefits including job creation, increased industrial activity through expansion of supply chains and development of local solutions, expansion of regional trade in service, market creation, the reduced balance of payments and revitalization of geographical energy resource is located.

2.3 Global Perspective of RETs

The increasing demand for energy and the need to address environmental concerns have led to a growing interest in renewable energy technologies globally. Renewable energy technologies, such as wind, solar, hydropower, and bioenergy, offer significant potential for reducing greenhouse gas emissions and mitigating the impacts of climate change (Jacobsson and Johnson, 2000). In recent years, renewable energy has become a priority for many countries as they work to transition away from traditional energy sources and towards more sustainable energy systems. Several countries have made substantial progress in developing and deploying renewable energy technologies. For example, Germany has become a leader in renewable energy, particularly in wind and solar power, with a target to generate 65% of its electricity from renewable sources by 2030. In China, the government has invested heavily in renewable energy, particularly in wind and solar, and has set a target to increase the share of renewable energy in its total energy mix to 20% by 2025. In the United States, the implementation of renewable energy has been driven by both federal and state policies, and the country has set a target to generate 20% of its electricity from renewable sources by 2030.

At a global level, there are several organisations and initiatives that facilitate the development and deployment of renewable energy technologies. The International Renewable Energy Agency (IRENA) for instance, is an intergovernmental organisation that promotes the adoption of renewable energy. Further, the Renewable Energy Policy Network for the 21st Century (REN21), a global network of non-governmental organisations, governments, and other stakeholders focuses on the promotion of renewable energy. The Global Green Growth Institute (GGGI), on the other hand, is an international organisation that supports developing countries in transitioning to more sustainable and inclusive economic growth paths using green energy, energy efficiency, and sustainable infrastructure.

Another notable global initiative is the United Nations Framework Convention on Climate Change (UNFCCC) which aims to mitigate and adapt to the impacts of climate change as well as promote the use of renewable energy as the means to achieve this goal. In addition to the institutional framework, other initiatives at the global level include the Paris Agreement ("the Agreement") adopted in December 2015 at the United Nations Framework Convention on Climate Change, which is an international legal framework negotiated by the United Nations Framework Convention on Climate Change (UNFCCC) which aims to strengthen the global response to the threat of climate change. The Agreement which implements the Convention on Climate Change requires that members maintain global average temperatures well below 2◦C above preindustrial levels (Article 2(1) (a)). Further, Article 2(1)(b) requires the development of low greenhouse gas emissions. The Agreement requires to determine, plan and report on the contributions to be made to achieve the global temperature goal. Further, it establishes mechanisms to assist developing countries in adapting to the impacts of climate change.

Additionally, the Kyoto Protocol of 1997 sets emission targets that highly industrialised countries should attain for emission reduction. Of particular interest to this study, is the provision of Article 2 (1)(a)(i) of the protocol which requires the promotion of sustainable development by implementing and/or further elaborating policies and measures in accordance with national circumstances such as enhancement of energy efficiency. Further, Article 2(1)(a)(iv) of the Protocol requires research on, and promotion, development, and increased use of, new and renewable forms of energy, carbon dioxide sequestration technologies, and advanced and innovative environmentally sound technologies.

However, the implementation of renewable energy technologies faces numerous challenges and barriers, including technical, economic, and institutional barriers. Despite these challenges, many countries have made substantial progress in developing and deploying renewable energy technologies, and the use of renewable energy is increasing around the world. Several factors have been identified as critical to the successful implementation of renewable energy, including government support and policies, financing mechanisms, technical expertise, and public acceptance. The literature highlights the importance of understanding the specific challenges and opportunities associated with renewable energy implementation in different countries and regions.

The initiatives that promote the development and deployment of renewable energy technologies at global level include:

2.3.1 Feed in tariffs

These are policy mechanisms that guarantee a fixed price for electricity generated from renewable sources, usually for a period of years. This helps to make the projects more viable Feed-in tariffs (FITs) are policy instruments that incentivize the production of renewable energy by guaranteeing a fixed price for the energy produced from renewable sources and feeding it into the grid. Kilic & Kekezoglu (2022) have argued that “FIT is a tariff guarantee. It is the most applied incentive system in the world. FIT practices differ in each country. These differences are incentive application period and incentive application methods. Incentives are applied differently in each country for periods between 10 and 25 years, depending on the type of consumer and the installed power of the PV plant.”

FITs provide a stable income for renewable energy producers, making investment in renewable energy more attractive. This in turn leads to an increase in the production and implementation of renewable energy technologies. There have been numerous studies and examples of FITs being implemented in different countries, including Germany, Spain, and the United Kingdom. In Germany, the introduction of FITs in the early 2000s led to a significant increase in the implementation of renewable energy technologies, particularly in wind and solar power. In Spain, FITs were also instrumental in the growth of renewable energy production and implementation. In the United Kingdom, FITs have been used as a policy instrument to increase the production and implementation of renewable energy, particularly in small-scale solar energy production by providing a stable revenue stream.

2.3.2 Renewable portfolio standards (RPS)

Renewable Portfolio Standards (RPS) are policy instruments that require electricity suppliers to generate a certain percentage of their electricity from renewable energy sources. The goal of RPS is to increase the deployment and use of renewable energy technologies, reduce greenhouse gas emissions, and promote energy security. RPS have been implemented in many countries, including the United States, the European Union, and Australia. In the United States, RPS policies have been implemented at the state level, with different states having different targets and requirements. In the European Union, the Renewable Energy Directive sets a target for member states to achieve a minimum share of renewable energy in their energy mix by 2020. In Australia, the Renewable Energy Target sets a target for the share of electricity generated from renewable sources.

2.3.3 Net metering

Net metering is a policy that allows consumers who generate their own electricity from renewable energy sources (such as solar or wind) to receive credit on their utility bill for the excess electricity they generate and supply back to the grid. This helps to encourage the deployment of renewable energy and can also help to reduce the overall demand for electricity from non-renewable sources. With net metering, the consumer's electric meter measures both the electricity used from the grid and the excess electricity generated and supplied back to the grid. When the consumer generates more electricity than they use, the excess electricity is supplied back to the grid and the consumer is credited for this excess generation on their utility bill. When the consumer uses more electricity than they generate, they are charged for the electricity they use from the grid at the retail rate.

Net metering policies vary from state to state and country to country, but generally, the consumer is credited for the excess electricity at the retail rate, which can provide a financial incentive for consumers to invest in renewable energy systems. In some cases, the consumer may be able to receive payments for the excess electricity they generate, although this is less common. Overall, net metering is a key policy tool for promoting the deployment of renewable energy, as it helps to encourage investment in renewable energy systems by providing consumers with a financial incentive to generate their own electricity. For instance, in the United States, Congress approved the Energy Policy Act of 2005 (EPACT05P.L. 109-58) which encouraged states to adopt net metering ((Lawson, 2019)

2.3.4 Government grants and subsidies

Some governments provide financial incentives through grants or subsidies to help reduce the cost of renewable energy technologies to make them accessible to a wider range of people. For instance, the United States of America (USA), the third country that invests more in renewable energy applications after China and Germany provides incentives to encourage the adoption of renewable energy technologies. The incentives that the USA has adopted include tax exemptions provided to household consumption points that turn to photovoltaic systems and public institutions are also directed to use renewable energy. Further, these incentives range from production tax reduction, investment tax reduction, business and grant subsidies, and portfolio standards. Grants which can cover up to 30% of the renewable facilities established. Furthermore, operating subsidies were imposed by obliging electricity supply companies to provide a certain percentage of electricity from renewable sources (Kilic & Kekezoglu, 2022).

2.3.5 Research and development funding

Research and Development (R&D) funding for renewable energy refers to the financial support provided by governments, corporations, or private organizations to support the development of new and improved technologies for renewable energy. This support can take many forms, including grants, loans, and tax incentives, and is aimed at promoting the growth of the renewable energy sector and encouraging investment in R&D initiatives. R&D funding for renewable energy is critical to the development of new and improved technologies that can make renewable energy more efficient, cost-effective, and accessible. This funding helps to support the development of innovative solutions to the technical and financial challenges faced by the renewable energy sector and enables researchers to explore new and promising areas of development.

Governments around the world are increasingly investing in R&D funding for renewable energy, recognizing the important role that this sector can play in reducing greenhouse gas emissions and mitigating the impacts of climate change. Many countries have established renewable energy R&D programs, such as the Energy Research & Development Division of the US Department of Energy (Department of Energy (US), 2021) or the Renewable Energy &

Energy Efficiency Partnership (REEEP, 2021) in Europe, to provide funding and support for renewable energy R&D initiatives.

2.3.6 Capacity building and technical assistance

Capacity building and technical assistance are critical components of the renewable energy sector, as they help to ensure that individuals and organizations have the skills and knowledge needed to effectively plan, develop, and implement renewable energy projects. This support is particularly important in developing countries, where the renewable energy sector is often in its early stages of development and there is a need for local expertise and technical knowledge. Governments, international organizations, and private sector actors are all involved in providing capacity-building and technical assistance for renewable energy. For example, the United Nations Development Programme has established the Global Environment Facility (GEF) to support capacity building and technical assistance for renewable energy in developing countries, while many private sector organizations provide training and support to their employees and partners in the renewable energy sector (UNDP, 2021).

2.4 The Zambian Context

This section provides an overview of the Zambian context in relation to renewable energy technologies (RETs), highlighting the country's generation capacity, potential energy sources, legal and policy framework, and key players in the renewable energy sub-sector. Zambia, predominantly dependent on hydropower, has faced challenges due to climate change and droughts, leading to a need for diversification in its energy sources. The country holds significant potential for solar, wind, geothermal, biomass, and waste-to-energy sources. The legal and policy framework in Zambia has been established to promote renewable energy development, with key state actors and institutions playing a critical role in its deployment.

2.4.1 Generation Capacity

RETs are some of the most promising and important assets that can have a multiplier effect on the development of any nation (Trimble, 2016). It is an eminent fact that the degree of industrialization is a function of the quantity of energy available and the extent to which that energy is utilized. Suffice it to note that Zambia's economy is subjugated by copper production, which accounts for at least 77% of its exports. This massive development in copper production entails heavy dependence on hydropower for electricity. However, a heavy drought in 2015/16 caused a severe depletion of water levels in the country's main reservoirs, triggering a hydro crisis and in 2016; national electricity generation fell by 13% from the previous year. The drought left the country with a power deficit at the peak of the crisis equivalent to almost half of the total generating capacity (GCF, 2018), resulting in load-shedding and major interruptions in supply. Power shortages were associated with substantial economic, social, and welfare costs. Hydropower continues to be unreliable and load shedding continued due to climate change which alters weather patterns such as prolonged droughts resulting in reduced rainfall in catchment areas which in turn leads to declining hydropower reservoirs. For instance, two large hydropower plants owned by ZESCO Limited have for decades, dominated power generation. However, declining rainfall has led to a reduction in the share of hydropower from 94% of total installed capacity in 2015 to 80% in 2018**.** Following the electricity crisis, there has been a deliberate policy to diversify energy sources, with new fossil fuel investment coming from Independent Power Producers (IPPs), (ERB, 2019).

According to the ERB (2021), as of 31st December 2021, the total national installed electricity generation capacity stood at 3,318.4 MW of which 81.5 percent was hydro generation based. Meanwhile, the national population with access to electricity stood at 32.8 percent of which 70.8 percent was in urban and 8.1 percent in rural areas. Further, Zambia has eight mini hydropower stations: Musonda falls power station (10MW) located in Luapula Province, Chishimba Falls power station (6MW) and Lunzua power station (14.8MW) located in Northern Province, Shiwang’andu power station (1MW) located in Muchinga, Lusiwasi Lower power station (12MW) and Lusiwasi Upper Power Station (15MW) located in Central Province, Zengamina power station (0.70MW) and Kasanjiku (0.64MW) power station located in North-western Province. The solar industry is dominated by grid-connected Bangweulu (54.3 MWp), Ngonye (34 MWp) located in Lusaka South Multi-Facility Economic Zone (LSMFEZ), and CEC's Kitwe Riverside (1MWp) solar power stations. Additionally, the existing solar off-grids include eight under Solera Power, Standard Micro-Grid (0.01MWp), Chibwika Royal Establishment (0.032MWp), and Engie Power Corner (0.028MWp), (ERB, 2021).

Hydro generation accounted for 81.5 percent followed by coal at 9.9 percent. Additionally, HFO accounted for 3.3 percent, while Solar was at 2.7 percent and Diesel at 2.6 percent. Figure 2.1 below shows the installed electricity generation by technology in 2021.

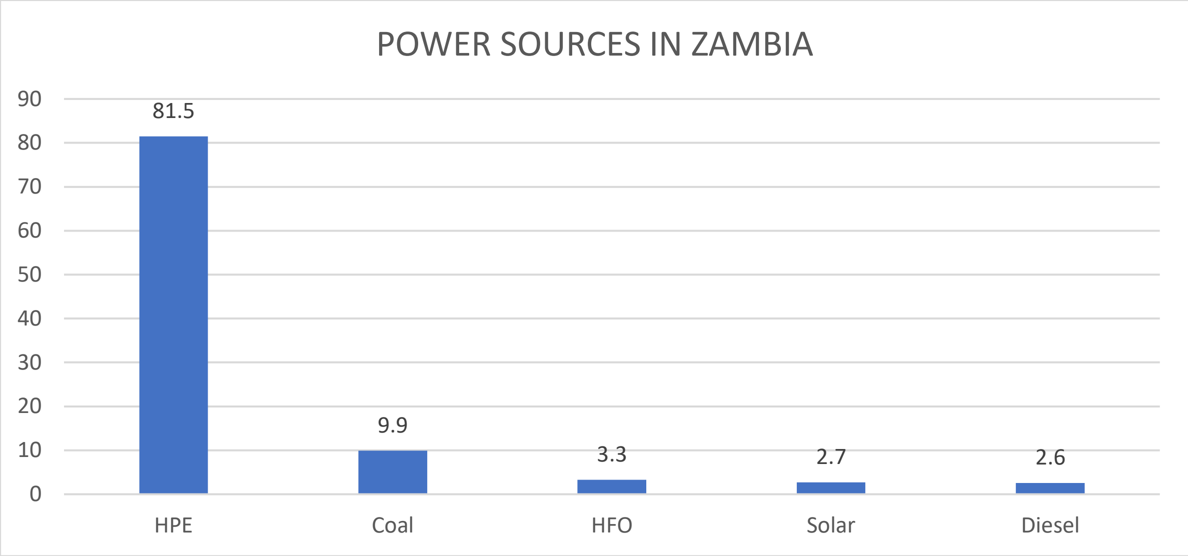


Figure 2.1: Installed electricity generation by technology – 2021

2.4.2 Potential Energy Sources

As alluded to above, Zambia's electricity generation is predominately hydro and that over-reliance on hydro has resulted in an energy crisis owing to the impact of climate change. Despite this challenge, it should be noted that Zambia has the second largest potential for solar power in the world, currently virtually unused, and an abundance of rivers and water resources in rural areas (UNDP, 2014). Building on this potential, solar- and hydropower are identified as the most appropriate renewable energy technologies for Zambia.

The existing potential of various sources of energy excluding hydro is highlighted below:

Solar

The average solar irradiation in Zambia is 5.5kWh/m²/day with approximately 3,000 sunshine hours annually. This provides good potential for photovoltaic and solar thermal applications (including electricity generation, solar home systems, solar water pumping, and solar water heating). Solar power generation accounts for 3 percent of the total installed generation capacity. According to a Zambia- China renewable energy technology project launched in 2014, solar radiation levels in Zambia are among the highest in the world with annual averages of about 7100 MJ/m2 (UNDP, 2014).

Wind

The wind resource regime in Zambia has an average wind speed of 6 meters per second measured at eighty meters (80m) above the ground. According to the National Energy Policy of 2019, the available wind resource is sufficient for electricity production, water pumping for household use, and irrigation.

Geothermal

The country has more than eighty (80) hot springs spread out in different parts which indicates potential for geothermal for both power generation and direct applications such as agriculture (greenhouses), dairy industry, and aquaculture (Mudenda et. al, 2018).

Biomass

This is the predominant source of energy in Zambia accounting for more than 70 percent of the total primary energy supply. The main forms and products of biomass include wood fuel (charcoal and firewood), biogas, pellets, briquettes, biofuels, and gel fuel mainly used as a household fuel for cooking and heating. The high dependence on wood fuel is due to low access and unreliable electricity supply, high cost of efficient alternatives, and inadequate enforcement of legislation and coordination among key sector institutions. Mudenda et. al. (2018), argue that about 80% of the Zambian population depends on traditional biomass which has been often harvested unsustainably and used inefficiently resulting in faster rates of forest depletion. The authors have argued that overexploitation of this source has affected the rainfall pattern.

Waste to Energy

Zambia has the potential to utilize waste to produce energy, electricity, and other by-products. The forms of waste to be targeted may include but are not limited to municipal solid waste, sewerage wastewater, agricultural crop residues, livestock manure or waste, wood chips or biomass, and industrial waste.

2.4.3 Legal and Policy Framework

The legal and policy framework governing renewable energy includes the Electricity Act No. 11 of 2019, Energy Regulation Act No. 12 of 2019, the Rural Electrification Act of 2003, the 8th National Development Plan, and the National Energy Policy.

The Electricity Act of 1995 and subsequent amendments liberalized the sector to enable private entities to participate in the electricity industry. In 2019, the Act of 1995 was repealed and replaced by Act No. 11 of 2019. The 2019 Act in so far as it relates to renewable energy technologies enables the ERB to regulate entities that generate, transmit, distribute, and supply electricity however ever generated. Additionally, the Act aims to facilitate adequate investment in the sector. Notably, one of the key functions of the ERB is to facilitate investment in the development, construction, and operation of electric plants using renewable energy sources. However, the Act does not stipulate how this should be achieved, and at the time of this literature review, no regulations or guidelines have been issued by the ERB. Further, the Minister responsible for energy is mandated under Section 52 of the Act to make regulations for the development and use of renewable energy resources to generate electricity. These regulations have, however, not been promulgated and the regulation of the renewable energy sub-sector is therefore governed by the general legal provisions that apply to non-renewable sources of energy.

On the other hand, the Energy Regulation Act No. 12 of 2021 continues the existence of the ERB and mandates it to, among others, license players in the sector, to determine, regulate and review charges and tariffs as well as to initiate, conduct and promote research surveys, studies, training, and investigations in the energy sector. Further, Section 43 of the Act establishes the Energy Fund whose purpose is to ensure the stability of supply in the energy sector; develop the sector, ensure the availability of strategic reserves, or any other purposes as may be prescribed by an Act of Parliament. It is noted that other than the uses of the fund as stipulated in the Act, no regulations have been enacted to provide for other uses of the fund. It is worth noting that Act is of general application, that is, it applies to all forms of energy regardless of the resource used to generate the same and the only reference to renewable energy is in the definition section.

Additionally, the Rural Electrification Act No 20 of 2003 establishes the Rural Electrification Authority (REA) whose mandate includes administering and management of the Rural Electrification Fund and developing the rural electrification master plans. The Act further empowers REA to promote the utilization of available rural electrification technological options.

In addition to the foregoing, it is noted that several pieces of legislation have a bearing on renewable energy, and these include the Lands Act Chapter 185, the Lands (Acquisition) Act Chapter 189, Environmental Management Act No. 12 of 2011, Water Resource Management Act No. 21 of 2011 and Zambia Development Agency Act.

In addition to the legal framework, Zambia's guiding policy on energy is the National Energy Policy (NEP) of 2019 implemented by the Government following the expiration of the NEP of 2008 which expired in 2018. This Policy endeavors to attain sustainable energy development and promote increased private sector participation. It is noted that the development of the Policy was necessitated by changes in the dynamics as well as the emerging issues in the energy sector. In addition, the effects of climate change and advances in technology necessitated the development of the NEP 2019. The general objectives of the Policy include responding to emerging market dynamics, promoting reliable and affordable energy, promoting the implementation of cost-reflective tariff mechanisms in the pricing of energy services, and encouraging a multiplicity of players through appropriate institutional and legal frameworks. Further, the Policy aims to promote the use of alternative energy sources and technologies for increased provision of clean and efficient energy services.

Regarding renewable energy, it is noted that one of the specific objectives of the Policy is the exploitation of renewable energy (Objective 5 of the NEP, 2019). To achieve this objective, it is noted that the measures put in place are to increase the exploitation of renewable energy to diversify the energy mix, strengthen institutional capacity for research in renewable energy, enhance coordination among key stakeholders for effective implementation of renewable energy technologies and promotion of wider usage of renewable energy technologies. The implementation framework for the Policy emphasizes the need for coordination among key players and places an obligation on state-owned utilities to develop and maintain energy infrastructure. Additionally, the Policy calls for a review of legislation to develop an appropriate broad-based and comprehensive regulatory framework.

The 8th National Development Plan (8th NDP) aimed to promote renewable and alternative energy by use of sources, such as solar, wind, biomass, geothermal and nuclear to diversify the energy mix and improve supply. The strategy for the promotion of alternative sources emphasized the need for resource mapping and promoting the development and use of renewable energy technology systems, including implementing a feed-in tariff and bidding system which is attractive for private investment. This plan has, however, been replaced by the Eighth National Development Plan (8NDP) 2022-2016 which lists energy sector reform as a key strategic area of focus. In particular, the 8NDP stipulates that reforms in the electricity sub-sector will be implemented to make the sector more efficient and effective. In this regard, the focus will be to increase the generation capacity and promote alternative green and renewable energy sources. Further, the operations of ZESCO Limited will be streamlined to promote efficiency and sustainability. Additionally, as part of the diversification agenda, the Government aims to continue promoting investments in green and clean energy solutions (8NDP).

2.4.4 Key Players in the Renewable Energy Sub-sector

Key state actors and institutions that play a critical role in the deployment of renewable energy technologies in Zambia concerning policy, implementation, and regulations are presented in table 2.1 below:

Table 2.1: Key state actors/institutions in the Renewable Energy Sub-sector

No.	Institution	Role
1.	Ministry of Energy	Policy formulation
2.	Energy Regulation Board	Sector regulator
3.	Rural Electrification Authority	Rural Electrification
4.	ZESCO Limited	National Utility
5.	Independent Power Producers	Private power utilities

The institution that is mandated to set the energy policy, that is, including renewable energy is the Ministry of Energy (MoE). MoE is responsible for the development of the energy policy as well as the management of energy resources in a sustainable manner. In line with Government Gazette Notice No. 1123 of 2021, the responsibilities of MoE include the development of renewable energy sources, electricity, and the formulation of the energy policy.

The regulatory function for the energy sector vests in the Electricity Regulation Board (ERB) which was established in 1995 by an Act of Parliament, that is, the Energy Regulation Act. The functions of the ERB include licensing undertakings in the energy sector, monitoring levels and structures of competition, and investigating and remedying consumer complaints.

On the other hand, the Rural Electrification Authority (REA) is a statutory body established under the Rural Electrification Act No. 20 of 2003. Its primary aim is to provide electricity infrastructure to rural areas in Zambia using appropriate technologies. REA is mandated with the tasks of administering and managing the Rural Electrification Fund (REF); developing and implementing the Rural Electrification Master Plan (REMP) and mobilizing funds to support rural electrification.

ZESCO Limited is a vertically integrated state-owned power utility engaged in the generation, transmission, distribution, and supply of electricity. It is a dominant participant in the Zambian electricity market and as of 2019, its generation capacity stood at 2,348 Mega Watts (MW) with a customer base of 1,000,000. Additionally, ZESCO is the off-taker of the majority of the power produced by independent power producers and owns most of the generation, transmission, and distribution infrastructure in the country (National Energy Policy, 2019).

In addition, the liberalization of the electricity sector in 1995 has seen an increase in the number of private actors in the sector. These actors include Independent Power Producers (IPPs), Transmission Network Service Providers (TNSPs), and Distribution Network Service Providers (DNSPs) as well as mini-grid operators (Energy Sector Report, 2021). According to the ERB (2021), the private players in the electricity sector are Copperbelt Energy Corporation Plc (CEC), Lunsemfwa Hydro Power Company (LHPC), North Western Energy Corporation Limited (NWEC), Ndola Energy Company Limited (NECL), Zengamina Power Limited (ZPL), Itezhi Tezhi Power Company Limited (ITPC), Maamba Collieries Limited (MCL), Dangote Industries Zambia Limited, Bangweulu Power Company Limited, and Ngonye Power Company Limited.

2.5 Drivers to the Implementation of Renewable Energy Technologies (Research Objective One)

The ability to obtain and maintain renewable energy usage in long term is dependent on the factors that have a bearing on energy access these being affordability, range of energy service levels, quality, usability, dependability, and the spectrum of available renewable energy technologies (Mudenda et. al, 2018, Avil et. al 2017). The various factors that drive the deployment of renewable energy technologies are:

2.5.1 Range of Energy Services Available

As alluded to above, Zambia's electricity supply is predominately hydro which accounts for about 80% of the total generation capacity. Mudenda et. al, (2018), argue that to ensure access to energy users should have the ability to choose from a wider range of available renewable energy technologies. It is noted that Zambia has varying potential for alternative sources of energy other than hydro which remain underexploited. Thus, ensuring access to energy calls for making available to users ’other alternative sources of energy such as solar, wind, geothermal, and biomass.

2.5.2. Dependability and Quality

The modes of energy should have a certain level of reliability to guarantee sustainable use from the households’ point of view. This is because, as (Trimble, 2016) suggests, the unreliability and shortage of grid power in many areas hampers economic development severely. In a Solar Homes Systems Project conducted in the Eastern Province of Zambia, it was discovered that people were less willing to pay if the systems were not delivering the acclaimed quality of marketed services and products. The study revealed that businesses offering good-quality components were more successful than those supplying low-cost unreliable systems (Musonda, 2017). A study conducted by Amir and Khan (2022), on the status of renewable energy in Africa found that one of the major concerns for the development of renewable energy was the availability of electricity.

2.5.3 Usability

For RETs to be adopted by households, they need to meet the needs of the households adequately and efficiently. Complicated technology often is received with resistance while simple technologies usually receive acclaim for ease of adaptability and ability to positively influence livelihoods. For instance, outcomes of the Solar Homes Systems Project undertaken in Eastern Province (Zambia) reveal that households admitted to having an improved standard of living owing to the transition to solar energy technology (UNDP, 2014). They were able to acquire televisions and video players powered by solar systems; the improved quality of lighting also enabled studying for longer hours and a broader level of domestic services (Glemarec, 2012).

2.5.4 Government support and policy

Government policies and incentives are crucial in fostering the development and implementation of renewable energy technologies in Zambia. Zambia has taken several steps to promote the adoption of renewable energy, including the development of feed-in tariffs and the establishment of a renewable energy policy. In 2017, the Zambian government launched the Renewable Energy Feed-in Tariff (REFiT) strategy, aiming to encourage investment in small- and medium-scale renewable energy projects (ERB, 2017). The strategy has been designed to support various renewable energy sources, including solar, wind, small hydro, and biomass projects, with a capacity of up to 20 MW. By providing a guaranteed purchase price for electricity generated from renewable sources, the REFiT strategy can create a more attractive environment for investors and developers in Zambia. Additionally, the Zambian government approved the National Energy Policy in 2019, which sets ambitious targets for increasing the share of renewable energy in the country's energy mix (Ministry of Energy, 2019). The policy envisions that by 2030, at least 40% of Zambia's total energy supply should come from renewable sources, excluding large hydro. To achieve this goal, the policy promotes the use of various renewable energy technologies, including solar, wind, biomass, and geothermal energy. These efforts by the Zambian government demonstrate the critical role of government support and policy in advancing renewable energy technologies in the country.

2.5.5 Financial incentives

Financial incentives play a vital role in driving the development and implementation of renewable energy technologies, as they help to lower the costs and risks associated with such projects. In Zambia, the government, along with international organizations, have introduced various financial incentives to promote the adoption of renewable energy solutions.

1. Tax incentives: The Zambian government has provided tax incentives for renewable energy projects, such as the reduction or elimination of import duties and value-added tax (VAT) on renewable energy equipment (ZDA, 2021). This helps to lower the costs of renewable energy technologies, making them more accessible and attractive to investors.

2. Grants and funding programs: Zambia has received financial support from international organizations, such as the World Bank, the African Development Bank, and the European Union, to promote renewable energy projects in the country. For example, the World Bank's Scaling Solar program has facilitated the development of solar power plants in Zambia, providing affordable and clean energy to the country's grid (World Bank, 2016).

3. Access to finance: The Zambian government has also established the Rural Electrification Fund (REF) to facilitate access to finance for renewable energy projects in rural areas (REA, 2021). The REF supports various renewable energy solutions, including solar, wind, and biomass, to increase electricity access in rural communities.

These financial incentives play a crucial role in promoting the development and implementation of renewable energy technologies in Zambia, helping the country to transition to a more sustainable and low-carbon energy future.

2.6 Barriers to Implementation of Renewable Energy Technologies (Research Objective Two)

Despite the potential benefits and opportunities associated with renewable energy technologies (RETs), several barriers hinder their implementation in Zambia. These barriers include policy inadequacies, capacity inadequacies, low levels of awareness, financial costs of RET facilities, and technical challenges (Pegels, 2009; Mudenda et al., 2018; Tembo, 2020; Amir and Khan, 2022).

2.6.1 Policy inadequacies

As demonstrated above, the guiding policy on energy in Zambia is the National Energy Policy of 2019 (the Policy). Even though the Policy under Objective Number 5 seeks to exploit renewable energy, it is silent on how this should be achieved. Additionally, the Policy calls for a review of legislation to align the same with emerging trends in the sector, the key pieces of legislation that were reviewed after the Policy took effect are, the Energy Regulation Act No. 12 of 2019 and the Electricity Act No. 11 of 2019. As already alluded to above, these key pieces of legislation fall short of creating an enabling environment or promoting the use of renewable energy technologies.

The existence of inadequate policies to promote renewable energy is a significant barrier to the implementation of renewable energy technologies. A review of literature discloses that Government policies may promote the uptake of renewable energy by supporting the development and implementation of subsidies, research projects, public awareness campaigns, pilot programs, regulations, or waivers on import duties (Watson and Johnson, 2010). For instance, the European Union (EU) has set a directive for a binding target of 32% of the total energy consumption to be obtained from renewable energy sources (KaroKosta and Petropoulou, 2022). These targets are referred to as renewable energy mandates and have been implemented in other jurisdictions to promote the use of renewable energy sources. In the United States, the Energy Policy Act of 2005, requires each federal government in a fiscal year to consume at least 75% of its total electricity from renewable sources. The Zambian energy policy on the other hand merely calls for the exploitation of renewable energy without stating the specific targets and timeframes. Further, another form of policy incentive that Governments provide to entities that utilize environmentally friendly methods to generate electricity is through the issuance of Renewable Energy Credits (RECs). The Renewable Energy Credits can, in turn, be traded and sold on the open market, providing an incentive to companies that produce "green" power. It offers a competitive setting for consumers to pay for renewable energy and a cost-effective tool to support renewable energy generation. It is worth noting that the National Energy Policy is silent on the provision of any form of incentives to producers of energy that use alternative sources. Thus, there is a need to ascertain whether incentives should be part of the Policy, or whether a lack thereof is a deterrent to private investment in alternative sources of energy. An effective pathway to energy transition requires a mix of incentives for clean energy- energy market reform, carbon emissions pricing, and fossil fuel subsidy reform.

2.6.2 Capacity inadequacies

Additionally, the structure of the power market, that is, a market dominated by a state monopoly whose skill and competencies tilt towards a particular technology may impede the development of alternative sources of energy. It is noted that the Zambian electricity sector is dominated by a monopolistic state utility, ZESCO Limited (National Energy Policy, 2019). A study conducted by Pegels (2009) on the prospects of renewable energy in South Africa, revealed that among the major barriers to investments in renewable energy technologies are South Africa's energy innovation system and its inherent power structures. The author argues that South Africa's innovation system is characterized by a high path dependency on fossil fuels which has its roots in the apartheid period when independence from external energy supplies was a political necessity. The two main energy providers, Eskom (electricity) and Sasol (fuel) are responsible for the bulk of investment in energy research and development. At the same time, they are almost monopolistic employers of university graduates in the relevant fields. These patterns have led to an extreme bias in innovative capacity towards fossil fuel innovation. Renewable energy technologies, on the other hand, lack the capacity basis at all levels of education. As monopolistic energy providers, both Eskom and Sasol wield considerable power. They use their influence to protect those of the energy market's features suited to their core competencies. Fostering an environment for renewable energy providers is certainly not part of this strategy. Pegels (2009), further argues that capacity for renewable energy is lacking at every stage of the technology cycle from research and development to installation and maintenance.

It is noted that ZESCO Limited is the largest producer of electricity in Zambia and its generation capacity is predominately hydropower therefore, this study will through interviews with key personnel in the sector determine whether ZESCO Limited's competencies are biased toward hydropower which has proved unreliable following the rainfall patterns. Lyambai (2018), in his study on accelerating energy access through public-private partnerships in Zambia, found, among others, that the situation in Zambia showed that national budgets and traditional utility and grid extension models of development cannot suffice in the provision of energy to all hence the need to adjust financial markets and regulatory environments to catalyze private investment flows. Saili (2019) also found that the factors that influence project portfolio selection in the renewable energy sector in Zambia include players, leadership, risk factors, and governance.

2.6.3 Low levels of awareness

Additionally, Aydin (2019) argues that existing conditions in Azerbaijan make it unfavorable for private bodies to invest in renewable energy sources thereby necessitating the need for optimal regulations for the promotion of the renewable energy source sector such as production, transfer, distribution, and delivery of energy. Mudenda et al (2018), found that barriers to the successful adoption of clean energy technologies include underserved populations, policy inadequacies; an underexploited renewable energy sector, and heavy reliance on a service-challenged hydro-power utility. Further, Tembo (2020) argues that the barriers to the development and adoption of biogas in Mokambo, Zambia include inadequate policies and strategies on modern energy. The study further found that a lack of community awareness of renewable energy technologies is a barrier to the development and adoption of biogas. In addition, a study on the potential, barriers, and prospects of biogas production in Zambia, found that many technical and socioeconomic constraints have hindered the full adoption and sustainability of biogas production in Zambia. Lack of mobilization of external and local funds, the complexity of the carbon market, lack of policy, strategy, and regulations in biogas production, high capital, and maintenance costs, lack of trade and investment incentives, resistance to change among the beneficiaries, lack of co-operation between implementers of biogas projects and researchers, inadequate research and development due to insufficient funding, low levels of full-time equivalent researchers who are qualified at Ph.D. level, inadequate expertise and training in biogas production and unfair equity are some of the major constraints hindering adoption and implementation of biogas projects in Zambia (Shane et al, 2015). These studies are limited to the adaptation of biogas as an energy source.

2.6.4 Financial Costs of RETs Facilities

RETs are capital intensive, requiring significant upfront costs. With the majority of the rural poor not electrified and in far-flung and often inaccessible areas, connection to the national electricity grid is economically feasible but requires high capital costs. Hence new and innovative technologies are required and must be cost-effective (UNDP, 2014). Literature documented in other developing countries indicates that services from RETs are unaffordable to the majority of the poor in rural and peri-urban areas (Musonda, 2017). However, renewable energy technologies are the cheaper solution in off-grid areas. Khan and Ruse (2018) argue that the absence of financing drivers is one of the major handing factors against mass solarisation in Bangladesh. The authors further argue that initial high cost is one of the major barriers to alternative energy technologies. Additionally, a study on "Assessment of Renewable Energy: status, challenges, COVID-19 impacts, opportunities, and sustainable energy solutions in Africa" found that the major concern for the development of renewable energy was the availability and affordability of electricity. The study further revealed that improvement in urban planning, enough finance for infrastructural development, and better urban legislation, and policies are the key changes that need to be inculcated. Additionally, the study found that power market design and finances for energy infrastructural development are needed (Amir and Khan, 2022). The authors argue that high initial cost connection costs and high electricity costs in the electrification process are major challenges in transitioning to sustainability. These challenges it is argued may be addressed as to the affordability of low-income groups and government must regulate and offer subsidies to mitigate these issues at the initial level of infrastructural development cost and make electricity affordable for all consumers (Amir and Khan, 2022). On the other hand, Glemarec (2012), argues that rapid technological innovations and increased commercialization have resulted in a decrease in manufacturing costs, hence lower prices for RETs and more creative accessibility.

Given the foregoing, the cost and affordability of renewable energy technologies are a barrier to their implementation. The Estimate of Revenue and Expenditure (Output Based Budget) of Zambia for the period 1st January to 31st December 2022 indicates that the sum of K6,338,415 has been set aside for diversification and improvement of the energy mix through renewable and alternative energy development. From the said sum, the sum of K3.4 million has been allocated towards salaries and K2.9 has been set aside for general operations. Further, it is noted that through the Ministry of Energy, solar systems for electrification and water pumping will be installed in four public institutions. However, the budget allocation does not cover issues such as electricity infrastructure development, and neither does it make provision for the Ministry to come up with mechanisms for the provision of incentives to investors as the bulk of the funds is allocated to salaries.

2.6.5 Technical

According to Hafner et al (2018), one of the critical issues relating to the production of energy from renewables is that wind and solar depend on a fluctuating source thus their contribution to power generation is variable and sometimes unpredictable. The authors argue that this contrasts with fossil fuels and other dispatchable renewables, that is, production can be regulated, initiated, and ceased on demand. The authors further argue that hydropower and biomass unlike other renewables are susceptible to climate change and thus are impacted by reduced rainfall, higher temperatures, and desertification. The foregoing, therefore, necessitates innovating and optimizing the production process and finding smart synergies to increase the overall efficiency of natural resource use. The impact of climate change on generation using hydro cannot be over-emphasized as the control had to initiate load management (ERB, 2019). Whilst this is the case, the National Energy Policy is silent in so far as providing or ensuring the provision of smart synergies in the use of alternative sources of energy. Besides, no policy framework exists to provide incentives to would-be investors or existing investors regarding the provision of storage technologies. Avila et. al. (2017) argue that not only is the size but also the timing of peak demand important because of the hourly availability of variable renewable resources. The authors further argue that storage technologies play a major role in deploying renewable energy in particular the batteries can be used to store solar energy during peak production times and discharge it in the evening during peak demand hours. Further, during overgeneration conditions, the supply of power exceeds demand and requires flexibility, such as demand response, grid storage, or, ultimately, a reduction in output from conventional generation plants. Therefore, when conventional generation cannot be backed down any further to accommodate the oversupply of variable generation, it leads to curtailment. Curtailment occurs when a system operator decreases electricity output from a wind or solar plant below what it would normally produce. Curtailment reduces the economic and environmental benefits of solar and wind plants because each unit of curtailed energy represents a unit of energy unsold (Avila et. al, 2017).

Amir and Khan (2022), argue that increasing access to electricity requires finances for energy infrastructural development as this could subsequently lead to the expansion of the power market and industry. The authors further argue that decentralized power systems and regional renewable energy integration are key areas that need to be focused upon. Further, inadequate power transmission and distribution capacity in Africa has led to increased cost of electricity. In 2012, across Sub-Saharan Africa, the average cost of electricity generation was around 115 USD per megawatt-hour (MWh). Due to a big distribution loss of 18%, this cost raised (for generation costs only) to 140 USD per MWh. Additionally, Avila et. al (2017) have argued that Sub-Sahara Africa lacks system capacity which has contributed to electricity scarcity. The scarcity is attributed to a lack of generation capacity for grid-connected regions, absence of proper grid infrastructure to deliver generated power, poor maintenance of generation plants, regulatory challenges that prevent a steady flow of revenue to maintain and invest in new generation capacity, and the dispersal of the population in remote areas.

2.7 Empirical Review

The empirical studies on renewable energy technologies (RETs) in Africa provide a comprehensive outlook on the barriers and drivers that influence energy access and sustainability. The literature reveals common themes such as financial constraints, policy limitations, technological issues, and socio-political dynamics, among others, that affect the implementation of RETs across various African nations.

Diecker, Scott, and Wheeldon (2016) identify inadequate access to finance as one of the crucial impediments to energy projects in countries like Niger. This financial barrier often manifests as high interest rates, lack of available credit, or complicated loan procedures that discourage potential investors and consumers alike. Given that Zambia, like Niger, is a developing nation, it is not far-fetched to consider that similar financial challenges could be hampering the growth of RETs in the country. Indeed, the high cost of implementing renewable energy technologies often serves as a deterrent for both governmental and non-governmental stakeholders. However, this raises questions about how Zambia can overcome these financial hurdles. Could public-private partnerships or international grants help in mitigating these financial constraints?

Twidell (2015) elaborates on another critical barrier—improper stakeholder engagement and holistic consultations, especially in rural areas. This is particularly relevant for Zambia, which has a significant rural populace with limited access to electricity. The absence of proper stakeholder engagement can lead to project failures, as local communities may not adopt or maintain the introduced technologies. Moreover, projects can face resistance due to cultural beliefs or lack of understanding of the technologies. This highlights the need for participatory approaches that include community members in decision-making processes, thus ensuring that the projects meet the actual needs of the people and are culturally sensitive.

Furthermore, Glemarec (2012) criticizes the oversimplification of renewable energy projects in Africa, where the focus often lies solely on installing infrastructure like solar panels. While such installations indeed offer a quick fix to energy deficits, they lack the sustainability that comes with comprehensive planning, which includes maintenance, scalability, and community engagement. In the Zambian context, this is particularly important as the country seeks to diversify its energy portfolio. The focus should not just be on quick solutions but on developing a robust and sustainable energy ecosystem that can adapt and scale according to future needs.

Another layer of complexity is added by Trimble (2016), who underscores the disconnect between national policies and local understanding or implementation. Often, renewable energy policies are designed and enacted at the national level, with little to no dissemination at the grassroots level. This disconnect can lead to failed implementations, as local communities may not understand the benefits or procedures related to renewable energy projects. It begs the question: Are Zambia's renewable energy policies trickling down to the local levels, especially rural communities? If not, how can this gap be bridged to ensure more effective implementation?

The structure of the power market also offers insights into the deployment of RETs. Avila et al. (2017) discuss the vertical integration of electric utilities in sub-Saharan Africa and the subsequent efforts to unbundle these to allow independent power producers (IPPs) to participate. This restructuring aims to improve the efficiency and effectiveness of the power sector. In Zambia, it would be pertinent to examine whether similar unbundling efforts are underway and, if so, how they are impacting the adoption of RETs. Are IPPs finding it easier to enter the Zambian market, and what are the policy implications of this?

Lastly, Kammen et al. (2015) highlight the vulnerabilities associated with an over-reliance on large dams for power generation. They argue that this reliance exposes countries to climate risks, given the seasonal variability of hydropower output and the impact of prolonged droughts. This is extremely relevant for Zambia, given its significant dependence on hydroelectric power. The study calls for diversification into other forms of renewable energy to create more resilient power systems.

2.8 Lessons Learnt from the reviewed studies

Based on the comprehensive review of various studies, several key lessons can be gleaned that are critical for the effective implementation and scaling of Renewable Energy Technologies (RETs) in Africa, and by extension, in Zambia. Firstly, the role of policy cannot be overstated. A supportive and well-structured policy framework is instrumental in facilitating the adoption and sustained growth of RETs. These policies need to be multi-faceted, addressing not just the technological aspects but also financial incentives, stakeholder engagement, and infrastructural development. Secondly, the capacity building emerges as a critical lesson. It's not just about the technologies themselves but also about building the human and institutional capacities to implement, manage, and sustain these technologies. Training programs, knowledge-sharing platforms, and educational curriculums need to be developed to prepare a workforce that is competent in the renewable energy sector. Thirdly, awareness and education are paramount. Lack of awareness and understanding among the general populace and even among policymakers can be a significant barrier to the adoption of RETs. Public awareness campaigns, workshops, and educational programs can go a long way in changing perceptions and encouraging more widespread acceptance and use of these technologies. Fourthly, the issue of financing and incentives is crucial. For renewable technologies to be implemented on a large scale, there needs to be a clear financial pathway that makes it feasible for both governments and private entities to invest in them. This could range from direct government subsidies to tax incentives for private companies investing in renewable energy projects. Finally, overcoming technical barriers and ensuring infrastructure readiness are vital for the large-scale deployment of RETs. Challenges related to energy storage, grid readiness, and technology compatibility need to be systematically addressed to ensure that the deployment of renewable technologies is both efficient and effective.

2.9 Chapter Summary

In this chapter, a comprehensive exploration of the literature on Renewable Energy Technologies (RETs) was undertaken to offer a multi-faceted understanding of the subject matter. The chapter commenced with an in-depth examination of the very concept of RETs, addressing not just the technological aspects but also the sustainability and environmental implications. This foundational knowledge served as a springboard for more specialized discussions on how RETs could effectively be integrated into existing energy systems. Key drivers instrumental in the successful implementation of RETs were discussed, including supportive policy frameworks, capacity-building measures, and financial incentives. The chapter highlighted the necessity of a well-structured policy environment to catalyze the adoption of RETs, emphasizing the need for policies to be holistic, encompassing not just technological considerations but also social, financial, and infrastructural elements. Moreover, the importance of building institutional and human capacity was elaborated upon, citing the need for training programs, educational curriculums, and knowledge-sharing platforms. It was noted that a competent workforce is crucial for the long-term sustainability of RET projects. On the financial front, the chapter explored various mechanisms to fund and incentivize RET projects, from government subsidies to private investment opportunities. The role of innovative financing solutions was underscored as a critical enabler for large-scale RET adoption.

Conversely, the chapter did not shy away from discussing the myriad barriers hampering RET implementation. These ranged from technical challenges and infrastructure deficits to social and cultural hurdles. It was argued that these barriers are not insurmountable and can be overcome with concerted efforts and multi-stakeholder involvement. The empirical review section offered insights from various studies, encapsulating experiences and lessons from different geographies, but with a focus on the African context. This empirical evidence enriched the chapter by providing real-world examples and case studies, thereby linking theoretical frameworks to practical outcomes.

CHAPTER 3

THEORETICAL AND CONCEPTUAL FRAMEWORK

3.0 Introduction

Every research journey embarks with a foundational understanding of the theories and concepts relevant to the subject matter. This chapter serves as the bedrock upon which the entire study stands, meticulously weaving together the theoretical and conceptual threads that guide the research's direction, analysis, and conclusion. The purpose of this chapter is multifold. Firstly, it aims to articulate the theoretical underpinnings that resonate with the research topic, offering clarity on the academic and practical theories that inform the study. These theories do not just provide a historical or academic context but align the research with established paradigms, ensuring that the study is grounded in recognised scholarly traditions. Secondly, the chapter delineates the conceptual framework, which is instrumental in mapping out the key concepts, variables, and constructs that are central to the research. This framework is not just a theoretical exercise but serves as a practical guide, helping to shape the research questions, methodology, and analysis. It acts as a lens, bringing into focus the intricate relationships between various components, illuminating patterns, and guiding the researcher's path.

3.1 Theoretical Framework

A theoretical framework serves as the support upon which the entire investigation is constructed. At its core, a theoretical framework is a structured set of concepts, theories, and propositions that present a systematic view of phenomena (Grant & Osanloo, 2014). These concepts, theories, and propositions are interrelated and are derived from existing knowledge to provide a foundation for understanding the research problem (Ravitch & Riggan, 2017). The framework not only guides the direction of the research but also anchors it in the broader academic discourse (Creswell & Poth, 2017).

The role of the theoretical framework in research is manifold. Firstly, it provides a lens through which the research is viewed, helping to shape its focus, scope, and depth (Creswell, 2013). By grounding the research in established theories, the framework ensures that the study is not an isolated exploration but is connected to a broader scholarly conversation (Maxwell, 2012). Furthermore, it helps identify gaps, challenges, and opportunities in the existing literature, positioning the research in a context where it can contribute meaningfully to the academic community (Layder, 1998). Secondly, the theoretical framework underpins the research's methodology. By providing clarity on the underlying theories and concepts, it informs the research questions, objectives, and hypotheses (Cohen, Manion, & Morrison, 2011). The framework also plays a pivotal role in data collection and analysis, offering a structured approach to interpreting findings in light of the guiding theories (Miles, Huberman, & Saldaña, 2013).

3.1.1 Identification of Relevant Theories and Their Application to the Research

The exploration of drivers and barriers to the deployment of renewable energy technologies in Zambia is intrinsically tied to understanding the underlying theories that influence such deployments. These theories not only provide a foundational understanding of the broader subject matter but also offer a framework through which the specific context of Zambia can be viewed.

Diffusion of Innovations Theory:

Introduced by Everett Rogers in 1962, the Diffusion of Innovations Theory endeavors to elucidate the mechanisms through which new ideas and technologies gain traction and spread within societies. At its essence, this theory sheds light on the processes that lead to individuals and institutions embracing or resisting new technological solutions. In the realm of renewable energy, this becomes critically pertinent, as it seeks to illuminate the adoption rate of such technologies. Factors such as the perceived advantages of renewable energy solutions, their congruence with existing energy infrastructures, the complexities or simplicities associated with their deployment, and other socio-economic dynamics play influential roles in determining this adoption rate.

Theory of Planned Behavior:

Icek Ajzen, in 1985, introduced the world to the Theory of Planned Behavior, which posits that human actions are not random but are deeply rooted in behavioral, normative, and control beliefs. This theory becomes instrumental when assessing the renewable energy landscape of Zambia. Behavioral beliefs, or how stakeholders perceive renewable energy; normative beliefs, or how societal norms and expectations influence perceptions; and control beliefs, or how perceived external factors might facilitate or hinder renewable energy adoption, become pivotal points of exploration.

Socio-Technical Transition Theory:

This theory dives deep into the intricacies of societal and technological evolution. It postulates that societal needs can be the driving force behind technological innovations and, in a feedback loop, these technological advancements can reshape societal structures (Crabtree, 2004). In Zambia, where the demand for energy is escalating, understanding this interplay between societal demands and technological responses becomes paramount. This theory offers a lens to assess how emerging energy needs in Zambia might be steering technological advancements in the renewable energy sector and how, in turn, these innovations might be influencing societal behaviors, expectations, and structures.

Upon application, it becomes evident that these theories do not function in isolation. Their interconnectedness provides a comprehensive framework for this research. The Diffusion of Innovations Theory, for instance, not only aids in gauging the adoption rate of renewable technologies in Zambia but also in understanding the underlying reasons for such rates, whether they be societal perceptions, infrastructural challenges, or economic dynamics. Similarly, the Theory of Planned Behavior offers a profound understanding of the behavioral aspects of stakeholders. By harnessing this theory, this research can probe into the attitudes of key players in Zambia's energy landscape, delving into how their perceptions of renewable energy, combined with societal norms and perceived external controls, shape their propensity to adopt, invest in, or promote renewable technologies. Lastly, the Socio-Technical Transition Theory provides a broader perspective, mapping out the symbiotic relationship between societal needs and technological responses. By leveraging this theory, the research can chart out how Zambia's escalating energy demands are influencing, and being influenced by, the trajectory of renewable energy innovations.

3.2 Conceptual Framework

Delving into the realm of Zambia's renewable energy landscape necessitates a conceptual framework, which offers a structured representation of the intricate dynamics at play. This framework not only serves as a roadmap to navigate the multifaceted aspects of the research but also acts as a bridge, linking the broad theoretical constructs to the specific context of Zambia's energy sector. A conceptual framework in research offers a systematic and organized representation of the key ideas, variables, and relationships that the study aims to explore (Smith & Jones, 2015). Such a framework is vital as it helps researchers, and those engaging with the research, to visualize and understand the core constructs and their interplay. In the context of this research on Zambia's renewable energy technologies, the conceptual framework serves a dual purpose. Firstly, it operationalizes the theoretical constructs, making them more accessible and relevant. For instance, while theories might discuss broad ideas like "adoption" or "behavioural attitudes," the conceptual framework contextualizes these in terms of specific variables such as "adoption rate of solar energy" or "stakeholder perceptions towards wind energy." Secondly, the framework ensures that the research remains anchored to its primary objective, which is to unravel the intricacies of renewable energy deployment in Zambia. By providing a clear visual and narrative structure, it acts as a constant reminder of what the research seeks to achieve, ensuring that the investigation does not deviate from its intended path.

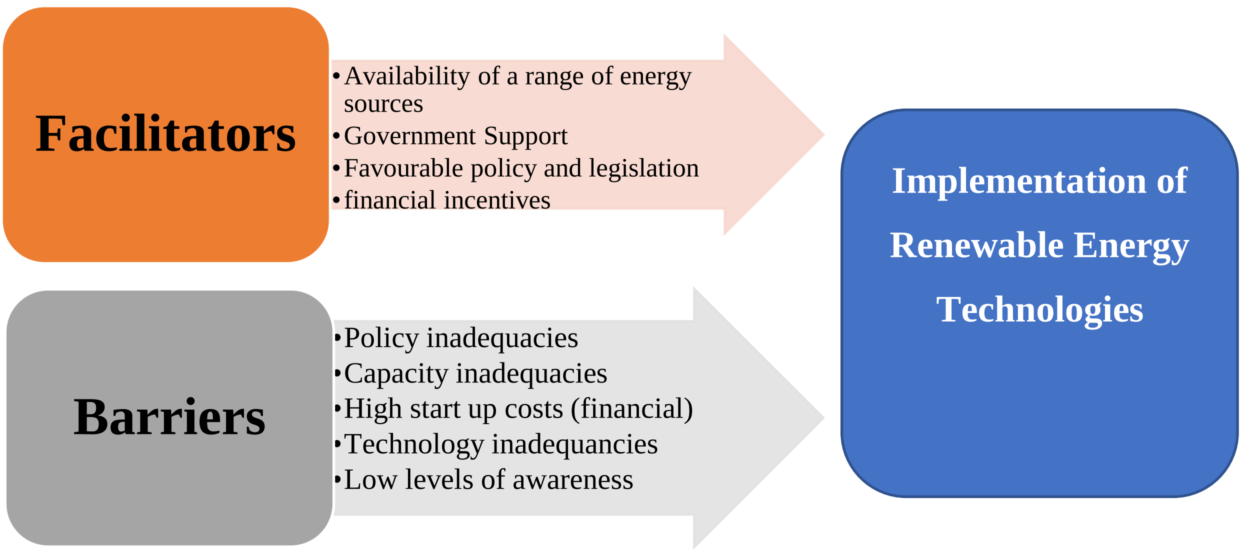
3.2.1 Development of the Conceptual Framework from Theories

The genesis of the conceptual framework for this study lies in the foundational theories previously outlined. Each theory, with its unique perspective and emphasis, contributes specific constructs to the framework. For instance, the Diffusion of Innovations Theory, with its focus on how new ideas and technologies permeate through cultures, directly feeds into the framework's emphasis on adoption rates and the perceived advantages of renewable technologies. These constructs help the research gauge the pace and extent of renewable energy technology uptake in Zambia and understand the factors propelling or impeding this uptake. Similarly, the Theory of Planned Behavior, with its triad of behavioral beliefs, normative beliefs, and control beliefs, enriches the framework with insights into the attitudinal and societal dynamics at play. By integrating these constructs, the research can probe deeper into the motivations, pressures, and constraints that stakeholders in Zambia's energy sector experience, offering a more nuanced understanding of their decision-making processes. Lastly, the Socio-Technical Transition Theory, with its emphasis on the interplay between societal needs and technological innovations, introduces a layer of depth to the framework. It brings to the fore constructs like societal energy demands and technological advancements, providing a lens to view how societal aspirations and challenges shape, and are shaped by, the renewable energy landscape in Zambia.

The conceptual framework serves as a coherent and integrated representation of the primary factors and dynamics influencing the deployment of renewable energy technologies in Zambia. At its core are several pivotal components. The "Adoption Rate" acts as a barometer, measuring the enthusiasm and speed with which renewable technologies find acceptance in Zambia. "Perceived Advantages" delves into the perceived merits of these technologies, capturing the optimism or skepticism of stakeholders. "Technological Infrastructure" offers insights into Zambia's readiness to embrace renewable energy, highlighting potential infrastructural strengths or gaps. "Economic Incentives" throws light on the financial dynamics, revealing the economic allure or deterrents associated with renewable technologies. Lastly, "Policy Frameworks" provides a macro view, showcasing how governmental and regulatory policies either bolster or hinder renewable energy initiatives. Crucially, these components do not exist in silos. They are intertwined, influencing, and being influenced by each other. For instance, robust policy frameworks might lead to enhanced economic incentives, which in turn could accelerate the adoption rate of renewable technologies.

Figure 3.1 below provides a visual representation of the conceptual framework guiding this research on Zambia's renewable energy deployment. The diagram succinctly captures the main components and their interrelationships. At its center is "Zambia's Renewable Energy Deployment," which is intricately linked to key influencing factors such as adoption rate, perceived advantages, technological infrastructure, economic incentives, and policy frameworks. These components not only standalone but also interact with each other, reflecting the complex dynamics at play in Zambia's renewable energy landscape.

Figure 3.1: conceptual framework



3.3 Operationalization of Variables

In this study, the process of operationalization involved defining and delineating the research variables in measurable terms. This section elaborates on the independent and dependent variables, their definitions, and the methodologies adopted for their observation and measurement.

3.3.1 Independent Variable

The independent variable(s) served as the primary drivers or influences in the research. For this study, the independent variable was the "factors affecting the adoption of renewable energy technologies in Zambia." These factors encompassed elements like policy frameworks, technological infrastructure, economic incentives, societal attitudes, and perceived advantages. To measure the independent variable, a combination of qualitative surveys and document analysis was employed. Specifically, participants' responses provided insights into their perceptions and experiences with these factors. Moreover, the analysis of key documents such as the National Energy Policy, the Renewable Energy Strategy, and the Electricity Act furnished additional data on the state and impact of these factors in Zambia's renewable energy landscape.

3.3.2 Dependent Variable

The dependent variable(s) represented the outcomes or effects resulting from the independent variable(s). In this context, the dependent variable was "the rate of deployment and adoption of renewable energy technologies in Zambia." Essentially, this variable gauged how the aforementioned factors (independent variables) influenced the pace and extent to which renewable energy technologies were embraced in Zambia. To observe and measure the dependent variable, data was gathered on the current status, growth rate, and future projections of renewable energy deployment in Zambia. The primary data sources for this were the responses from the participants, which captured stakeholders' first-hand experiences and observations. Additionally, secondary data sources, including annual reports and strategic plans from key energy entities, offered quantitative metrics on renewable energy adoption rates, capacity additions, and future goals.

Chapter Summary

This chapter laid the groundwork for the study by establishing a comprehensive theoretical and conceptual framework. It introduced the theories relevant to understanding the deployment of renewable energy technologies in Zambia and explained their applicability to the research questions and methodology. The theoretical framework acted as a guide, steering the focus and methods of the study. It connected the research to wider academic conversations and helped identify gaps and opportunities in existing literature. The chapter also presented a conceptual framework specific to the Zambian context. This framework translated the broad theoretical ideas into actionable constructs and variables, serving as a practical guide for the research. It outlined the main factors that influence the adoption of renewable energy technologies in Zambia, providing a structured approach to exploring this complex landscape. Furthermore, the chapter detailed the operationalization of variables, clarifying how the independent and dependent variables were defined and measured. The independent variables, which were the factors affecting the adoption of renewable technologies, were assessed using qualitative surveys and document analysis. On the other hand, the dependent variable, which was the rate of adoption of these technologies, was measured through data gathered from multiple sources including stakeholder experiences and official reports. As we move to the next chapter focused on methodology, it's important to note that the theories and concepts laid out in this chapter guided the rest of the research. These ideas are closely tied to the goals of the study, making sure that the methods and findings that follow are well-grounded and meaningful for understanding how renewable energy technologies are being used in Zambia.

CHAPTER 4

METHODOLOGY

4.0 Introduction

The methodology chapter elucidates the structured approach undertaken during this research, detailing every stage from the foundational philosophy to the practical steps of data collection and subsequent analysis. This chapter delineates the choices made in terms of research philosophy, design, target population, sampling framework, sample size, and sampling technique. Moreover, it sheds light on the data collection instruments, procedures, and their respective validity and reliability. Ethical considerations, vital for maintaining the integrity of the research process, are also elaborated.

4.1 Research Philosophy

Research philosophy is a guiding principle that underlies the research's methods and processes. It encompasses the researcher's perception of reality and how knowledge about this reality can be obtained and validated (Saunders, Lewis, & Thornhill, 2019). For this research, the primary focus is to unravel the intricate dynamics of drivers and barriers to renewable energy deployment in Zambia. In alignment with the study's objectives, the interpretivist philosophy was adopted. Interpretivism posits that reality is not fixed or singular; rather, it is constructed based on individuals' experiences, perceptions, and societal contexts (Bryman, 2016). By embracing this philosophy, the research does not solely aim to list drivers and barriers but seeks a deeper understanding of their nuances and implications in the Zambian renewable energy landscape. Guided by the principles of interpretivism, the research acknowledges the importance of individuals' perceptions and experiences, ensuring the findings capture the multifaceted reality of the topic. The research also adhered to an inductive approach, which is pivotal for exploring new or less examined areas. Instead of starting with a preconceived theory, the inductive approach enables the development of patterns or theories based on empirical data, allowing for a richer and more informed understanding of the subject matter.

4.2 Research Design

For this study, a descriptive research design was employed, which is tailored for presenting an accurate representation of a specific phenomenon. By opting for a qualitative survey strategy, the research was able to delve into the intricate details and complexities of the renewable energy sector in Zambia. Unlike quantitative surveys, which primarily focus on numerical data, qualitative surveys emphasize the depth and richness of participants' perspectives. This approach is harmonious with the research's objective of comprehensively understanding the various aspects of renewable energy deployment in Zambia. Furthermore, the research opted for a cross-sectional design. This means that data was gathered at a specific point in time, providing a snapshot of the status of renewable energy deployment in Zambia. Such a design is both efficient and effective, furnishing a timely and pertinent reflection of the current situation.

4.3 Target Population and Sampling Framework

In exploring the renewable energy landscape of Zambia, it was essential to gather insights from those deeply involved in the electricity subsector. The study focused on prominent entities that play a significant role in policy formulation, regulation, generation, and distribution of electricity in Zambia. These entities encompass the Ministry of Energy, Energy Regulation Board, Rural Electrification Authority, ZESCO Limited, and Kariba North Bank Extension Power Corporation Limited. The insights and expertise of professionals from these organizations were deemed pivotal to the research, as they offer first-hand experience and understanding of the challenges and opportunities in Zambia's renewable energy sector.

4.4 Sampling Technique and Determination of Sample Size

The nature of this research demanded a specialized sampling technique that could capture the nuances and intricacies of Zambia's renewable energy sector. Thus, a purposive sampling technique was employed. Under this approach, participants were deliberately chosen based on their extensive knowledge, experience, and involvement in renewable energy. To ensure the study encapsulated a wide spectrum of views, the maximum variation sampling (MVS) method was used. This method facilitated the inclusion of diverse opinions from various stakeholders within the electricity subsector. In qualitative research, achieving data saturation is crucial to ensure comprehensive coverage of the subject matter. Therefore, the sample size was determined with an emphasis on reaching a point where no additional insights or new information emerged from the interviews. Considering the number of key stakeholders, available resources, and the goal of achieving data saturation, the study aimed to engage with a broad range of experts across the selected entities.

4.5 Final Sample Size

In this research, the primary focus, given its qualitative nature and the use of purposive sampling, was not on the vastness of the sample but on the depth and richness of insights it could offer. Senior management personnel, known for their extensive experience and knowledge, were deemed as pivotal informants for this study. While the initial intent was to approach a minimum of three senior management professionals from each of the key entities such as the Ministry of Energy, Energy Regulation Board, Rural Electrification Authority, ZESCO Limited, and Kariba North Bank Extension Power Corporation Limited. Ultimately, the research managed to secure participation from 14 senior professionals from these entities. These participants, though fewer in number than initially anticipated, brought forth invaluable insights and a deep understanding of the nuances of renewable energy deployment in Zambia. The depth of their expertise and their varied perspectives ensured that the research was both comprehensive and insightful, even with a reduced sample size.

4.6 Data Collection Instruments and Procedures

The primary instrument for data collection in this study was structured interviews. The interview questions were meticulously crafted to cater to the study's objectives, primarily focusing on understanding the drivers and barriers to the implementation of renewable energy technologies in Zambia. This qualitative approach was pivotal in capturing the richness of the perspectives, experiences, and opinions of the stakeholders in Zambia's renewable energy sector.

The secondary data collection method was a focused document review, which complemented the questionnaire. This systematic examination encompassed several pivotal documents directly related to Zambia's renewable energy sector. The documents analysed included:

- The Zambia Power Development Framework
- Ministry of Energy Strategic Plan 2018-2021
- The National Energy Policy 2019
- Renewable Energy Strategy and Action Plan-2022
- The Electricity Act No. 11 of 2019 Analysis
- The Energy Regulation Act No. 12 of 2019 Analysis
- The Paris Agreement
- United Nations Framework Convention on Climate Change (UNFCCC)

Each document was scrutinized to extract information pertinent to Zambia's renewable energy strategies, commitments, and challenges, thereby offering an in-depth understanding of the renewable energy landscape in the country.

4.7 Data Analysis

After collecting the data, a rigorous analysis was conducted. The responses from the participants were thematically analysed to derive meaningful insights. This involved coding the responses, identifying patterns, and categorizing them into themes and sub-themes. The thematic analysis provided a structured way to delve deep into the data, drawing out significant insights and understanding the nuances of stakeholders' perspectives. For the document review, a content analysis approach was employed. Each document was dissected to extract relevant information, which was then synthesized to provide a comprehensive understanding of Zambia's renewable energy landscape. This dual approach to data analysis, incorporating both primary and secondary data, ensured a multi-faceted understanding of the research topic.

4.8 Validity and Reliability of the Study Tool

To ensure the study's robustness, measures were taken to bolster the validity and reliability of the research tools. The response's content validity was enhanced by basing it on existing literature and refining it through expert feedback. Its construct validity was ensured by grounding the interview questions in the research objectives, and its face validity was enhanced through a pilot test, which helped identify and address potential ambiguities.

Reliability, on the other hand, speaks to the consistency of the research tool. The document review's reliability was further bolstered by adopting a standardized approach to content extraction and analysis.

4.9 Data Management and Quality Assurance

The success and credibility of a research endeavour are deeply intertwined with its approach to data management and quality assurance. These aspects not only guarantee the robustness of the findings but also reflect the scientific rigor of the investigation.

Data Management: All data sourced from the responses and document reviews underwent a meticulous organization process.. To further safeguard against unforeseen technical glitches, regular backups were instituted. On the other hand, the document review findings were dual stored: digitally for easy access and analysis, and in hard copy as a tangible backup. Moreover, a comprehensive data management plan, which mapped out the journey from data collection to its eventual disposal, was religiously adhered to, ensuring a seamless flow.

Quality Assurance: The very essence of this research was to capture profound insights into Zambia's renewable energy landscape. To enhance the quality of these inputs, participants, during the data collection phase, were nudged to expound on their answers, ensuring depth and detail. The data analysis phase further upheld quality. By iterating through multiple rounds of coding, it was ensured that the emergent themes genuinely resonated with the participants' sentiments. The document review, too, was subjected to rigorous scrutiny. Consistency checks and cross-referencing ensured that the data extraction was both accurate and exhaustive.

4.10 Ethical Considerations

Conducting research, especially of this magnitude and significance, comes with its set of ethical responsibilities, each of which was diligently fulfilled.

Ethical Clearance: Before embarking on the research journey, it was imperative to obtain approval from the concerned authorities. The University of Zambia Research Ethics Committee granted clearance, reaffirming that the research's design, intent, and methodologies were in alignment with the stipulated ethical norms.

Informed Consent: An integral aspect of research ethics is recognizing and respecting participants' autonomy. Each participant was apprised of the research's nitty-gritty. From its objectives and methodologies to potential implications and outcomes, everything was laid out transparently. Only upon receiving their informed consent, a nod to their understanding and willingness, did the data collection proceed. Emphasizing their right to bow out at any phase, without any repercussions, further reinforced their autonomy.

Confidentiality and Anonymity: In research, especially one that hinges on participants' candidness, ensuring confidentiality is paramount. At no stage was raw data, which could potentially reveal participants' identities, shared or disclosed. Even during the reporting phase, utmost care was taken to present data in an aggregated form, obfuscating individual identifiers. Any direct quotations or distinctive insights were meticulously vetted, ensuring they remained anonymous.

4.10 Chapter Summary

In this chapter, we systematically unpacked the research methodology, offering readers a view of the processes that underpin the study. The chapter illuminated the critical role of interpretivism in shaping the research's direction, emphasizing the belief that reality is constructed based on individual perceptions, influenced by societal contexts. This perspective was pivotal in guiding the approach toward understanding the multifaceted landscape of Zambia's renewable energy sector. The subsequent sections provided a granular exploration of the research design. The descriptive nature of the study, combined with a qualitative survey strategy, was designed to capture a holistic and nuanced understanding of the state of renewable energy deployment in Zambia. The chapter highlighted the importance of a robust data management system and the measures instituted to safeguard the integrity and quality of the collected data. Quality assurance, a cornerstone of this research, was elaborated upon, emphasizing the mechanisms in place to ensure that the data's depth, breadth, and authenticity were maintained. From iterative coding processes during data analysis to rigorous consistency checks in document reviews, every step was designed to enhance the reliability and validity of the findings. The ethical considerations section reaffirmed the research's commitment to upholding the highest standards of integrity and responsibility. Every participant's rights, from informed consent to confidentiality, were safeguarded, ensuring that the research process was both transparent and respectful.

CHAPTER 5

RESULTS PRESENTATION AND DISCUSSION

5.1 Introduction

This chapter delves into the heart of the research, presenting an assessment of the data obtained from various stakeholders in Zambia's energy sector. The focus will be on understanding the factors and considerations that influence the deployment of renewable energy technologies, and the associated challenges and prospects that emerge from these insights. The responses analysed in this chapter were solicited from a select group of entities, namely: the Energy Regulation Board (ERB), ZESCO, Kariba North Bank, Kariba North Bank Extension Power Cooperation Limited, Rural Electrification Authority, the Ministry of Energy, and independent experts who freelance in the renewable energy sector. These entities and individuals were specifically targeted due to their significant roles, expertise, and influence in shaping Zambia's renewable energy landscape. To offer a comprehensive picture of the gathered data, this chapter will provide a succinct overview of the demographics of the Participants, shedding light on their organizational affiliations, roles, and experience.

5.2 Overview of Data Collection

The foundation of data collection for this research was structured interviews. The interview guide consisted of eighteen open-ended questions, designed to extract comprehensive and insightful responses, specifically focusing on understanding the drivers, barriers, and the broader scenario of renewable energy technology deployment in Zambia. This qualitative approach was pivotal in capturing a rich array of perspectives that contribute to a deeper understanding of the subject.

Additionally, a focused document review process was undertaken. This secondary method of data collection involved a thorough examination of several pivotal documents related to Zambia's renewable energy sector. The documents analysed included: the Energy Regulation Act, the Electricity Act, the Rural Electrification Act, the National Energy Policy, and the Renewable Energy Master Plan. Furthermore, international instruments that Zambia is a signatory to, including the United Nations Framework Convention on Climate Change (UNFCCC), and the Paris Agreement, were reviewed. The main thrust behind this document review was not merely to glean insights from these authoritative texts but to juxtapose and harmonize the findings with the responses from the participants.

5.3 Analysis of the Responses

5.3.1 Demographics

In pursuit to acquire a profound understanding of the nuances within Zambia's renewable energy landscape 14 participants representing a blend of organizational hierarchies and expertise levels were interviewed. The participants come from a diverse range of roles, from hands-on engineers to top-level decision-makers, and having experience spanning just a few months to over two decades. Their insights, based on both the breadth and depth of their experiences, provided a comprehensive picture of the current state and future potential of renewable energy in Zambia.

Table 5.1: Demographics of the participants

Respondent	Position/Role	Years of Experience	Organization's Involvement in Renewable Energy
1	Self Employed	25 years (7 in renewables)	Specializes in Consultancy
2	Head Operations and Maintenance	>17 years	Hydro-power generator, Grid operator, and Power Off-taker of renewable IPP (PV Plants) (ZESCO Limited)
3	Senior Engineer	3 years	Operates a 360MW Hydro Power facility and is diversifying with Solar PV (KNBEPC Limited)
4	Senior Electrical Engineer/System Studies	5 years	Packages Renewable Energy projects for funding and approves IPP connection agreements (ERB)
5	Maintenance Manager	Over 19 years	Hydro power generation with solar plant developments in progress (ZESCO Limited)
6	Maintenance Engineer	19 years	About to implement renewable projects (KNBEPC Limited)

7	Project Accountant	9 years	Development and implementation of RE projects (Ministry of Energy)
8	Project Geologist	Clean Energy Industry	Consumers (REA)
9	Principal Engineer	2 months	Striving to produce renewable energy (REA)
10	Head of Finance	>20 years (Hydro-based)	Focus on Hydro Electricity generation with plans for solar plants (ZESCO Limited)
11	Systems Engineer	4 years	Implemented solar and wind projects (Ministry of Energy)
12	Accountant	11 years	Hydro power Generation organization (KNBEPC Limited)
13	Accountant	3 years	Involved in hydro power generation (REA)
14	Senior Manager Licensing	10 years	Involved in regulation (ERB)

Through this demographic data, it is evident that the participants are not only well-versed in traditional energy sources like hydropower but are also paving the path for the increased adoption and implementation of diverse renewable energy technologies in Zambia.

5.3.2 Drivers in the Deployment of Renewable Energy Technologies

Drivers Promoting Renewable Energy Deployment

From the responses, several factors were identified that play a crucial role in promoting the deployment of renewable energy technologies in Zambia. Table 5.2 below shows the factors promoting the deployment of renewable energy technologies other than hydropower.

Table 5.2: Factors Promoting Renewable Energy Deployment

Factors	**Description**

Optimization of Energy Policy	The need to streamline the energy policy to facilitate broader participation, especially given the current dominance by politically exposed people (PEP). The onus on government to ensure attractive tariffs or contract prices to foster growth in the renewable sector.
Diverse Energy Resources	Advocacy for an integrated energy mix to counteract over-reliance on Hydropower, given its susceptibility to climate change. Factors like cost-effectiveness of renewables, consistent solar radiation, and wind speeds boost the sector's appeal.
Availability and Shift in Energy Approach	The accessibility of the grid, market opportunities, and a noticeable shift from hydro-power dependence were identified as central drivers.
Regulatory and Financial Framework	The existence of renewable energy policies, grid codes, and other guiding frameworks. Cost-reflective tariffs and the financial stability of Off-takers were considered pivotal.
Changing Climate and Demand	Altered climatic conditions combined with escalating power demand due to developmental imperatives are robust drivers for renewables.
Government Role and Incentives	The government's proactive stance, inclusive of incentives for new investments, policies favourable to foreign investments, land provision, and overall peace and stability, amplify the potential for renewable energy deployment.
Energy Security, Diversification, and Environmental Concerns	A confluence of energy security, diversification, and surging energy demands, blended with environmental and climate change concerns, highlight the urgency of renewable energy deployment.

Government Policies and Regulations Supporting Renewable Energy Deployment

The responses highlighted that the Government's policies and regulations are instrumental in nurturing the renewable energy sector. Table 5.3 shows the role of the Government in supporting the advancement of renewable energy.

Table 5.3: Government's Role in Supporting Renewable Energy

Interventions	**Description**

Treatment of Investors	Perception of favoritism, especially towards politically exposed individuals, necessitates a transparent approach.
Reforms in the Electricity Industry	Recent reforms, such as the grid codes and duty exemptions on renewable equipment, are considered transformative. The inception of the OPPPI unit to expedite project approvals and investments was underscored.
Policies and Regulations	Existing policies offer a structured pathway for market players, with the new Zambian grid code enhancing investment security.
Government Collaborations	Collaborative ventures, such as the MOU with Saudi Arabia for a 2000MW solar plant, exemplify the government's commitment.
Private Sector Participation	The decision to include private entities, such as Ngonye Power, in the energy sector was commended.
Tax Exemptions	Tax incentives, particularly the removal of import duty on solar products and related VAT exemptions, boost the sector's attractiveness.
Bottleneck Removal	The government's proactive approach in streamlining licensing and ensuring investor ROI was highlighted.
Comprehensive Renewable Energy Policies	Specific policies like Feed-in Tariffs, the Renewable Energy and Energy Efficiency Partnership (REEEP), and the Renewable Energy Licensing, among others, have bolstered the renewable energy landscape.

Role of Public-Private Partnerships (PPPs) in Renewable Energy Deployment in Zambia

Public-Private Partnerships (PPPs) have emerged as significant contributors to bridging gaps and fostering renewable energy deployment in Zambia. Participants elaborated on how PPPs contribute to various aspects of renewable energy projects, from funding to implementation and beyond. Table 5.4 synthesizes the perspectives shared by stakeholders, offering a direct look at how PPPs are viewed as a vehicle for advancing renewable energy deployment in Zambia.

Table 5.4: Significance of PPPs in Renewable Energy Deployment

Role of PPPs	Description

Promotion of Sovereign Guarantees	PPPs reinforce the appeal of renewable projects through sovereign guarantees.
Acceleration of Implementation	They expedite the rollout of renewable energy projects.
Funding Attraction	PPPs are adept at drawing funding, making renewable projects financially feasible.
Risk-sharing and Long-Term Sustainability	Shared risk models and the vested interests of private partners ensure project sustainability.

Financial Incentives and Capacity-Building Initiatives in Zambia

Financial incentives and capacity-building initiatives play a pivotal role in shaping the trajectory of renewable energy in Zambia. Stakeholders highlighted a variety of such programs, ranging from tax incentives to training initiatives, that are instrumental in making renewable energy projects more feasible and sustainable. Table 5.5 consolidates these insights, offering a comprehensive view of the financial and educational tools that are currently shaping Zambia's renewable energy landscape.

Table 5.5: Financial and Capacity-Building Initiatives

Initiatives	Description
Financial Incentives	Tax breaks and customs duty exemptions enhance the sector's appeal.
Capacity Building and Training	Training programs, technical assistance, scholarships, and initiatives like OGRESS have been pivotal in bridging knowledge and skills gaps in the renewable sector.

Successful Strategies or Initiatives for Renewable Energy Deployment in Zambia

The strategies and initiatives enumerated below have been instrumental in catalysing the deployment of renewable energy technologies in Zambia. The participants highlighted various approaches, such as Feed-in Tariffs and public-private partnerships, that have made a noticeable impact in promoting renewable energy deployment. Table 5.6 captures these strategies, providing an organized summary of the most effective avenues that are contributing to the advancement of renewable energy in Zambia.

Table 5.6: Successful Strategies for Renewable Energy Deployment

Strategies/Initiatives	Description
Feed-in Tariff	Assures attractive prices for renewables, although full implementation is pending.
PPPs and Off-grid Solutions	Have played a foundational role in the sector.
Government Collaborations	MOUs and partnerships, such as the one with Saudi Arabia for a 2000MW solar plant, are significant.
Zambia Renewable Energy Financing Framework (ZAREFF)	Aims to attract private sector investment through public funds.

5.3.3 Factors Affecting the Deployment of Renewable Energy Technologies in Zambia

The deployment of renewable energy technologies in Zambia is influenced by various factors, both technical and financial. The understanding of these factors can offer insights into the current state of renewable energy in Zambia and suggest ways forward.

The renewable energy sector in Zambia faces several barriers, ranging from policy-related issues to technical and financial challenges. For instance, Participant No. 5 highlighted the following as the barriers to the deployment of renewable energy technologies "*lack of readily available renewable energy policies, Grid Codes, guidelines and regulations, non cost reflective Tariffs, lack of skilled technocrats who understand the technologies and who would ensure smooth implementation of the policies and projects and poor financial status off-takers of renewable energy power*." Additionally, the participants provided insights into these barriers:

Table 5.7: Barriers to Renewable Energy Deployment

Barrier Type	Details
Tariff and Policy	- Tariff structure not supporting price variations - Delays in policy development (e.g., Net-metering)

Technology & Infrastructure	- High costs due to imports - Weak grid infrastructure in specific areas
Financial	- High capital requirements - Lack of attractive financial incentives
Regulatory & Institutional	- Regulatory hindrances - Lack of skilled technocrats
Awareness & Information	- Limited public awareness and understanding

Technical challenges, particularly related to grid infrastructure, have a significant impact on how renewable energy technologies are deployed in Zambia.

Table 5.8: Technical Challenges Impacting Renewable Energy Deployment

Challenge	**Details**
Grid Infrastructure Limitations	- Weak grid infrastructure not supporting variability - Restrictions on renewable energy integration
Intermittency of Sources	- Intermittency in solar power due to non-continuous sunlight
Integration & Infrastructure	- Need for technical expertise - Logistical challenges in grid expansion

Financial constraints often serve as roadblocks, hindering the successful deployment of renewable energy technologies in Zambia. These challenges range from the difficulties in securing capital to the burden of high initial costs. Participant No. 11 stated, "*The main barriers include high capital requirements, lack of financing, lengthy licensing procedures and inadequate investment in transmission infrastructure*." Participant No. 13 also stated, "*The upfront capital costs of installing renewable energy systems, such as solar panels or wind turbines, can be a significant barrier for individuals, communities, and businesses, especially in a country with economic challenges. Limited access to financing options, such as loans or grants, can prevent potential investors or project developers from pursuing renewable energy* *projects.*" Table 5.9 outlines these financial obstacles, giving a detailed account of the specific monetary issues that are impeding progress in Zambia's renewable energy sector

Table 5.9: Financial Constraints Impacting Renewable Energy Deployment

Constraint	Details
Access To Capital	- Expensive Borrowing - Significant Capital Requirement for Projects
Upfront Costs	- Prohibitive Initial Costs for Installations
Import Duties	- Duties On Imported Solar Development Equipment

5.3.4 Effectiveness of the Drivers

The deployment of renewable energy technologies is contingent upon several drivers. Their effectiveness plays a pivotal role in the scale and pace of adoption. To gain a comprehensive understanding of the effectiveness of these drivers, insights from Participants were analyzed.

Perceived Effectiveness of Identified Drivers

The effectiveness of drivers in promoting renewable energy technologies varies among stakeholders. Here are the opinions of some Participants regarding their perceived effectiveness:

Participant's Opinions on Effectiveness
This has not impacted much as most of the promotion has been on grid-connected projects.
They have been effective despite obstacles.
Not very effective.
With the policies and tariffs that are quite good for business, many applications for connection agreements are being sought by private participants.
It is effective enough, but more training is required.
Not effective.

Land is readily available as most rural areas in Zambia are underdeveloped and proposed investments are therefore supported.
They have played a significant role in promoting renewable energy technologies in Zambia, but there's room for improvement.

Challenges in Implementing Drivers

The implementation of drivers and strategies to promote renewable energy adoption comes with challenges. Here are the challenges identified by Participants:

Challenges Faced
Resistance by the off-taker. The single off-taker model has not been effective.
Limitation on the amount of renewable energy that grid infrastructure can take up.
Office bearers lacking the right skill or understanding.
Financing has been a major setback.
Road network to most potential sites is poor.
Navigating complex regulatory frameworks and potential policy inconsistencies.
Securing adequate and affordable financing remains a challenge.

Suggestions for Improving the Effectiveness of Drivers

For a more robust renewable energy sector, it is essential to enhance the effectiveness of drivers. Some suggestions from the Participants:

Suggestions for Improvement
Introduce variable tariff or pricing depending on demand.
Support more off-grid renewable energy sources.
Engage further with stakeholders and develop robust sensitization.
Expand and diversify financial incentives.

Encourage collaboration with international partners and industry leaders.
Invest in training and capacity-building programs.
Simplify and expedite permitting processes.

While drivers have played a role in promoting renewable energy deployment in Zambia, there is potential for significant improvement. By acknowledging the challenges faced and considering the suggestions provided, Zambia can further amplify its renewable energy adoption efforts.

5.4 Document Review Analysis

5.4.1 The Zambia Power Development Framework

The "Zambia Power Development Framework" offers a comprehensive perspective on the state of renewable energy in Zambia.

In line with the first research objective, the document brings to light several drivers contributing to the deployment of renewable energy technologies in Zambia. Central to these is the Zambian government's proactive stance, as evidenced by strategic blueprints like the "Eighth National Development Plan (8NDP)" and "Vision 2030." These plans underscore the government's ambition to diversify the nation's energy portfolio, ensuring a resilient energy sector. Moreover, Zambia's renewable energy potential is vast, with solar leading the charge. The country benefits from over 2,000 hours of sunshine yearly, translating to 3-6 kWh/m^2/day of solar energy. Additionally, although not as tapped into as hydro resources, there's recognized potential in biomass and geothermal energy. The global community hasn't remained aloof, with entities such as the World Bank, African Development Bank, and the International Renewable Energy Agency (IRENA) extending both technical and financial aid to buttress Zambia's renewable energy endeavors. Furthermore, while the document accentuates the value of private sector participation in this domain, it stops short of naming specific entities involved or their respective initiatives.

The second research objective seeks to unearth factors that might impede the deployment of renewable energy technologies in Zambia. Topping this list is Zambia's pronounced reliance on hydropower, which caters to over 85% of its electricity requirements. This over-dependence has its pitfalls, particularly when drought conditions prevail, causing significant power shortages. Another impediment comes in the form of infrastructure bottlenecks. The current transmission and distribution framework falls short, especially in rural settings, hindering broader electricity access. Financial constraints further compound the issue. High initial costs associated with renewable technologies, paired with restricted access to cost-effective financing, pose formidable challenges. The document underscores the need for innovative financial mechanisms to draw in private sector investments. Lastly, on the regulatory front, while the government's policy-making initiatives deserve commendation, the pace of actual policy execution remains wanting. A more streamlined regulatory framework could potentially expedite investments in the sector.

Regarding the third objective, the efficacy of the drivers is examined. The Zambian government has articulated a clear vision for renewable energy, primarily through strategies like the 7NDP. However, the chasm between policy formulation and its practical implementation is evident. In the international arena, collaborations have proven invaluable. A case in point is IRENA's pivotal role in framing Zambia's renewable readiness assessment. Yet, the momentum from such partnerships must be sustained to guarantee the fruition of ongoing projects. The private sector's potential in Zambia's renewable energy landscape is unmistakable. The document champions heightened private sector engagement but doesn't delve into the specifics of their involvement or assess their impact in detail. On the public engagement front, while there's an acknowledged need to ramp up public awareness drives to foster community comprehension and acceptance of renewable energy projects, the document doesn't furnish an exhaustive evaluation of prevailing public awareness levels.

5.4.2 Ministry of Energy Strategic Plan 2018-2021

The "Ministry of Energy Strategic Plan 2018-2021" serves as a guiding document for Zambia's vision in the energy sector over the specified years. Underpinning its strategies and objectives is the broader national aspiration captured in Zambia's Vision 2030 and the Seventh National Development Plan (7NDP). The emphasis on a diversified and sustainable energy mix is clear, echoing the country's determination to reduce over-reliance on any single energy source.

Among the drivers for the deployment of renewable energy technologies, the document spotlights several strategic focus areas. Key among these is the promotion of renewable energy sources and the push to increase electricity access across the nation. The Ministry also places significant emphasis on stakeholder engagement. Recognizing the pivotal role the private sector can play in driving renewable energy initiatives, the Plan seeks to foster closer collaborations with private entities. Furthermore, there's a concentrated effort to map and quantify Zambia's renewable resources, including solar, wind, and geothermal, to provide a clear picture for potential investors.

Despite the optimism, the Strategic Plan does not shy away from acknowledging the challenges that lie ahead. Infrastructure remains a pressing concern, especially in the realm of electricity transmission and distribution. The integration of renewable energy sources is stymied by these infrastructural limitations. Financing the ambitious projects and modernizations is another hurdle, with the document underscoring the necessity of both local and foreign investments. Regulatory bottlenecks, though not elaborated in depth, emerge as potential impediments, suggesting a need for more streamlined processes. Moreover, the Ministry is acutely aware of capacity constraints, be it in human resources, technical expertise, or institutional robustness. Such constraints could potentially slow down or compromise the quality of renewable energy initiatives.

Evaluating the effectiveness of the outlined drivers, the Ministry's roadmap offers both clarity and commitment. Strategies are not merely documented but are accompanied by implementation plans, showcasing a drive to turn policy into tangible action. Partnerships are heralded as vital cogs in the machinery, with the Plan emphasizing collaborations at both national and international levels. The inclusion of a structured monitoring and evaluation framework suggests a commitment to regular introspection, ensuring that strategies remain effective and relevant. However, the Plan also hints at areas needing bolstering, such as public sensitization. The successful deployment of renewable energy technologies hinges on public awareness and acceptance, indicating that initiatives in this domain need to be ramped up.

5.4.3 The National Energy Policy 2019

Upon closely examining "The National Energy Policy 2019," several key insights aligned with the research objectives emerge, offering a deeper understanding of Zambia's approach to renewable energy.

The Zambian government, through this policy, showcases an unwavering commitment to ensuring energy security, accessibility, and sustainability for all its residents. There is a well-defined roadmap set out to diversify Zambia's energy mix, aiming to reduce the heavy reliance on hydroelectricity. This intention is further cemented by the promise to enact robust legal and regulatory frameworks such as the Electricity Act and the Energy Regulation Act. These legislative tools are designed to guide and promote renewable energy investments, fostering an environment conducive to the expansion of renewable energy.

Private sector participation emerges as a dominant theme in the policy, underpinning the government's vision for a collaborative approach to energy. By creating a supportive environment, the government hopes to entice private entities to invest, develop, and manage renewable energy projects in tandem with public institutions. This synergy is perceived as essential for the rapid and sustainable development of the energy sector. Furthermore, the policy underscores the importance of continuous innovation by emphasizing the role of research and development. The government seeks to identify potential renewable energy sources and technologies that resonate with Zambia's unique geographical and socio-economic landscape. This proactive approach highlights the nation's dedication to staying at the forefront of global renewable energy trends.

However, the path to renewable energy is not without its challenges. The policy candidly recognizes the infrastructural impediments that currently plague the energy sector. To harness Zambia's vast renewable energy potential, there's a pressing need for significant investments in upgrading and expanding the existing energy infrastructure. Additionally, the sector grapples with a dearth of skilled personnel, emphasizing the urgency for capacity-building initiatives to train local experts in a variety of renewable energy technologies. Financial constraints also emerge as a significant bottleneck. Given the capital-intensive nature of renewable energy projects and the limited avenues for affordable financing, the policy underscores the importance of innovative financing models. By attracting both domestic and foreign investments, Zambia aims to overcome these financial hurdles.

Evaluating the effectiveness of these drivers, the policy stands as a testament to the government's dedication to renewable energy. However, the litmus test for its success remains in the swift and efficient implementation of the strategies and actions it espouses. A multi-stakeholder approach is championed, calling for a unified effort from government institutions, the private sector, civil society, and international partners. To ensure the realization of Zambia's renewable energy goals, the collective endeavors of all these stakeholders are paramount. The policy also acknowledges the significance of robust monitoring and evaluation mechanisms, committing to regular assessments that gauge progress and allow for strategy recalibration when necessary.

5.4.4 Renewable Energy Strategy and Action Plan-2022

The "Renewable Energy Strategy and Action Plan-2022" delineates Zambia's ambitions and plans in the renewable energy sector. Upon a meticulous analysis of the document in the context of the research objectives, the following insights have emerged:

Regarding the first objective, which aims to identify drivers in deploying renewable energy technologies in Zambia, the document outlines several. Central to Zambia's renewable energy aspirations are strategic frameworks. One such vital strategy is the Renewable Energy Feed-in Tariff (REFiT), designed specifically to provide incentives for generating electricity from renewable sources, barring large hydro projects. This strategy aims to offer a financial lure to potential stakeholders, ensuring the sector's growth. Furthermore, the government, in collaboration with international partners, has established various financial instruments to bolster the renewable energy sector. The GET FiT program stands out, offering premium payments to renewable projects, making them financially more palatable to investors. On the infrastructure front, the strategy underscores the significance of rural electrification, especially through the development of renewable energy-driven mini-grids.

When exploring the second objective, which seeks to ascertain the factors affecting the deployment of renewable energy in Zambia, the document touches upon several pivotal points. A major hurdle identified is the presence of market barriers. The limited involvement of the private sector in renewable energy projects, largely due to perceived risks and inadequate information about the sector, has been a significant constraint. Additionally, there are clear technical and capacity challenges. The integration of renewable energy sources into the national grid, coupled with a dearth of local expertise to handle such technologies, has slowed down the sector's growth. Regulatory challenges also surface in the document. While supportive policies are in place, gaps in the regulatory framework, such as the lack of standard Power Purchase Agreements for REFiT-aligned projects, can act as deterrents for potential investors.

Lastly, in relation to the third objective, which assesses the effectiveness of the identified drivers, several observations arise from the document. The government's commitment is evident in its policy directives, but the real test of these policies, including the REFiT strategy, lies in their on-ground implementation. Financial mechanisms, like the GET FiT program, have the potential to transform the renewable energy landscape. However, their effectiveness is tied to their execution and the active involvement of all stakeholders. The strategy's emphasis on mini-grids as a solution for rural electrification is commendable. Yet, their success is contingent on a blend of technical expertise, adequate financing, and robust community engagement.

5.4.5 The Electricity Act No. 11 of 2019 Analysis

The "Electricity Act No. 11 of 2019" stands as a pivotal piece of legislation governing the energy sector in Zambia. At its core, it offers a structured and comprehensive legal framework that touches upon both renewable and non-renewable energy sources, setting the stage for a more organized and streamlined approach to energy deployment.

When focusing on the drivers for renewable energy deployment in Zambia, the Act emerges as a significant enabler. By offering a clear-cut legislative pathway, it creates an environment conducive for stakeholders, ensuring that they have a set of guidelines to adhere to. One of the standout features is the clarity it provides concerning licensing and permits. With explicit provisions set for the processes surrounding electricity generation, transmission, distribution, and supply, stakeholders are given a roadmap that ensures renewable energy projects are in line with specific standards. Moreover, the emphasis on consumer protection underscores the Act's comprehensive nature. By safeguarding the rights and interests of consumers, it not only ensures their protection but potentially boosts their confidence, thereby possibly facilitating a broader acceptance and adoption of renewable energy.

However, every framework comes with its set of challenges. In the context of this Act, rigorous regulatory compliance can be a double-edged sword. While it guarantees quality, safety, and standardization, it might also present hurdles, especially for newcomers to the renewable energy arena. The conditions and standards set forth can be resource-intensive, demanding significant effort for adherence. Additionally, the Act's provision for tariff regulations, set by the Energy Regulation Board, could impact the economic feasibility of renewable energy projects. While necessary for consumer protection, the tariff structures might affect how attractive renewable energy projects appear in terms of profitability.

On the topic of effectiveness, the Act's provisions seem robust. The establishment of the Energy Regulation Board stands out as a masterstroke. Entrusted with a multitude of responsibilities, from regulating the sector and granting licenses to promoting an efficient industry structure, this body ensures that the Act's drivers are not just on paper but are actively enforced. The Board's oversight guarantees that standards are met, licenses are appropriately awarded, and the industry operates within a set framework. Furthermore, by incorporating mechanisms for dispute resolution, the Act ensures that any potential conflicts or challenges that might impede renewable energy projects are swiftly and effectively addressed. In wrapping up, the "Electricity Act No. 11 of 2019" paints a detailed picture of Zambia's energy landscape. By introducing a blend of drivers and addressing potential challenges, it sets the stage for a future where renewable energy might play a more dominant role in the country's energy matrix. The Act's thorough approach, combined with its emphasis on governance, standards, and consumer protection, makes it a cornerstone in Zambia's journey towards a more sustainable energy future.

5.4.6 The Energy Regulation Act No. 12 of 2019 Analysis

"The Energy Regulation Act No. 12 of 2019" provides a comprehensive framework for overseeing the energy sector in Zambia, laying down regulations that also influence the deployment of renewable energy technologies.

When exploring drivers for the deployment of renewable energy technologies, the Act prominently features the establishment of the Energy Regulation Board (ERB). This body is granted the responsibility of regulating the energy sector in Zambia, placing a notable emphasis on the promotion and integration of renewable energy. The ERB's presence promises a standardized approach to energy development in the country, which is pivotal for creating a conducive environment for renewable energy investments. Additionally, the Act delineates clear procedures for obtaining licenses for various energy undertakings, which is crucial for potential investors and developers eyeing the renewable energy sector. Beyond the licensing aspects, there's a pronounced focus on consumer protection. By setting safety and quality standards for energy services, the Act aims to elevate public trust in renewable energy technologies.

Moving on to the factors affecting the deployment of renewable technologies, the Act's provisions related to tariff regulation stand out. The ERB's authority in determining energy tariffs has implications for the attractiveness of renewable energy investments. While appropriately set tariffs can incentivize renewable energy projects, unfavorable tariffs could deter potential investors. The Act also mandates regular reporting from entities, encompassing performance, financial, and technical facets. Such provisions ensure transparency and accountability, but also introduce potential bureaucratic challenges for developers. Moreover, the Act spells out penalties for non-compliance, ensuring that renewable energy projects align with Zambia's stipulated standards and regulations.

On assessing the effectiveness of these drivers, the ERB's extensive powers become evident. Its centralized role in licensing, monitoring, and oversight can streamline the deployment of renewable technologies by maintaining uniform standards. The Act's inclusion of a dispute resolution mechanism is another testament to its foresight, promising judicious handling of any conflicts that may arise from renewable energy projects. Furthermore, the emphasis on public hearings, especially in tariff determination, reflects the Act's commitment to inclusive decision-making. Such engagements not only ensure that tariffs and regulations are balanced but also foster public trust and interest in renewable energy initiatives.

5.4.7 The Paris Agreement

The "Paris Agreement" serves as a beacon for international collaboration, targeting the mitigation of climate change impacts. At its core, it accentuates principles, objectives, and actions that nations should adopt, considering the collective need to address the escalating concerns of climate change. Delving into the first research objective, which seeks to identify drivers for the deployment of renewable energy technologies in Zambia, several key points emerge from the document. The Paris Agreement underscores the power of international collaboration and commitment. As a global compact, it not only fosters cooperation among nations but also catalyzes the exchange of knowledge, expertise, and resources. Furthermore, the document places significant emphasis on scientific knowledge. By relying on the most recent and reliable scientific findings, countries like Zambia can harness cutting-edge insights and technological advancements in renewable energy. Lastly, the agreement distinctly recognizes the unique needs of developing nations, advocating for specific support mechanisms, be it in the form of funding or technological assistance.

Addressing the second research objective, which revolves around discerning factors that might impede or challenge the deployment of renewable energies in Zambia, the Paris Agreement offers valuable insights. A primary concern is the ramifications of climate change impacts. For a country like Zambia, which relies heavily on hydropower, the repercussions of climate anomalies, such as prolonged droughts, can severely impact its energy matrix. Additionally, the agreement alludes to the financial and technological constraints that developing countries often grapple with. In the context of Zambia, these barriers could significantly influence the rate and efficiency of renewable energy deployment.

Turning attention to the third research objective, which aims to gauge the effectiveness of drivers in deploying renewable energy technologies, the Paris Agreement provides a framework for evaluation. The very existence of such an international pact testifies to the potential effectiveness of global collaboration. However, for Zambia, the proof of the pudding lies in the tangible benefits it reaps, be it in terms of technological transfers, funding, or capacity-building endeavors related to renewable energies. The Agreement's emphasis on adaptation measures and dedicated financial mechanisms further reinforces its commitment to bolstering developing nations. Yet, the real metric of success for Zambia hinges on the translation of these lofty ideals into concrete on-ground renewable energy projects and initiatives.

5.4.8 United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC), which was finalized in New York on 9 May 1992, stands as a testament to global commitment and cooperation to address the pressing issue of climate change. Recognizing the potential detrimental impacts of unchecked greenhouse gas emissions on the planet's climate, this treaty was established to promote international collaboration, with the ultimate goal of preventing hazardous human interference with the climate system.

Addressing the drivers in the deployment of renewable energy technologies, the UNFCCC has been instrumental in countries like Zambia. As a signatory, Zambia has access to international technical and financial support, specifically tailored to promote the transition to cleaner energy sources. The convention's emphasis on sustainable development and regular reporting mechanisms offers Zambia a structured path to identify and harness opportunities, promoting the adoption and integration of renewable energy technologies.

However, like many developing nations, Zambia faces challenges in its journey towards a renewable energy future. Under the auspices of the UNFCCC, the nation has consistently emphasized the need for greater financial and technical support. Access to cutting-edge, affordable technology remains a considerable challenge. Furthermore, there's a persistent need for capacity building at various levels, ensuring that both institutional and human resources are equipped to manage and optimize renewable energy projects. The convention also highlights the importance of technology transfer, ensuring that innovations in renewable energy are not just confined to developed nations but are accessible and adaptable for countries like Zambia.

Evaluating the effectiveness of the UNFCCC as a facilitator for renewable energy deployment can be approached through various lenses. The convention organizes global climate conferences, known as COPs (Conferences of the Parties), which serve as a platform for member nations to review progress, address challenges, and set future directions. The submission of National Communications and Biennial Update Reports by countries provides insights into national efforts, achievements, and areas that need attention. Financial mechanisms like the Global Environment Facility (GEF) also play a pivotal role, assisting nations like Zambia in their endeavours.

5.5 Discussion of the findings

As highlighted in Chapter One, the objectives of this research were:

Objective 1	To establish the drivers in the deployment of renewable energy technologies in Zambia.
Objective 2	To establish the factors affecting the deployment of renewable energy technologies in Zambia.
Objective 3	To assess the effectiveness of the drivers in the deployment of renewable energy technologies.

A discussion of the findings with respect to the objectives and literature is presented below:

5.5.1 Drivers to the deployment of renewable energy

The drivers to the deployment of renewable energy in Zambia identified through this research, play a crucial role in making renewable energy not only a feasible but a viable option for the nation. The first research objective aimed to establish these drivers. In achieving this aim interviews with key experts as well as extensive document review were conducted. The findings reviewed that Government commitment, as evidenced in policies and strategic plans underscored the intention to diversify the energy mix, reduce dependency on hydroelectric power, and promote the uptake of other renewable energy technologies. This finding mirrors the emphasis in the literature on the pivotal role that government support plays in fostering sustainable energy transitions (Kapika & Eberhard, 2013; Chileshe & Syampungani, 2016).

Additionally, the findings underscored the recognition of the existence of other alternative renewable energy sources. For instance, the findings reviewed the existence of potential for solar energy and other forms of energy. This aligns with literature from (Mwape & Guma, 2018; and Mwanza & Ulgen, 2020), which underscores the need to leverage diverse and ample renewable resources. Similarly, the findings reviewed that international partnerships and collaborations are drivers to the deployment of renewable energy. This resonates with scholarly works that emphasise the significance of global partnerships in advancing the renewable energy agenda.

Further, private sector involvement emphasised by the participants and document review correspond with literature by Kapika & Eberhard, 2013, who underscore the role that private entities play in driving innovation, providing financing, and deploying large-scale renewable energy technologies. The need for increased private sector involvement was a recurring theme, with Participants noting that while the potential of the private sector was recognized, its full involvement had not been achieved.

5.5.2 Barriers to Renewable Energy Deployment

The second research objective endeavored to identify the barriers to the implementation of renewable energy technologies. Zambia’s historical overreliance on hydropower, a barrier highlighted in the "Zambia Power Development Framework," and the responses from the participants corresponds with the finding in literature that have highlighted the vulnerabilities that have resulted from over dependence on hydro (Mulenga, 2019; Miara et al., 2019).

Challenges in infrastructure were presented as a significant barrier. Lack of and/or outdated transmission and distribution systems especially in rural areas, align with literature emphasising the critical role of robust infrastructure in supporting the deployment of renewable energy. Further, financial constraints identified in the findings are in line with existing literature on the high upfront costs associated with renewable energy projects. Additionally, the limited access to affordable financing is identified as barriers to renewable energy deployment.

While the government's commitment to renewable energy was considered a drive, the findings revealed that the pace of policy implementation was a concern. This finding corresponds with literature discussing challenges in translating policy intentions into effective actions in the renewable energy sector (Mudenda et al., 2018). To add on, the knowledge and skill gap identified in the findings aligns with literature on the need to build human capacity and address knowledge gaps in renewable energy deployment. Further, public awareness raised as a barrier in the findings is also underscored in literature (Pegels, 2009; Mudenda et al., 2018; Tembo, 2020; Amir and Khan, 2022).

5.5.3 Assessing the Effectiveness of Drivers

The third research objective aimed to gauge how well the identified drivers have been aiding the deployment of renewable energy technologies in Zambia.

The effectiveness of the Zambian government's commitment, as highlighted in strategic documents, is a subject of debate in line with literature emphasizing the need for continuous evaluation and adjustment in the renewable energy sector (Sovacool & Geels, 2014; Smith & Kern, 2010). The recognition of abundant renewable resources, particularly solar, is acknowledged, but the gap between potential and actual deployment suggests room for improvement, aligning with literature calling for maximizing the effectiveness of available resources.

International partnerships and funding mechanisms are recognized as strong drivers, aligning with literature that emphasizes the importance of sustained support and continual partnerships for long-term growth in the renewable energy sector. Private sector participation is acknowledged as a potential game-changer, but challenges like regulatory uncertainties and financial constraints need addressing, aligning with literature emphasizing the need for a conducive environment for private entities to invest confidently.

5.6 Implications

The analysis of drivers, barriers, and the effectiveness of strategies related to the deployment of renewable energy technologies in Zambia has yielded profound insights with far-reaching implications. These insights extend across the realms of policy-making, practical implementation, and future research within Zambia's renewable energy sector, providing a comprehensive understanding of the trajectory the country's energy landscape is set to follow.

Zambia's commitment to diversify its energy sources beyond predominantly hydro-based ones represents not just a strategic shift but an urgent necessity. To ensure the success of this diversification, policy directives must prioritize and allocate resources toward exploring and implementing alternative renewable sources, such as solar, wind, and geothermal technologies. Additionally, recognizing financial constraints as a critical barrier underscores the need to establish robust financial frameworks. This entails a reconsideration and potential reshaping of existing financial strategies. Promoting public-private partnerships and leveraging international collaborations for financial support can provide the necessary impetus for the renewable sector. However, financial strategies alone are insufficient; the regulatory ecosystem requires an overhaul. Challenges in the regulatory landscape call for policies that foster transparency, stability, and clarity essential elements for instilling and sustaining investor confidence.

On the policy front, a two-pronged approach focusing on strengthening infrastructure and fostering international collaborations is essential. Policies should aim to enhance grid connectivity and champion off-grid solutions, particularly in remote areas, while simultaneously nurturing and solidifying international relationships that Zambia has been cultivating.

In practical terms, the deployment of renewable energy solutions should be tailored to Zambia's unique needs. Given the country's vast and diverse demographic and topographical profile, decentralized renewable energy solutions, especially targeting rural landscapes, can revolutionize energy accessibility. However, deployment is just one aspect. A robust system to train technicians, engineers, and local communities is crucial for the sustainable implementation and maintenance of these renewable solutions. The establishment of dedicated vocational training avenues can address this need. Furthermore, the importance of community engagement cannot be overstated. Renewable energy projects should be conceived not as external interventions but as community projects. Engaging local communities and making them stakeholders, rather than just beneficiaries, can ensure a seamless and harmonious project lifecycle.

From a research perspective, the vast potential of renewable energy in Zambia necessitates a diverse approach. Instead of over-relying on a single source, future research endeavors should explore the multifaceted world of renewable energy, assessing the potential and challenges each source presents in the Zambian context. As Zambia moves towards a renewable future, periodic impact studies become indispensable. These studies, evaluating the socio-economic, environmental, and community impacts of renewable projects, can offer valuable data, aiding the refinement of future strategies. Moreover, the technological domain of renewable energy, abundant with innovations, should be a focal point of research. Exploring storage solutions, devising efficient transmission systems, or integrating various renewable sources are areas ripe for exploration.

5.7 Conclusion

The journey to understanding the dynamics of renewable energy deployment in Zambia, as explored in this study, has unveiled a panorama of insights, intricacies, and implications. The multifaceted research, which spanned expert opinions, and an extensive document review, has furnished a comprehensive picture of where Zambia stands in its renewable energy endeavors and where it aims to be. Central to the findings is the acknowledgment of Zambia's pressing need to diversify its energy sources. This urgency is not just to combat the vulnerabilities of an over-reliant hydro-based energy system but also to address the broader challenges of climate change, energy security, and socio-economic development. The identified drivers, ranging from robust governmental policies, and international collaborations to the inherent renewable energy potential that Zambia boasts, are strong pillars supporting the nation's renewable energy aspirations. However, the journey is not without its impediments. The barriers, both infrastructural and financial, coupled with regulatory challenges, underscore the complexities of the renewable energy landscape. Yet, these barriers are not insurmountable. The effectiveness of the drivers, as analysed, suggests a promising trajectory, but with a caveat — the need for consistent evaluation, adaptation, and evolution. The implications of these findings are profound. They beckon a cohesive alignment of policy, practice, and research. Policies need to be dynamic, adapting to the changing renewable energy landscape. Practical implementations should be grounded in the realities of Zambia's unique demographic and topographical nuances. And research should be visionary, foreseeing challenges, and proactively exploring innovative solutions.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter marks the conclusion of the investigation into Zambia's renewable energy sector. It aims to encapsulate the significant findings derived from the study and to chart out actionable recommendations that can shape the trajectory of renewable energy deployment in Zambia. By integrating the views of experts with meticulous document reviews, this chapter seeks to offer a holistic understanding and a pragmatic roadmap for Zambia's renewable energy future.

6.2 Conclusion

The research aimed to explore the factors influencing the deployment of renewable energy technologies in Zambia, excluding hydro-based sources. This study provided insights into the dynamics of renewable energy adoption, identifying the key drivers and barriers, and assessing the effectiveness of these drivers.

In Zambia, the push towards renewable energy is driven by a combination of factors. The government's role has been crucial, with policies and strategic plans signaling a commitment to renewable energy. These policy frameworks are designed to encourage the use of renewable sources, moving away from a heavy reliance on hydropower. The government's initiatives, reflected in documents like the 'National Energy Policy' and the 'Zambia Power Development Framework', have laid the groundwork for this shift. Alongside government efforts, international support has been a significant driving force. Zambia's involvement in global agreements, notably the Paris Agreement, has opened doors to international aid and guidance. These agreements emphasize the importance of reducing climate change impacts and support the adoption of renewable energies. For Zambia, this means access to global knowledge, resources, and a framework that aligns with worldwide efforts to combat climate change. Public awareness and interest in renewable energy have also been growing in Zambia. This change in public perception is critical as it creates a more supportive environment for renewable energy projects. The increasing understanding of the benefits of renewable energy among the public fosters a climate where such initiatives can be more readily accepted and integrated.

However, the path towards renewable energy adoption in Zambia is not without obstacles. Financial constraints stand out as a major barrier. The cost of implementing renewable energy projects, often higher than traditional energy sources, poses a significant challenge. This financial hurdle is exacerbated by limited access to funding and investment, both locally and internationally. Infrastructure also presents a major challenge. Zambia's current energy infrastructure, primarily designed for hydropower, is not fully equipped to integrate a diverse range of renewable energy sources. This limitation hinders the widespread adoption of technologies like solar and wind power. Upgrading and expanding the energy infrastructure to accommodate these technologies require substantial investment and planning. Regulatory issues also play a role in slowing down the adoption of renewable energy. While policies are in place, their implementation often faces delays and bureaucratic challenges. These regulatory bottlenecks can deter potential investors and complicate the process of rolling out new renewable energy projects.

The effectiveness of the drivers in promoting renewable energy in Zambia varies. Government policies, while well-intentioned, often struggle in implementation. The gap between policy formulation and execution needs to be bridged for these policies to be truly effective. International support has been beneficial, but for sustained growth, Zambia needs continuous and diversified international partnerships. Public awareness is increasing, but more targeted efforts are required to educate and involve communities in renewable energy initiatives.

6.3 Recommendations

As Zambia moves towards a more sustainable energy future, the insights gained from this research offer valuable guidance. These recommendations, shaped by expert opinions and an extensive review of relevant documents, aim to address the identified challenges and capitalize on the opportunities in Zambia's renewable energy sector.

Diversification of the Energy Mix

Zambia's historical reliance on hydropower, while beneficial in certain aspects, has also revealed its vulnerabilities, particularly in the face of climate change and its associated impacts such as droughts. This reliance has highlighted the pressing need to diversify the country's energy portfolio. Zambia's abundant solar resources, with over 2,000 hours of sunshine annually, present a largely untapped opportunity. Harnessing solar energy, along with other renewable sources such as wind and biomass, is vital for creating a more resilient and sustainable energy mix. Diversification will not only provide a safeguard against the limitations of hydropower but will also position Zambia as a regional leader in renewable energy.

Streamlining the Regulatory Framework

The effectiveness of Zambia's transition to renewable energy is heavily influenced by its regulatory environment. Currently, bureaucratic complexities, lack of transparency, and prolonged delays in project approvals often discourage potential investors and stakeholders. Simplifying these regulatory processes is crucial. Ensuring transparency and reducing bureaucratic hurdles will create a more inviting environment for investment in the renewable sector. Streamlining regulations will not only attract more investment but also accelerate the implementation of renewable energy projects, helping Zambia to achieve its sustainable energy goals more rapidly.

Public Awareness and Acceptance

The success of renewable energy projects is significantly dependent on public acceptance and support. Currently, misconceptions and lack of awareness about renewable energy technologies can pose substantial obstacles. To address this, stakeholders need to invest in comprehensive public awareness campaigns. These campaigns should aim to clarify misconceptions, highlight the benefits of renewable energy, and address any local concerns. Utilizing local languages, engaging with community leaders, and leveraging traditional communication methods can enhance the effectiveness of these campaigns. Building a sense of ownership and support among communities is essential for the successful implementation and sustainability of renewable energy projects.

Innovative Financing Mechanisms

One of the primary barriers to the adoption of renewable energy in Zambia is the high associated costs. The capital-intensive nature of these projects, combined with perceived risks, often makes financing a challenge. To overcome these financial hurdles, innovative financing mechanisms are required. Collaborations with international donors, tapping into global green funds, and exploring options such as green bonds could provide essential funding. Additionally, public-private partnerships (PPPs) could bring together the strengths of both sectors, ensuring not only the provision of funds but also the efficient execution of renewable energy projects.

International and Regional Cooperation

In today's interconnected world, international and regional cooperation is essential for achieving sustainable energy goals. Zambia can benefit significantly from partnerships with other countries and international organizations. Aligning its energy strategies with global sustainability goals can open up avenues for technical, financial, and policy support. Regional collaborations could lead to shared grid infrastructures, joint research initiatives, and even cross-border renewable energy projects. These collaborations can optimize resource utilization, reduce costs, and enhance the overall impact of renewable energy initiatives.

Expert Insights for Practical Implementation

The strength of these recommendations lies in their grounding in practical insights provided by experts familiar with Zambia's energy sector. These professionals emphasize addressing practical challenges, from financing to public acceptance, ensuring that the recommendations are actionable and grounded in the realities of Zambia's energy context. The integration of expert insights ensures that these strategies are not merely theoretical but are pragmatic and tailored to Zambia's specific needs and conditions.

While this study sheds light on critical aspects of Zambia's renewable energy landscape, there are avenues for future research to deepen our understanding and address emerging challenges. Some potential areas for further investigation include:

Impact of Technological Advances: Future studies could delve into the potential impact of emerging technologies, such as energy storage solutions or advanced grid management systems, on enhancing the integration and efficiency of renewable energy sources within Zambia's energy grid.

Socio-Economic Implications: Understanding the socio-economic implications of renewable energy adoption in Zambia is crucial for ensuring inclusive and sustainable development. Future research could explore the effects of renewable energy projects on employment generation, local economic growth, and social welfare.

Policy Evaluation and Adaptation: Continuous evaluation of existing renewable energy policies and their alignment with evolving national and global energy agendas is essential. Future research could focus on assessing the effectiveness of current policies, identifying areas for improvement, and proposing adaptive measures to address emerging challenges.

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APPENDICES

Appendix I: Structured Interview Guide

Thank you for agreeing to participate in this study. Before we begin, I would like to explain the purpose of this research, which is to investigate the drivers and barriers to the implementation of renewable energy technologies in Zambia. Your insights are valuable in helping us better understand the current situation and identifying strategies to support the growth of the renewable energy sector. Please note that your participation is voluntary and your responses will be kept confidential.

Background Information

1. Could you please provide your current position/role in the organization?
2. How long have you been working in the energy sector, and specifically with renewable energy technologies?
3. Can you briefly describe your organization's involvement in the renewable energy sector in Zambia?

Drivers of Renewable Energy Technologies Deployment

4. In your opinion, what are the key factors or drivers promoting the deployment of renewable energy technologies in Zambia?
5. How have government policies and regulations supported the deployment of renewable energy technologies? Could you provide specific examples?
6. What role do public-private partnerships play in facilitating the deployment of renewable energy technologies in Zambia?
7. How have financial incentives and capacity-building initiatives, such as training programs or technical assistance, supported the growth of renewable energy technologies in Zambia?

Barriers to Renewable Energy Technologies Deployment

8. What do you perceive as the main barriers hindering the deployment of renewable energy technologies in Zambia?

9. How have technical challenges, such as grid infrastructure limitations, affected the deployment of renewable energy technologies in the country?
10. How have financial constraints, such as limited access to capital or high upfront costs, impacted the deployment of renewable energy technologies in Zambia?
11. To what extent have social and cultural factors, such as lack of awareness or resistance to change, influenced the deployment of renewable energy technologies in Zambia?

Effectiveness of Drivers

12. In your opinion, how effective have the identified drivers been in promoting the deployment of renewable energy technologies in Zambia?
13. Could you provide examples of successful strategies or initiatives that have supported the deployment of renewable energy technologies in Zambia?
14. In implementing these drivers or overcoming barriers to renewable energy technologies deployment, what challenges have you encountered?
15. How do you think the effectiveness of these drivers could be improved to further support the growth of renewable energy technologies in Zambia?

Recommendations and Future Prospects

16. Based on your experience and expertise, what recommendations would you make to improve the deployment of renewable energy technologies in Zambia?
17. What do you see as the key opportunities for growth and development in the renewable energy sector in Zambia in the coming years?
18. In light of the current situation and future prospects, what role do you envision renewable energy technologies playing in Zambia's energy mix in the next decade?