A Study of the Challenges in Adoption of Renewable Energy in Nigeria

by

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Table of Contents

Student Declaration Form I
Abstract II
Acknowledgment III
CHAPTER 1 - INTRODUCTION 1
1.1 Introduction 1
1.2 Background to the study 5
1.3 Research Gap 11
1.4 Research Aims and Objectives 13
1.5 Contribution to the Existing Literature on Renewable Energy Adoption 17
1.6 Summary 19
CHAPTER 2 – LITERATURE REVIEW 21
2.1 Introduction 21
2.2 Renewable Energy 22
2.3 Key Theories and Models Reviewed in Literature 24
2.3.1 Stakeholder Theory 24
2.3.2 Institutional Theory 25
2.3.3 Multi-Level Perspective (MLP) 25
2.3.4 Technology-Organisation-Environment (TOE) Framework 25
2.3.5 Socio-Technical Systems Theory 26
2.3 Types of Renewable Energy 26
2.4 Renewable Energy Integration 28
2.5 Renewable Energy Projects and Initiatives 29
2.6 Renewable Energy and Energy Security 31
2.7 Drivers of Renewable Energy Adoption 31
2.8 Factors Affecting Renewable Energy Adoption 34
2.9 Challenges of Renewable Energy Adoption 41
2.10 Why Renewable Energy Projects Fail 44
2.11 Renewable Energy Project Management 52
2.12 Theoretical Framework 61
2.13 The Research Gaps in the Literature 67
2.13 Main Findings from Previous Studies that Influenced This Research 69
2.15 Summary 71
CHAPTER 3 - RESEARCH METHODOLOGY 73
3.1 Introduction 73
3.2 Research Philosophy 75
3.3 Research Strategy 78
3.4 Research Design 86
3.5 Leveraging Stakeholder Theory for Qualitative Data Collection 93

3.6.Ethical Considerations 101
3.7 Reliability and Validity in Qualitative Research 104
3.8 Summary 106
CHAPTER 4 – CASE STUDIES 109
4.1 Introduction 109
4.2 Business Environment and the Industrial Context 110
4.3 Case Study Protocol 116
4.4 The Case Study Project 1: Katsina Wind Farm 126
4.5 The Case Study Project 2: Bayero University Kano (BUK) Hybrid Solar PV Park 133
4.6 The Case Study Project 3: University of Maiduguri (UNIMAID) Solar Project 144
4.7 Summary 149
CHAPTER 5 – DATA ANALYSIS AND DISCUSSION 151
5.1 Introduction 151
5.2 The Case Study Project 1: Katsina Wind Farm 151
5.3 The Case Study Project 2: Bayero University Kano (BUK) Solar Project 167
5.4 The Case Study Project 3: University of Maiduguri (UNIMAID) Solar Project 174
5.5 Cross-Case Analysis of Renewable Energy Adoption 184
5.6 Summary 215
CHAPTER 6 – CONCLUSION 217
6.1 Introduction 217
6.2 Key Findings 218
6.3 The Implications of the Research 223
6.4 Limitations of the Research 230
6.5 Suggestions for Further Studies 234
6.6 Summary 237
7.0 REFERENCES 241
APPENDICES 282
Appendix I: Interview Questions 282
Appendix II: Participant Information Sheet 285
Appendix III: Consent Letter 293

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Abstract

This study investigates the challenges and opportunities in the adoption of renewable energy in Nigeria, focusing on economic, political, technological, and social factors. Despite Nigeria's abundant renewable energy resources, the transition to sustainable energy remains slow, hindered by policy instability, high capital costs, inadequate infrastructure, and regulatory bottlenecks. Furthermore, public skepticism and limited awareness further constrain widespread adoption. This research applies Stakeholder Theory to explore how multi-stakeholder interactions influence the success or failure of renewable energy projects. Through a qualitative case study approach, three key renewable energy projects—the Katsina Wind Farm, the Bayero University Kano (BUK) Hybrid Solar PV Park, and the University of Maiduguri (UNIMAID) Solar Project—are examined to provide a comprehensive understanding of the sector's dynamics. The findings reveal that bureaucratic inefficiencies, governance issues, and technical challenges have contributed to delays in the Katsina Wind Farm. Conversely, the BUK Hybrid Solar PV Park demonstrates how institutional leadership and donor funding can successfully facilitate solar energy expansion. The UNIMAID Solar Project underscores the role of renewable energy in enhancing energy security in conflict-prone regions but also highlights sustainability concerns and security risks. These cases illustrate the complexities of renewable energy implementation in Nigeria and provide insights into the interplay between policy frameworks, financial constraints, technological capacity, and societal engagement.

The study contributes to knowledge by identifying strategic interventions to enhance renewable energy adoption. Key recommendations include the introduction of targeted subsidies and tax incentives to attract private sector investment, the development of capacity-building initiatives to enhance technical expertise, and the strengthening of public-private partnerships to improve project sustainability. Furthermore, the research advocates policy coherence, improved regulatory frameworks, and community engagement strategies to foster social acceptance and encourage grassroots participation in renewable energy initiatives.

Ultimately, this research underscores the necessity for a coordinated, multi-stakeholder approach to accelerate Nigeria's transition to sustainable energy. By addressing economic, political, technological, and social barriers in a holistic manner, this study provides valuable insights that can inform policy reforms, enhance investment strategies, and promote the long-term integration of renewable energy into Nigeria's national energy mix.

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CHAPTER 1 - INTRODUCTION

1.1 Introduction

The need to combat climate change, improve energy security, and stimulate sustainable economic growth has made the transition to renewable energy a global imperative (Ellabban et al., 2014). Nevertheless, renewable energy technologies are essential in limiting environmental impact and reducing reliance on fossil fuels in the broader commitment to decreasing carbon footprints and transitioning to cleaner energy sources. Solar, wind, hydro, and biomass energy projects are on the rise as investments drive the evolution of the global energy landscape. However, the speed and effectiveness of this transition vary significantly worldwide, influenced by economic conditions, policy contexts, technological advancements, and societal attitudes toward renewable energy (He et al., 2023; Wu et al., 2023).

Nigeria, as Africa's most populous nation and one of its largest economies, faces a significant energy deficit that has hindered industrial growth and socio-economic development. A large proportion of the Nigerian population lacks access to reliable electricity, with frequent power outages and a heavy reliance on expensive and environmentally harmful diesel generators. The country's energy sector is predominantly fueled by fossil sources, particularly crude oil and natural gas, which account for most of the electricity generation. Despite its wealth of natural resources, including an abundance of solar, wind, hydro, and biomass potential, Nigeria's renewable energy sector remains underdeveloped. The slow pace of renewable energy adoption is attributed to multiple factors, including inadequate policies, financial constraints, lack of infrastructure, and societal reluctance to embrace new energy technologies (Udoakah, 2018; Okafor and Onuoha, 2020).

Economic and political challenges have played a crucial role in shaping the trajectory of renewable energy development in Nigeria. High upfront costs associated with the installation of solar panels, wind turbines, and other renewable energy infrastructure pose a significant barrier to adoption. Many potential investors hesitate to commit to renewable energy projects due to concerns over policy instability, inconsistent government incentives, and difficulties in securing financing (Olowosejeje, 2019). Moreover, a weak regulatory framework, compounded by bureaucratic inefficiencies,

has slowed the progress of renewable energy initiatives (World Bank, 2020). While the Nigerian government has introduced various policies to encourage renewable energy adoption, such as the Renewable Energy Master Plan (Energy Commission of Nigeria, 2005) and the National Renewable Energy and Energy Efficiency Policy (Federal Government of Nigeria, 2012), implementation remains inconsistent, and enforcement mechanisms are weak (GIZ, 2020).

Technological advancements play a pivotal role in the adoption of renewable energy globally, but Nigeria has struggled to keep pace due to inadequate research funding, limited technical expertise, and weak institutional support for innovation (Akinbami, 2020; Adegbemi et al., 2019). Despite the widespread adoption of solar photovoltaics (PV) and wind energy technologies in various parts of the world, Nigeria's renewable energy sector remains hampered by low investment in research and development (R&D) and an over-reliance on imported technologies (Sambo, 2019; Akuru and Okoro, 2020). The lack of local manufacturing capacity increases costs, delays implementation, and creates dependency on foreign expertise (Ogunbiyi, 2021). Furthermore, integrating renewable energy into the national grid poses substantial technical challenges, including grid instability, inadequate transmission infrastructure, and the absence of robust energy storage systems (Nnodim et al., 2021; Yusuf et al., 2020). Many rural communities, which stand to benefit the most from decentralized renewable energy solutions, are constrained by limited affordability, weak policy support, and lack of incentives for distributed generation (Iwayemi, 2020; Okonkwo and Uchenna, 2018). Therefore, there is a critical need for strengthening local capacity, improving knowledge transfer, and fostering international collaborations to bridge Nigeria’s technological gap in the renewable energy sector (Adebayo and Ogunleye, 2022).

Beyond technological and economic barriers, societal attitudes and public awareness play a decisive role in shaping the adoption of renewable energy in Nigeria. Despite increasing global recognition of the environmental and economic benefits of clean energy, public skepticism remains a significant barrier (Ebhota and Tabakov, 2020). Misinformation, a lack of exposure to successful renewable energy projects, and deep-rooted dependence on conventional energy sources—such as diesel generators and natural gas power plants—have slowed down acceptance (Okafor and Joe-Uzuegbu, 2019; Ajayi, 2020). In rural communities, cultural beliefs and behavioral patterns

influence perceptions of energy reliability and trust in modern energy systems (Ogunmodimu and Okoroigwe, 2021). In some cases, public resistance stems from past failures of government-led electrification initiatives, where communities received inconsistent or unreliable services, reinforcing a preference for traditional fossil fuel-based systems (Obiora et al., 2019). To counteract this resistance, targeted awareness campaigns, community-driven renewable energy projects, and inclusive energy governance structures will be necessary to promote behavioral change and foster societal acceptance (Akinyele et al., 2021; Olowosejeje and Adeyanju, 2019).

This research seeks to provide comprehensive insights into the factors shaping renewable energy adoption in Nigeria, assessing the economic, political, technological, and social barriers that have hindered progress (Sovacool and Geels, 2020; Aklin and Urpelainen, 2018). By analysing case studies and stakeholder perspectives, the study aims to identify best practices and policy recommendations that can enhance the sustainability and scalability of renewable energy projects (Owusu and Asumadu-Sarkodie, 2016; IRENA, 2021). Addressing these concerns is essential to ensuring a more resilient and diversified energy sector in Nigeria, which, in turn, will contribute to economic growth, energy security, and environmental sustainability (Ebhota and Tabakov, 2020; UNDP, 2022). Through targeted interventions and collaborative efforts among policymakers, investors, and communities, Nigeria can position itself as a leader in renewable energy development in Africa and beyond (Adebayo, 2021; Newell, Phillips and Pueyo, 2021; World Bank, 2020).

Despite Nigeria's immense renewable energy potential, the country continues to struggle with its adoption and integration into the national energy framework (Sovacool and Geels, 2020; Acheampong, Erku-Kutan and Abor, 2021). Nigeria is endowed with vast renewable resources, including solar, wind, hydropower, and biomass, yet these resources remain largely underutilized (IRENA, 2021; Ebhota and Tabakov, 2020). The nation's energy sector remains heavily dependent on fossil fuels, contributing to high carbon emissions, environmental degradation, and an unstable energy supply (IEA, 2022; UNDP, 2022). Efforts to transition to renewable energy have been impeded by a range of complex and interconnected barriers, including economic constraints, policy inconsistencies, limited technological advancement, and societal resistance to change (Newell, Phillips and Pueyo, 2021; Ebhota and Tabakov, 2020).

The failure of numerous renewable energy projects raises significant concerns about the underlying structural and institutional challenges that hinder progress (Sarkodie and Adams, 2020; Aklin and Urpelainen, 2018). Past projects, such as government-led solar electrification programs and independent power producer (IPP) initiatives, have struggled due to a lack of long-term strategic planning, weak governance, financial constraints, and inadequate technical expertise (World Bank, 2020; Acheampong et al., 2021). Moreover, corruption, regulatory bottlenecks, and bureaucratic inefficiencies have further exacerbated the difficulties in implementing and scaling up renewable energy solutions (REN21, 2022; Okafor, Egbue and Umar, 2020). The absence of a consistent and coherent regulatory framework has led to investor uncertainty, deterring both local and foreign investment in the sector (Ogunbiyi, 2021; IRENA, 2022).

Existing research has largely focused on specific barriers to renewable energy adoption, such as financial limitations or technical inefficiencies, without adequately addressing the broader interplay of economic, political, technological, and social factors (Sovacool and Geels, 2020; Acheampong, Erku-Kutan and Abor, 2021). This fragmented approach limits the effectiveness of policy interventions and impedes the development of a comprehensive and sustainable renewable energy strategy (Ebhota and Tabakov, 2020; REN21, 2022). Additionally, public attitudes and perceptions regarding renewable energy remain underexplored, despite their critical role in influencing adoption rates (Okafor, Egbue and Umar, 2020; Newell, Phillips and Pueyo, 2021). Many communities and businesses in Nigeria are reluctant to transition to renewable energy due to concerns about cost, reliability, and feasibility (IRENA, 2021; IEA, 2022). Misinformation, limited awareness campaigns, and a general lack of trust in renewable energy technologies contribute to this scepticism (Ogunbiyi, 2021; Ebhota and Tabakov, 2020).

Another critical issue is the challenge of integrating renewable energy into Nigeria's existing power grid. The national grid infrastructure is outdated and lacks the necessary capacity to efficiently accommodate decentralized renewable energy systems (IEA, 2022; Acheampong et al., 2021). Frequent grid failures, technical inefficiencies, and inadequate energy storage solutions present significant obstacles to achieving large-scale renewable energy deployment (Sarkodie and Adams, 2020; IRENA, 2022). Additionally, rural communities, which stand to benefit the most from decentralized renewable energy solutions, often face higher barriers to adoption due to inadequate

financing mechanisms, limited technical expertise, and weak institutional support (World Bank, 2020; Okafor et al., 2020).

To address these gaps, this study seeks to provide a holistic and interdisciplinary analysis of the factors influencing renewable energy adoption in Nigeria. It will examine the economic, political, technological, and social dimensions that shape the renewable energy landscape, assess public attitudes and perceptions, and identify key challenges faced in renewable energy projects (Aklin and Urpelainen, 2018; Acheampong et al., 2021). By incorporating case studies of past and ongoing projects, the research will derive lessons that can inform future policy and investment decisions (IRENA, 2022; Ogunbiyi, 2021).

Furthermore, this study aims to develop evidence-based recommendations that can facilitate the sustainable expansion of renewable energy in Nigeria. These recommendations will focus on improving regulatory frameworks, enhancing financial incentives, strengthening institutional capacity, and fostering greater public engagement in renewable energy initiatives (REN21, 2022; Newell et al., 2021). Through a multidimensional approach, this research intends to contribute to the development of a more resilient, inclusive, and sustainable energy system that can support Nigeria's long-term economic and environmental goals (UNDP, 2022; IEA, 2022).

1.2 Background to the study

Renewable energy refers to energy derived from natural resources that are replenished or renewed at a rate equal to or faster than their consumption (Ellabban et al., 2014). These energy sources include sunlight, wind, water (hydroelectric), biomass, and geothermal heat, all of which are widely regarded as sustainable alternatives to fossil fuels due to their ability to provide long-term energy security while minimizing environmental impact. Renewable energy technologies convert these natural resources into electricity, heat, or mechanical power, providing a clean and efficient solution to the growing energy demand across the world (Ellabban et al., 2014). The transition to renewable energy is considered critical in the fight against climate change, as it significantly reduces greenhouse gas emissions, mitigates air pollution, and promotes environmental conservation (Lund, 2007).

One of the primary advantages of renewable energy is its role in enhancing energy security by reducing dependence on finite fossil fuel reserves and minimizing exposure to volatile global oil and gas markets (Akinbami, 2020; Acheampong, Erku-Kutan and Abor, 2021). Countries with limited fossil fuel resources are increasingly investing in renewable energy infrastructure to diversify their energy mix and reduce reliance on energy imports (REN21, 2022; UNDP, 2022). This shift not only improves national energy security but also stimulates economic growth by creating new employment opportunities in research and development, manufacturing, installation, and maintenance of renewable energy systems (IRENA, 2022; IEA, 2022). The International Renewable Energy Agency (IRENA, 2021) estimates that the renewable energy sector has the potential to create millions of jobs worldwide, with Africa being one of the key regions where renewable energy deployment could drive significant employment growth.

Despite the numerous benefits of renewable energy, its adoption remains hindered by several challenges, particularly in developing economies like Nigeria. One of the primary barriers is the high capital cost associated with the installation, operation, and maintenance of renewable energy technologies. Unlike fossil fuel-based power generation, which benefits from decades of infrastructure development and subsidies, renewable energy projects often require substantial upfront investment before they become financially viable (Guney et al., 2019; He et al., 2023). The lack of financial incentives and appropriate funding mechanisms further exacerbates the issue, as potential investors remain hesitant to commit to projects with uncertain returns.

In addition to financial constraints, policy and regulatory barriers also inhibit the growth of the renewable energy sector. Many developing nations, including Nigeria, lack coherent, long-term policies that support the integration of renewable energy into national grids (Okafor, Egbue and Umar, 2020; World Bank, 2020). Frequent policy reversals, bureaucratic inefficiencies, and weak enforcement of regulatory frameworks discourage both domestic and foreign investment in renewable energy projects (Sovacool and Geels, 2020; Ogunbiyi, 2021). Furthermore, frequent leadership changes and political instability have disrupted long-term planning efforts, preventing renewable energy initiatives from achieving sustained growth and scalability (He et al., 2023; IRENA, 2021).

The lack of grid infrastructure and modernization further compounds the problem. In Nigeria and many other developing economies, the national grid is outdated, prone to frequent failures, and lacks the capacity to integrate large-scale renewable energy (Acheampong et al., 2021; IEA, 2022). Energy storage limitations, transmission inefficiencies, and unreliable distribution networks restrict the full deployment of renewable energy solutions, especially for off-grid and rural electrification programs (Sarkodie and Adams, 2020; Ebhota and Tabakov, 2020). The successful integration of renewables into Nigeria's energy mix requires substantial investments in grid modernization, smart grid technologies, and decentralized energy systems (REN21, 2022; Ogunbiyi, 2021).

Technological limitations also pose a significant barrier to renewable energy adoption in Nigeria, primarily due to outdated energy infrastructure, poor grid connectivity, and limited access to modern energy technologies (Sovacool and Geels, 2020; Acheampong, Erku-Kutan and Abor, 2021). The national electricity grid is inefficient, unreliable, and plagued by frequent breakdowns, making the integration of large-scale renewable energy projects highly challenging (Ebhota and Tabakov, 2020; IEA, 2022). The existing grid infrastructure was designed primarily for fossil fuel-based power generation, and its inability to accommodate decentralized renewable energy solutions has resulted in significant energy losses, technical inefficiencies, and reduced capacity utilization (Okafor, Egbue and Umar, 2020; Ogunbiyi, 2021).

Nigeria's rural communities, which stand to benefit the most from renewable energy technologies, face considerable obstacles due to limited grid connectivity and inadequate investment in off-grid electrification (IRENA, 2021; REN21, 2022). Many remote areas still rely on inefficient, polluting, and costly energy sources such as diesel generators and firewood, despite the abundant availability of solar and wind resources in the country (Acheampong et al., 2021; Ogunbiyi, 2021). The lack of technological infrastructure to harness these resources has led to a continued reliance on unsustainable energy practices, exacerbating energy poverty and environmental degradation (Guney, 2019; IEA, 2022).

A key limitation is the lack of advanced energy storage solutions, which is crucial for ensuring grid stability and integrating intermittent renewable energy sources such as solar and wind (Lund, 2007; IEA, 2021). Battery storage technology, which is essential for managing fluctuations in renewable energy supply, remains cost-prohibitive and

inaccessible in many parts of Nigeria (He, Kammen and Wang, 2023; Ebhota and Tabakov, 2020). Moreover, the absence of smart grid infrastructure further hinders the efficient distribution and management of renewable energy (Sovacool, 2021; Acheampong et al., 2021).

The shortage of technical expertise and limited research funding further exacerbates Nigeria's renewable energy challenges (Okafor et al., 2020; Ogunbiyi, 2021). The lack of skilled professionals in renewable energy system design, installation, and maintenance significantly affects project implementation and long-term sustainability (IRENA, 2021; REN21, 2022). While universities and research institutions have begun incorporating renewable energy education into their curricula, the pace of development remains slow, and most technical training programs lack industry alignment (He et al., 2023; Sovacool and Geels, 2020). The inadequate funding for research and development (R&D) in clean energy technologies further restricts local innovation and the development of indigenous renewable energy solutions (IEA, 2022; Ogunbiyi, 2021).

Another major obstacle to renewable energy adoption is public perception and social acceptance. Many communities remain skeptical about the reliability and efficiency of renewable energy technologies, partly due to a lack of awareness and misinformation. Cultural and behavioral factors also play a role in shaping attitudes toward renewable energy, as many people are accustomed to conventional energy sources such as diesel generators and may resist transitioning to unfamiliar technologies. Without targeted public awareness campaigns and educational initiatives, these social barriers will continue to impede the widespread adoption of renewable energy in Nigeria (Wu et al., 2023).

Given these challenges, it is evident that a comprehensive and multi-faceted approach is required to enhance the adoption and integration of renewable energy into Nigeria's energy landscape. This includes policy reforms, financial investment, technological advancements, and extensive public engagement. However, while existing literature has explored many of these factors, research has largely been fragmented, failing to consider the interconnected nature of economic, political, technological, and social barriers to renewable energy adoption. This gap in the literature underscores the need for a more holistic and stakeholder-driven approach, which this study aims to address.

1.2.1 Global Context of Renewable Energy Adoption

The global transition towards renewable energy is being driven by the urgent need to combat climate change, enhance energy security, and foster sustainable economic development. Over the last two decades, countries around the world have made significant investments in clean energy technologies, with solar, wind, hydropower, and biomass emerging as viable alternatives to fossil fuels. According to IRENA (2022), renewables accounted for nearly 30% of global electricity generation in 2021, and this share is projected to rise sharply in the coming years.

In developed regions such as Europe, North America, and East Asia, the adoption of renewable energy has been facilitated by strong policy frameworks, well-developed infrastructure, access to finance, and public awareness. The European Union, for example, has integrated renewables into its Green Deal initiative and committed to carbon neutrality by 2050. China, the world's largest producer and installer of solar and wind energy technologies, has adopted aggressive strategies to scale up clean energy as part of its climate commitments (REN21, 2022). Similarly, the United States has launched federal and state-level programs to support innovation in renewable energy, energy storage, and electric mobility.

Multilateral organisations and global institutions such as the United Nations Development Programme (UNDP), World Bank, and the International Energy Agency (IEA) have also played pivotal roles in shaping the global energy transition. They provide technical assistance, funding, and policy support to emerging economies to help them align with global sustainability targets such as the Paris Agreement and the UN Sustainable Development Goal 7 (affordable and clean energy for all).

However, disparities persist between developed and developing nations in terms of access to technology, financial mechanisms, and institutional capacity. While industrialised countries are moving towards smart grids, hydrogen energy, and next-generation battery storage, many developing countries are still struggling with basic energy access and infrastructure reliability. This global divide has intensified calls for energy justice and equitable technology transfer to support the Global South in achieving energy transitions that are inclusive and resilient.

1.2.2 Local Context of Renewable Energy Adoption in Nigeria

Nigeria, as Africa’s most populous nation and largest economy, is endowed with abundant renewable energy resources, particularly solar, wind, hydro, and biomass.

Despite this potential, the country remains heavily reliant on fossil fuels, particularly gas and diesel, for electricity generation. Access to electricity is still a major challenge, with over 85 million Nigerians lacking reliable power supply, particularly in rural and peri-urban areas (IEA, 2022).

The Nigerian government has made several attempts to promote renewable energy through national policies and development plans. Initiatives such as the Renewable Energy Master Plan (REMP), Vision 30:30:30 (which aims to achieve 30% renewable energy in the mix by 2030), and the Electrification Roadmap developed in partnership with Siemens are indicative of growing policy interest in clean energy solutions. Additionally, regulatory bodies such as the Nigerian Electricity Regulatory Commission (NERC) and agencies like the Rural Electrification Agency (REA) have launched programs aimed at off-grid and mini-grid solar deployment.

However, the adoption of renewable energy in Nigeria faces numerous structural challenges. Chief among them is the lack of coherent and enforceable energy policies. While the country has multiple policy documents, the absence of legislative backing and poor coordination between agencies hinder implementation. Political instability, frequent policy reversals, and lack of continuity in governance often disrupt long-term planning (Ogunbiyi, 2021; Okafor et al., 2020).

The financial environment is also unfavourable for renewable energy investors. High capital costs, currency instability, lack of access to affordable credit, and the absence of structured incentive schemes deter private sector participation. Most renewable energy projects rely on donor funding or development finance, limiting scalability and sustainability.

Technological barriers further constrain adoption. Nigeria's national grid is outdated and highly centralised, making it incompatible with the integration of decentralised renewable energy systems. Frequent grid failures and transmission losses render large-scale renewable projects risky. In rural areas, lack of infrastructure and logistics severely restrict the deployment of off-grid solutions.

Moreover, Nigeria suffers from a shortage of skilled labour and technical know-how in renewable energy system design, installation, and maintenance. Educational institutions are only beginning to integrate renewable energy training into their curricula, and research and development activities are underfunded and fragmented (He et al., 2023; IRENA, 2021).

Social and cultural perceptions also play a role. Many Nigerians are more familiar with traditional energy sources such as generators and may not fully understand the benefits or functionality of renewable alternatives. This lack of awareness leads to scepticism and reluctance to adopt newer, cleaner technologies. Without targeted public sensitisation and community engagement, renewable energy projects may face local resistance or underutilisation.

In summary, while Nigeria's renewable energy potential is considerable, realising this potential requires a systemic overhaul involving policy reform, institutional strengthening, technological innovation, financial restructuring, and social mobilisation. Addressing these challenges holistically will be crucial to achieving a just and inclusive energy transition in Nigeria.

1.3 Research Gap

While significant research has been conducted on the potential of renewable energy sources, the existing literature has primarily focused on technical advancements, economic feasibility, and policy recommendations without adequately exploring the complex and interconnected barriers to renewable energy adoption (Ellabban et al., 2014; Lund, 2007). Many studies approach the issue from a single perspective, often analysing financial constraints (Guney et al., 2019), technological limitations (He et al., 2023), or regulatory challenges (NESP, 2020) in isolation. This segmented approach fails to capture the broader systemic barriers that hinder renewable energy development and integration in Nigeria (IRENA, 2021; IEA, 2020). Given that renewable energy adoption is influenced by a multi-dimensional interaction of economic, political, technological, and social factors, a holistic research approach is essential to fully understand the challenges involved (Sovacool et al., 2018).

One of the most glaring gaps in literature is the lack of research on the role of stakeholder engagement in renewable energy adoption. While governments, businesses, investors, and local communities all play critical roles in shaping the renewable energy landscape, existing studies have not adequately examined how these stakeholders interact, influence decision-making processes, and impact project implementation (Ogunbiyi, 2022; REN21, 2022). Prior studies have primarily concentrated on policy design and financial mechanisms (Ebhota and Tabakov, 2022) but have largely overlooked how stakeholder engagement—or the lack thereof—affects

project sustainability and scalability (IEA, 2021). Without an in-depth understanding of stakeholder dynamics, policy interventions remain fragmented and less effective, often leading to project failures and underperformance (IRENA, 2019).

Furthermore, there has been limited research on how public perception and social acceptance influence renewable energy adoption in Nigeria. Most studies tend to focus on economic and technical factors (He et al., 2023) while overlooking the importance of community engagement and behavioral change (GIZ, 2021). Studies from other developing economies indicate that public trust, awareness campaigns, and local involvement are critical determinants of renewable energy adoption (Sovacool and Griffiths, 2020). However, in Nigeria, research remains scarce on how misconceptions, lack of awareness, and cultural resistance shape attitudes toward renewable energy (Akinbami, 2022). Understanding public attitudes, knowledge gaps, and cultural perceptions regarding renewable energy are essential for designing effective awareness campaigns and community-driven initiatives that encourage adoption (Adegbite et al., 2020).

Another key research gap is the lack of empirical case study-driven research that evaluates the successes and failures of past renewable energy projects in Nigeria (Ebhota and Tabakov, 2022). While various policy recommendations have been proposed, there is insufficient real-world evidence assessing their effectiveness (IRENA, 2019). Studies from other African countries, such as South Africa and Kenya, emphasize the importance of empirical evidence in shaping effective policy measures (Baker et al., 2019), yet Nigeria lacks similar case-study-driven evaluations of its renewable energy projects. By incorporating case studies into this research, this study aims to derive practical lessons that can inform future strategies and policies for sustainable energy development (IEA, 2021; NESP, 2020).

By bridging these research gaps through a multi-dimensional and empirical approach, this study not only contributes to the scholarly discourse on renewable energy transitions but also establishes a structured foundation for analysing the interconnected economic, political, technological, and social factors shaping Nigeria's renewable energy landscape. This holistic perspective ensures that the study moves beyond fragmented analyses to provide actionable insights that inform regulatory frameworks, investment strategies, and stakeholder engagement. Furthermore, by incorporating real-world case studies, this research contributes to both theoretical and practical

understandings of renewable energy adoption in a developing economy context. The findings will be essential for policymakers, industry practitioners, and researchers seeking to create an enabling environment for sustainable energy development. The next section presents the theoretical framework underpinning this research, offering a conceptual basis for understanding the complex interdependencies that influence renewable energy adoption in Nigeria.

1.4 Research Aims and Objectives

The primary aim of this study is to investigate the key factors influencing the adoption and success of renewable energy projects in Nigeria, with a focus on economic, political, technological, and social dimensions. By analysing stakeholder interactions, policy frameworks, financial barriers, and public perception, this study seeks to provide a comprehensive understanding of the challenges facing Nigeria's renewable energy sector. Additionally, by drawing insights from past and ongoing renewable energy projects, the research aims to develop strategic recommendations to enhance the sustainability and scalability of renewable energy initiatives Nigeria.

Nigeria's energy crisis, characterized by inconsistent electricity supply, overreliance on fossil fuels, and limited access to clean energy solutions, underscores the need for a structured approach to renewable energy adoption. The findings of this study will contribute to national and global discussions on energy transition by offering a nuanced analysis of the obstacles hindering progress and the opportunities for accelerating Nigeria's shift toward sustainable energy solutions.

1.4.1 Research Objectives

To achieve the overarching aim, this study is guided by the following specific objectives, each aligned with a critical research question:

1. **To examine the economic, political, technological, and social factors that impact the adoption and success of renewable energy projects in Nigeria.** *Rationale:* The adoption of renewable energy is not solely dependent on technological feasibility; it is influenced by a combination of economic viability, government policies, infrastructure readiness, and public attitudes. High capital costs, limited financing options, inconsistent regulatory frameworks, and inadequate grid infrastructure have been identified as major barriers in previous studies. Additionally, societal factors, such as resistance to

change and low awareness of renewable energy benefits, play a significant role in shaping adoption patterns. This objective will enable a multi-dimensional exploration of these factors to determine their individual and collective impact on Nigeria's renewable energy landscape.

2. **To assess the role of social attitudes, perceptions, and awareness in shaping the uptake of renewable energy technologies in Nigeria.**

   Rationale: Public perception is a crucial yet often overlooked factor in renewable energy adoption. While technical and financial aspects are frequently discussed, limited research has been conducted on how social attitudes, misinformation, and cultural beliefs influence the acceptance or rejection of renewable energy technologies. Many communities remain skeptical about the reliability, affordability, and practicality of renewable energy solutions. Additionally, lack of exposure to successful projects, coupled with the dominance of conventional energy sources, has slowed adoption rates. This objective aims to assess the extent to which social attitudes and awareness campaigns affect public willingness to transition to renewable energy solutions.

3. **To identify and evaluate the specific challenges encountered in renewable energy projects in Nigeria.**

   Rationale: Although Nigeria has launched several renewable energy initiatives, many projects have failed or struggled due to challenges such as poor policy implementation, financial constraints, bureaucratic inefficiencies, and technical limitations. Understanding these challenges is critical for improving future project success rates. By examining case studies of past and ongoing renewable energy projects, this objective seeks to identify the recurring obstacles that have hindered their full implementation and sustainability. Evaluating these challenges will provide valuable insights into how policy gaps, financing limitations, and infrastructure deficiencies have affected project viability.

4. **To derive lessons from past and ongoing renewable energy projects that can inform future renewable energy initiatives in Nigeria.**

   Rationale: Effective policymaking and project implementation require learning from both successes and failures. Renewable energy projects in Nigeria have varied in terms of outcomes, with some demonstrating promising potential while others have faced significant setbacks. By analysing case studies, this

objective seeks to extract key lessons that can inform future renewable energy policies, investment strategies, and community engagement models. Identifying best practices and common pitfalls will enable stakeholders—including policymakers, investors, and developers—to design more resilient and scalable renewable energy solutions that align with Nigeria's unique socio-economic and infrastructural context.

By addressing these objectives, this study will contribute to a deeper understanding of the factors shaping renewable energy adoption in Nigeria and provide evidence-based recommendations to support a sustainable energy transition.

1.4.2 Research Questions

The study will be guided by the following key research questions:

1. How do economic, political, technological, and social factors impact the adoption and success of renewable energy projects in Nigeria?
2. How do social attitudes, perceptions, and awareness about renewable energy influence renewable energy adoption?
3. What are the specific challenges encountered in renewable energy projects in Nigeria?
4. What lessons can be learned from these case studies to inform future renewable energy initiatives in Nigeria?

By addressing these research questions, the study aims to provide a nuanced understanding of the renewable energy landscape in Nigeria and contribute to policy formulation and project planning that can enhance the country's transition to sustainable energy sources.

1.4.3 Conceptual Frameworks for Understanding Renewable Energy Adoption in Nigeria

The linear conceptual framework in this study is designed to provide a systematic, theory-driven lens through which the adoption of renewable energy in Nigeria can be understood (Figure 1.1). Anchored in Stakeholder Theory (Freeman, 1984), this framework positions stakeholder interactions at the core of renewable energy project development. It sequentially traces the causal pathways from theoretical grounding to contextual application, and from methodological choice to empirical outcomes.

The framework begins by establishing Stakeholder Theory as the foundational perspective, recognizing the importance of diverse actors—including government

bodies, private investors, local communities, and academic institutions—in shaping energy transitions. This is followed by a contextual layer, focusing on Nigeria's renewable energy landscape, characterized by regulatory instability, infrastructural deficits, and socio-economic disparities.

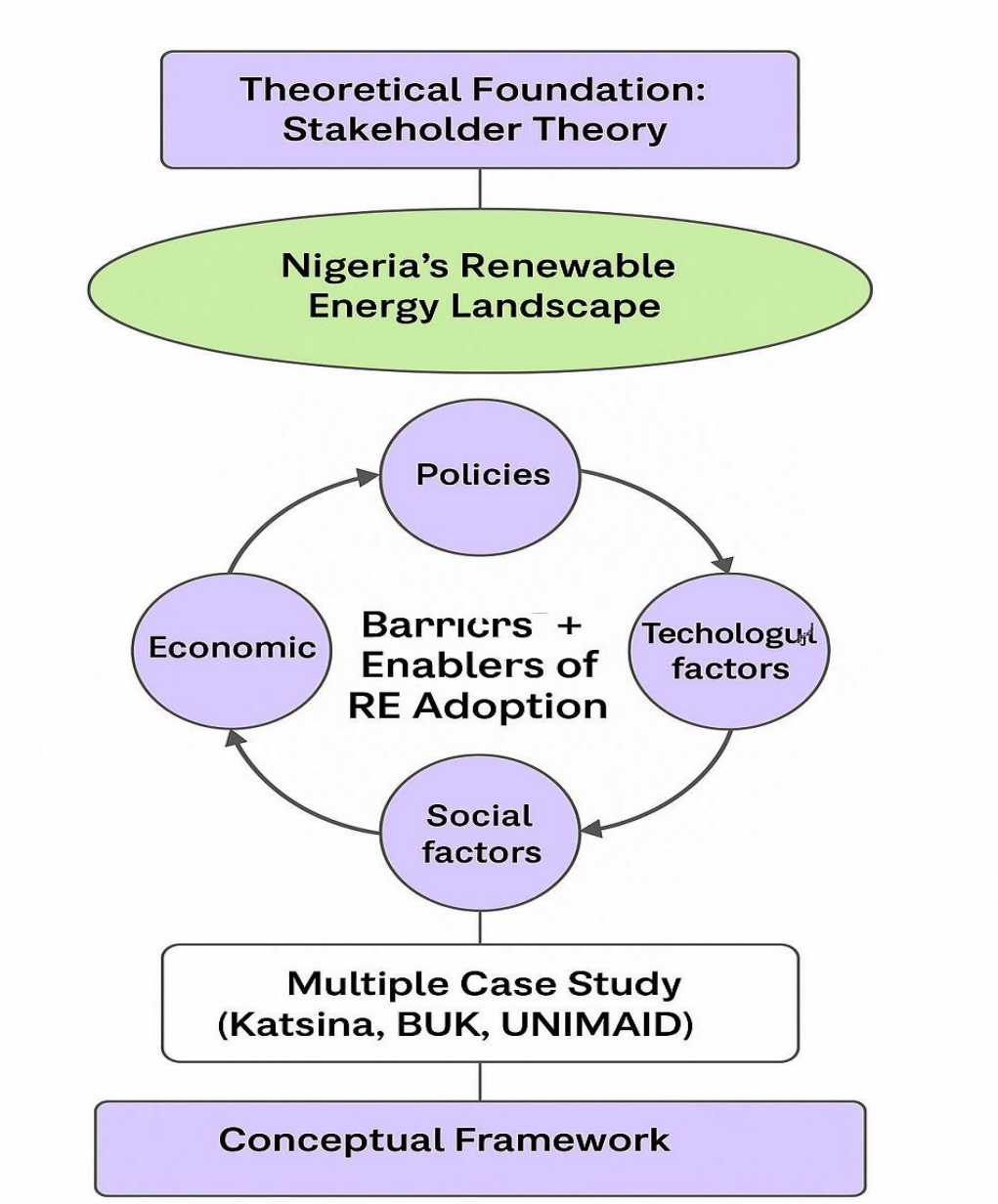

Figure 1.1 **Conceptual Framework: Theoretical Design Perspective**

Four core constructs—Policy, Economic, Technological, and Social Factors—are identified as key determinants that influence the trajectory of renewable energy projects. These constructs are investigated through a multiple case study methodology involving the Katsina Wind Farm, the Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project. Each case serves as an

empirical anchor for analysing how contextual variables interact with stakeholder dynamics to produce specific outcomes.

Ultimately, the framework leads to an outcome node, which captures both the barriers and enablers to renewable energy adoption. This outcome informs targeted policy recommendations, theoretical refinement, and strategic planning for future interventions in Nigeria's energy sector.

1.5 Contribution to the Existing Literature on Renewable Energy Adoption

The global discourse on renewable energy adoption has grown significantly over the past two decades, particularly as nations seek sustainable pathways to address climate change, energy poverty, and environmental degradation. Despite this growing body of literature, there remains a notable scarcity of interdisciplinary, empirically grounded research that holistically examines the intersection of technological, political, social, and economic barriers in developing contexts, especially in sub-Saharan Africa. This study provides a valuable contribution to this underexplored dimension by offering a nuanced analysis of renewable energy adoption in Nigeria—a country endowed with abundant renewable energy resources but challenged by systemic infrastructural, governance, and socio-cultural constraints.

One of the key contributions of this research lies in its use of a multi-stakeholder framework to analyse the dynamics of renewable energy adoption. While previous studies have predominantly focused on isolated themes such as the technical feasibility of renewable energy technologies (Ellabban et al., 2014; Lund, 2007), the cost-benefit analyses of energy investments (Guney et al., 2019), or policy prescriptions (NESP, 2020), this study integrates these dimensions within a broader socio-technical and institutional context. The research highlights that addressing technological limitations or improving policy instruments in isolation is insufficient; rather, renewable energy transition requires a coordinated, multi-actor approach involving state institutions, private investors, technology providers, community actors, and civil society organisations (Sovacool et al., 2018; IRENA, 2021).

Furthermore, this study advances the literature by foregrounding the role of stakeholder engagement in shaping renewable energy outcomes. Although stakeholder theory has been applied in corporate sustainability research (Freeman et al., 2010), its application within the renewable energy domain, particularly in developing economies, remains under-theorised. The study demonstrates how power

asymmetries among stakeholders, the exclusion of local communities, and fragmented governance structures contribute to project delays, lack of public trust, and underperformance of renewable energy systems. This insight complements and extends prior research which has called for more inclusive and participatory models of energy governance (Baker et al., 2019; Sovacool and Brisbois, 2019).

Additionally, the case study approach adopted in this research provides much-needed empirical depth. In Nigeria, much of the renewable energy literature has been diagnostic or policy-oriented, with limited real-world evidence evaluating project outcomes. By focusing on three distinct case studies, the Katsina Wind Farm, the Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project, the research contributes original empirical data that exposes the contextual realities of renewable energy deployment in diverse institutional and geographical settings. This comparative approach allows for cross-case analysis, offering insights into how factors such as political instability, institutional capacity, and local perceptions shape the success or failure of renewable energy interventions.

Another unique contribution is the exploration of renewable energy adoption in conflict-prone regions, particularly the UNIMAID Solar Project. Very few studies in the renewable energy literature address the intersection of energy security and political instability. This study offers a compelling case for how decentralised renewable systems can support institutional resilience, foster community inclusion, and mitigate energy poverty in fragile environments—thereby contributing to an emerging body of work on energy justice and resilience in vulnerable regions (Sovacool et al., 2021; Okafor et al., 2020).

Finally, this research contributes methodologically by applying a rigorous qualitative research design grounded in interpretivism and constructivist ontology. The use of semi-structured interviews, document analysis, stakeholder mapping, and thematic analysis offers a robust methodological framework that enhances the reliability and transferability of the findings. It also aligns with recent scholarly calls for methodological diversification in energy studies, especially in contexts where quantitative data is limited or unreliable (Creswell and Poth, 2018; Braun and Clarke, 2006).

In summary, the study makes three principal contributions to the literature on

renewable energy adoption: it bridges the gap between technical and socio-political analyses by presenting a holistic stakeholder-driven framework; it offers rare empirical insights from project-level case studies in a developing country context; and it expands understanding of the interplay between political, institutional, and technological variables in renewable energy transitions. These contributions are particularly relevant for researchers, policymakers, and development practitioners seeking to design context-sensitive strategies for scaling up renewable energy in Nigeria and comparable regions.

1.6 Summary

The introduction chapter of this research has outlined the critical need for transitioning to renewable energy in Nigeria, highlighting the multifaceted challenges and opportunities within the sector. The study's context is framed by Nigeria's significant renewable energy potential, juxtaposed against persistent energy deficits, heavy reliance on fossil fuels, and environmental concerns. The chapter established the pressing need for a holistic approach to understanding renewable energy adoption, considering economic, political, technological, and social dimensions.

A detailed problem statement underscored the complexities hindering renewable energy integration into Nigeria's national energy framework. It identified the economic constraints, policy inconsistencies, technological barriers, and societal resistance to change as key impediments to progress. The research gap analysis further revealed a lack of comprehensive studies that examine the interplay of these factors, as well as a gap in understanding the role of stakeholder engagement and public perception in renewable energy adoption. This study aims to bridge these gaps through a multi-dimensional approach, employing Stakeholder Theory to analyse how different actors influence project success and policy effectiveness.

The theoretical framework section introduced Stakeholder Theory as the lens through which this study will analyse renewable energy adoption in Nigeria. The Stakeholder Theory diagram illustrated the complex interactions between government agencies, investors, technology providers, local communities, and NGOs, emphasizing the need for coordinated efforts to drive sustainable energy transitions. By applying this theory, the study will explore how inclusive policy design, multi-stakeholder collaboration, and community engagement can enhance renewable energy project outcomes.

The research aims and objectives were clearly outlined, focusing on evaluating economic, political, technological, and social factors, assessing public attitudes, identifying specific challenges, and deriving lessons from past and ongoing projects. These objectives align with the research questions that seek to provide actionable insights into enhancing the sustainability and scalability of renewable energy initiatives in Nigeria.

In conclusion, Chapter 1 sets a solid foundation for the research by establishing a clear rationale, articulating the research problem, identifying gaps in existing literature, and outlining a structured approach to address these gaps. The subsequent chapters will build on this foundation, with Chapter 2 delving into a comprehensive literature review to further contextualize the study within the broader discourse on renewable energy transitions in developing economies. Through a rigorous analysis of case studies and empirical evidence, this research aims to contribute to policy development, investment strategies, and technological advancements that support Nigeria's path toward a more sustainable and resilient energy future. By advancing a stakeholder-driven approach and providing practical recommendations for policymakers, investors, and industry practitioners, this study aspires to play a pivotal role in shaping Nigeria's renewable energy landscape and ensuring long-term energy security, environmental sustainability, and economic development.

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

The global energy landscape is undergoing a significant transformation, driven by the urgent need to transition towards more sustainable and environmentally friendly energy sources. Renewable energy has emerged as a critical solution in addressing climate change, reducing carbon emissions, and ensuring long-term energy security. This chapter presents a comprehensive literature review on renewable energy, exploring its various forms, drivers, challenges, and implications for sustainable development.

Renewable energy encompasses diverse sources such as solar, wind, hydro, biomass, and geothermal energy, each offering unique advantages and applications. These energy sources are replenishable and have a lower environmental impact compared to conventional fossil fuels. The rapid advancement in renewable energy technologies has enabled increased adoption and integration into national energy systems, driving global efforts towards carbon neutrality and energy resilience.

Despite the numerous benefits associated with renewable energy, its adoption and implementation are influenced by several factors, including political, economic, technological, social, and environmental considerations. Government policies, economic incentives, technological innovations, and public awareness play pivotal roles in determining the pace and scale of renewable energy deployment. Furthermore, challenges such as high initial costs, intermittency of resources, infrastructure limitations, and resistance from fossil fuel industries pose significant barriers to widespread adoption.

The chapter further explores the success and failure of renewable energy projects across different regions, with a specific focus on developing countries like Nigeria. The analysis highlights the factors contributing to project failures, including inadequate planning, lack of stakeholder engagement, poor governance, and financial constraints. Additionally, the chapter explores renewable energy project management strategies that can enhance project sustainability, transparency, and community involvement.

By synthesizing key findings from various studies, this literature review provides insights into the evolving dynamics of renewable energy adoption, emphasizing the need for collaborative efforts among policymakers, researchers, and industry stakeholders. Understanding these complexities is essential in formulating

effective policies, investment strategies, and technological innovations that can accelerate the transition towards a more sustainable and energy-secure future.

2.2 Renewable Energy

Renewable energy refers to energy derived from natural resources that are replenished or renewed at a rate equal to or faster than their consumption (Ellabban et al., 2014). These energy sources, including sunlight, wind, water (hydroelectric), biomass, and geothermal heat, are considered sustainable and have minimal environmental impact compared to conventional fossil fuels (Ellabban et al., 2014; Lund, 2007).

Renewable energy technologies harness the power of these natural resources to generate electricity, heat, or mechanical power (Ellabban et al., 2014). They offer a cleaner and more sustainable alternative to non-renewable energy sources like coal, oil, and natural gas. By decreasing dependence on fossil fuels, societies can mitigate climate change, reduce greenhouse gas emissions, and promote energy security (Ellabban et al., 2014).

Renewable energy plays a crucial role in fostering sustainable development and addressing environmental challenges (Lund, 2007). It offers the potential to mitigate environmental degradation and contribute to a more sustainable energy future. As a result, renewable energy has gained increasing attention and support worldwide as a key component of sustainable development strategies (Ellabban et al., 2014).

Majid et al. (2014) examined renewable energy for sustainable development in India: status, future prospects, and challenges, employment, and investment opportunities. The researchers argued that strong government support and an increasingly opportune economic situation have pushed India to be one of the top leaders in the world's most attractive renewable energy markets. The government has designed policies, programs, and a liberal environment to attract foreign investments to ramp up the country in the renewable energy market at a rapid rate. It is anticipated that the renewable energy sector can create many domestic jobs over the following years (Majid, et al., 2020).

Guney et al. (2019) studied the effects of renewable and non-renewable energy on sustainable development using data from 40 developed and 73 developing countries. The findings showed that renewable energy has a positive and significant effect on sustainable development. This suggests that transitioning to renewable energy sources can contribute to a more sustainable future (Güney, et al., 2019). In the same vein, other

researchers argued that investment in renewable energy has a significant positive impact on reducing carbon emissions, which is crucial for mitigating climate change (He et al., 2023). Several environmental policies that can promote renewable energy investment, including feed-in tariffs, tax incentives, and public-private partnerships. Furthermore, policymakers implement targeted environmental policies to promote renewable energy investment and reduce carbon emissions (He et al., 2023).

Wu et al. (2023) look at the role of renewable energy consumption and financial development in environmental sustainability. They stated that renewable energy consumption has a significant positive effect on CO2 emissions reduction, while financial development has a significant negative effect on CO2 emissions. Furthermore, policymakers should prioritize renewable energy consumption and financial development as key strategies for promoting environmental sustainability in the region. It highlights the importance of these factors for achieving Sustainable Development Goals (SDG) and provides policy suggestions for enhancing environmental sustainability through renewable energy consumption and financial development (Wu, L., et al., 2023).

The adoption of renewable energy sources, low-carbon initiatives, and advanced logistical infrastructure can reduce carbon emissions and crime rates while promoting economic growth and tourism. Policymakers should prioritize investments in renewable energy sources, low-carbon initiatives, and transportation networks to achieve sustainable economic development. By doing so, they can promote economic growth while reducing carbon emissions and crime rates (Khan et al., 2022). While practical solutions for filling the green financing gap and encouraging investment in renewable energy projects such as increasing the role of public financial institutions and non-banking financial institutions, utilizing spill over tax, developing green credit guarantee schemes, establishing community-based trust funds, and addressing green investment risks via financial and policy de-risking. However, the lack of long-term financing, low rate of return, various risks, and lack of capacity among market players are major challenges for the development of green energy projects. However, practical solutions such as those proposed can help fill the green financing gap (Taghizadeh - Hesary et al., 2020).

In sum, renewable energy is vital for achieving a more sustainable and environmentally friendly future. India's progress in the renewable energy sector, along with the positive

impact of renewable energy on sustainable development showcases the potential for a cleaner and more sustainable energy landscape. By investing in renewable energy, promoting environmental policies, bridging the green financing gap, and prioritizing renewable energy consumption and financial development, policymakers can drive the transition towards a more sustainable future.

2.3 Key Theories and Models Reviewed in Literature

The adoption of renewable energy technologies is a complex and multi-dimensional process that involves technological, economic, political, and social factors. To capture this complexity, the literature review in this study draws upon several key theoretical frameworks and conceptual models that help explain the dynamics of energy transitions. The most prominent among these are Stakeholder Theory, Institutional Theory, the Multi-Level Perspective (MLP) on socio-technical transitions, and the Technology-Organisation-Environment (TOE) Framework. Each theory offers a distinct but complementary lens for understanding the barriers and enablers of renewable energy deployment in developing economies such as Nigeria.

2.3.1 Stakeholder Theory

Stakeholder Theory, originally developed by Freeman (1984), has evolved into a foundational framework for examining organizational governance beyond the traditional shareholder model. It emphasizes that firms and public institutions must consider the diverse interests of all parties affected by their decisions—including governments, civil society, investors, local communities, and NGOs—in order to achieve long-term sustainability. In the context of renewable energy, the theory is crucial because of the heterogeneous and sometimes conflicting interests of stakeholders in project design, financing, implementation, and usage (Mitchell, Agle & Wood, 1997; Reed et al., 2009). Scholars such as Sovacool and Brisbois (2019) and Li et al. (2020) have employed stakeholder theory to demonstrate that inclusive stakeholder engagement leads to greater project legitimacy, reduced conflict, and improved outcomes. The theory also addresses power asymmetries and institutional trust, which are particularly relevant in Nigeria, where stakeholder disempowerment, regulatory inefficiency, and low community participation often hinder energy transitions (Baker et al., 2019).

2.3.2 Institutional Theory

Institutional Theory explores how rules, norms, and organizational practices influence behaviour and decision-making. It posits that institutions—formal and informal—constrain and shape the actions of actors within a system (Scott, 2001). This theory is highly applicable to renewable energy adoption, especially in environments with weak regulatory frameworks, bureaucratic inertia, or policy inconsistency. In developing contexts, institutional voids often result in fragmented governance, impeding the scalability of renewable energy innovations. North (1990) highlights that path dependency and institutional lock-in can reinforce fossil fuel dominance, whereas Helmke and Levitsky (2004) point to the influence of informal institutions (such as patronage networks or community customs) on project acceptance and implementation. Institutional Theory helps explain why energy transitions succeed in some countries but stall in others due to varying levels of institutional maturity and alignment.

2.3.3 Multi-Level Perspective (MLP)

The Multi-Level Perspective (MLP) developed by Geels (2002) conceptualizes socio-technical transitions across three analytical levels: niches (micro-level), socio-technical regimes (meso-level), and landscapes (macro-level). This model provides a dynamic understanding of how innovations such as renewable energy technologies emerge in protected spaces, interact with dominant regimes (e.g., national energy systems), and respond to broader societal pressures (e.g., climate change or economic crises). MLP has been applied in numerous case studies on energy transition to analyse how incumbent actors, lock-in mechanisms, and resistance from existing power structures can hinder the scaling up of renewables (Markard, Raven & Truffer, 2012). It is particularly relevant in Nigeria, where the fossil fuel regime remains dominant, despite growing international and domestic pressure for a transition to sustainable energy systems.

2.3.4 Technology-Organisation-Environment (TOE) Framework

The TOE framework, developed by Tornatzky and Fleischer (1990), offers a comprehensive approach to understanding technological adoption by considering three domains: technology readiness, organizational capacity, and environmental context. It is increasingly applied to renewable energy studies in developing countries to explain adoption readiness among public agencies and private firms (Oliveira & Martins, 2011). The model underscores how technical infrastructure, management culture, and external

incentives (such as government subsidies or donor funding) influence decision-making. In the Nigerian context, this framework is useful for evaluating how factors such as limited local expertise, high capital costs, and fragmented policy environments constrain the diffusion of renewable technologies.

2.3.5 Socio-Technical Systems Theory

Socio-technical systems theory is another valuable model that examines the co-evolution of technologies, users, institutions, and societal practices. This approach recognizes that energy systems are not merely technical artifacts but embedded within social contexts that influence how they are designed, adopted, and sustained (Hughes, 1987; Smith, Stirling & Berkhout, 2005). This is particularly applicable in rural and peri-urban Nigeria, where energy needs, cultural values, and user behaviour significantly affect the success of renewable energy projects. The theory also emphasizes that transitions require simultaneous alignment across multiple domain technology, regulation, user preferences, and markets.

In summary, the literature reviewed highlights that no single theory sufficiently captures the multifaceted nature of renewable energy adoption. Instead, an integrated theoretical approach drawing upon Stakeholder Theory, Institutional Theory, MLP, TOE, and socio-technical systems thinking is necessary to explore the interdependence among policy, technology, organizations, and society. These theories collectively inform the analytical framework of this study, offering tools to assess why renewable energy projects in Nigeria succeed or fail and how more inclusive, resilient, and scalable models can be developed.

2.3 Types of Renewable Energy

Several researchers provide an overview of the different types of renewable energy sources, including:

2.3.1 Solar energy

Solar energy is a renewable resource that's accessible globally. Both solar thermal (Hajian, Simson and Kurnitski, 2022) and solar PV (Nasr Esfahani, Darwish and Williams, 2022) have found uses in many areas, such as homes (Maghrabie et al., 2021), water purification (Sonawane et al., 2022), transport (Muna and Kuo, 2022), drying

methods (Ndukwu et al., 2022), and watering systems (Sunny et al., 2022). Numerous studies have investigated these innovations and applications. Concentrated Solar Power stands out as a technology for generating both warmth and power. There's been substantial global funding to enhance Concentrated Solar Power. Since 2005, a variety of commercial Concentrated Solar Power setups have emerged. However, we're still gaining the expertise needed to transform Concentrated Solar Power into a consistent and economical energy solution.

2.3.2 Wind Energy

Wind energy harnesses the kinetic energy of the wind and can be directly transformed into mechanical power or indirectly into electricity. Central to this process is the wind turbine, which captures the wind's potential energy and converts it into mechanical power for various applications. The journey of wind turbines began in the early 20th century when the first one was constructed to produce electrical power. While there have been consistent advancements in wind turbine technology over the years, significant progress in design has been noted (Olabi et al., 2021). Contemporary innovations and enhancements in turbines and their components have led to marked improvements in power output and efficiency. Additionally, developments in specific generators and the incorporation of power electronic devices have paved the way for turbines without gears (Hansen et al., 2001). A wind turbine primarily consists of a tower, blades, and a nacelle, which encloses the generator, gears, and control mechanisms. Much like how an airplane wing facilitates lift, wind propels the turbine blades. This motion is transferred to the generator within the nacelle, which then converts the kinetic energy into electricity. This electricity is then relayed to the grid via a transformer.

2.3.3 Biomass

Biomass stands as a readily accessible energy source, utilized in a spectrum of applications, ranging from traditional combustion methods (Zhang et al., 2014; Contreras-Trejo et al., 2022; Xu and Sheng, 2022) to its direct use in fuel cells for electricity generation (Banerjee et al., 2022; Sayed et al., 2020; Pham and Yoon, 2020). While combustion is a time-honored technique, it doesn't optimally harness the energy potential inherent in diverse biomass materials. Transitioning biomass into biofuels, like biodiesel (Rizal et al., 2019; Borowiak et al., 2022; Yang et al., 2022) and biochar (Sieradzka et al., 2022; Han et al., 2022), emerges as a promising approach with

versatile applications.

2.3.4 Hybrid Renewable Energy Systems

While renewable energy sources are eco-friendly and have negligible environmental impact, many, such as solar and wind energy, are intermittent in nature. This necessitates their combination with energy storage systems. At times, multiple renewable energy sources are paired with various energy storage systems. The primary objective of these combinations is to ensure consistent energy supply throughout the day at an economical cost (Zdiri et al., 2022; Belboul et al., 2022; Khan et al., 2022). Numerous studies have explored the amalgamation of different renewable energy systems to offer carbon-neutral, enhanced, and cost-effective energy (Singh et al., 2020).

2.3.5 Fuel Cells and Green Hydrogen

Fuel cells generate electricity through an electrochemical reaction, typically using hydrogen as a fuel source, with water and heat as the only byproducts. When powered by green hydrogen—produced via electrolysis using renewable energy sources such as wind, solar, or hydropower—fuel cells become a truly zero-emission energy solution (Liu et al., 2022; Alves et al., 2022; Samsun et al., 2022). These technologies are gaining traction across various sectors, including transportation, industrial processes, and power generation, due to their high efficiency, scalability, and ability to support energy storage and grid stability. While challenges such as hydrogen production costs, infrastructure development, and storage limitations remain, ongoing research and policy support are accelerating the adoption of fuel cells and green hydrogen as key enablers of a cleaner and more resilient energy future. Fuel cells have demonstrated promising potential across various sectors, including transportation, notably in fuel cell vehicles, remote applications (Peloriadi et al., 2022), mobile devices (Sá et al., 2022), and stationary setups (Tiedemann et al., 2022; Felseghi et al., 2019).

2.4 Renewable Energy Integration

The integration of renewable energy sources into the energy systems of smart cities is a crucial strategy for achieving cleaner and more sustainable development (Hoang, et al., 2021). This approach recognizes the importance of utilizing renewable energy sources to reduce reliance on finite resources and mitigate the damaging effects of climate change caused by greenhouse gas emissions. However, implementing

integrated energy systems in smart cities can present challenges that need to be addressed.

A comprehensive review of renewable energy sources, including solar, wind, biomass, geothermal, hydropower, and ocean energy, highlights their potential and limitations (Halkos, et al., 2020). These renewable sources offer clean, sustainable, and cost-effective energy alternatives that have a significantly lower environmental impact compared to conventional energy technologies. Continued research and policy development are essential for fully realizing the benefits of renewable energy sources and addressing their limitations.

Solar and wind power are among the key renewable energy sources that provide clean, sustainable, and cost-effective energy (Alrikabi, et al., 2014). They offer numerous advantages, including their availability throughout the year without negatively impacting the environment. By harnessing solar and wind power, we can reduce air pollution, soil pollution, and water pollution associated with conventional energy technologies. Moreover, these renewable energy sources aim to provide long-term access to electricity generation at stable costs, particularly in developing regions.

The integration of renewable energy sources into energy systems is crucial for achieving cleaner and more sustainable development in smart cities (Hoang, et al., 2021). However, it is important to acknowledge the potential and limitations of different renewable energy sources, such as solar, wind, biomass, geothermal, hydropower, and ocean energy (Halkos, et al., 2020). These sources offer clean and sustainable alternatives with lower environmental impacts compared to conventional energy technologies. By prioritizing research, policy development, and implementation, we can maximize the benefits of renewable energy sources and address their limitations effectively. The adoption of renewable energy sources, particularly solar and wind power, can lead to a reduction in pollution and provide access to affordable and reliable electricity generation in both developed and developing regions (Alrikabi, et al., 2014). Embracing renewable energy technologies is a sagacious strategy that contributes to a cleaner, more sustainable future.

2.5 Renewable Energy Projects and Initiatives

Renewable energy initiatives and projects have become increasingly important in recent years, as countries around the world seek to reduce their reliance on fossil fuels and transition to more sustainable energy sources. Renewable energy, which includes

sources such as wind, solar, hydro, and geothermal power, offers a range of benefits, including lower greenhouse gas emissions, improved energy security, and increased economic opportunities. Governments, businesses, and communities are all playing a role in promoting renewable energy, through policies, investments, and innovation. In this context, it is important to understand the current state of renewable energy development, as well as the challenges and opportunities that lie ahead.

Wang, Li, and Zhang (2019) provide a comprehensive review of the international context of renewable energy development and proposes policy recommendations for China and other countries. The authors argue that sustainable development requires policies and strategies that can improve energy efficiency and reduce greenhouse gas emissions, and that renewable energy is an effective way to achieve these goals.

To support their argument, the authors summarize the research results released by relevant statistical departments and authoritative institutions and systematically comb the energy development situation of the European Union, United States, Australia, India, and Brazil. They analyse the development trend of wind, solar, biomass, geothermal, ocean, and hydrogen energy, and propose that China should draw up its own development path of renewable energy from international development experience and actively explore renewable energy policies and strategies adapted to different stages of development.

Wang, Li, and Zhang (2019) also emphasize the importance of long-term learning from international experience to meet ambitious climate mitigation goals and increase the absorption capacity of renewable energy sources. They note that the EU's renewable energy consumption is on the rise, the renewable energy industry is developing rapidly, and the overall greenhouse gas emissions are being reduced. They also highlight the expansion of renewable energy during the past few decades in other big economies, and the rapid development in renewable energy technologies for energy generation, which demonstrate that the transformation of the energy structure can realize ambitious climate mitigation targets.

The authors acknowledge that each form of renewable energy development involves spatial considerations, and that it is necessary to consider the development characteristics of different countries and different renewable energy sources and learn from the development advantages of various countries. They comprehensively sort out the development situation of renewable energy in the world's five major economic

countries, and analyse the development trend of wind, solar, biomass, geothermal, ocean, and hydrogen energy. Based on the condition of China's energy development and the role of the market, they propose a policy path that adapts to China.

2.6 Renewable Energy and Energy Security

So far, only two studies that directly examine the relationship between renewable energy and energy security were found. One of these studies is an information paper from the International Energy Agency (IEA), while the other is a book chapter. In this regard, Olz et al. (2007) investigated the contribution of renewables to energy security in IEA member countries, focusing on technological developments in the renewable energy sector. Their findings indicate that while the use of renewable energy in production is not without risks and the cost of incorporating it into the production process is relatively high compared to traditional energy sources, renewable energy systems offer a promising solution to mitigate energy security risks. Moreover, the widespread availability of renewable energy sources provides diverse options for electricity generation, heat production, and the manufacturing of transportation fuels across numerous locations. The adoption of renewable energy also presents significant opportunities for substantial reductions in greenhouse gas emissions and the realisation of various additional co-benefits. Paravantis and Kontoulis (2020) proposed an energy security index with various dimensions and components to examine the role of renewable energy in energy security. Their study focused on Denmark, Germany, China, Russia, and the US, without conducting an econometric or statistical analysis. The authors concluded that increasing energy generation from renewable sources can enhance energy security for these countries, even in the presence of social acceptability concerns and negative environmental impacts.

2.7 Drivers of Renewable Energy Adoption

Renewable energy adoption is driven by a variety of factors that influence the decision-making processes. According to (Igirigi, 2019), the drivers of renewable energy development can vary depending on the context and location. However, some common drivers identified include:

- The need to secure energy access: In rural areas in developing countries, renewable energy solutions can provide access to electricity and other energy services that may not be available through traditional means.

- Potential socio-economic benefits: Renewable energy solutions can create jobs, stimulate local economies, and improve public health by reducing air pollution.
- Climate change mitigation: The need to reduce greenhouse gas emissions and combat climate change is a major driver of renewable energy development.
- Resource availability: In areas with abundant renewable energy resources, such as solar or wind, the potential for renewable energy development is high.
- Incentive-based policy reforms: Government policies that incentivize the development of renewable energy solutions, such as tax credits or feed-in tariffs, can be a driver of renewable energy development. It is important to note that these drivers can interact with each other and with barriers to renewable energy development (Igirigi, 2019).

A survey conducted in Singapore revealed that the top three drivers of corporate renewable procurement were the desire to meet corporate sustainability goals, reduce energy procurement costs, and demonstrate corporate leadership (Li, et al., 2022). However, barriers such as lack of awareness about Renewable Energy Certificates (RECs), high upfront costs, and a lack of government incentives were identified as hindrances to the widespread adoption of renewable energy in Singapore. To overcome these barriers, policymakers can use this information to implement policies, infrastructure, and initiatives that accelerate renewable energy adoption in the country.

Similarly, in the European Union (EU), an analysis of the driving factors of renewable energy consumption emphasized the importance of considering both economic and social factors (Ballesta, et al., 2022). While economic factors were found to have a negative effect on renewable energy consumption, social factors, particularly education, exerted a positive effect. This implies that policies aimed at promoting renewable energy consumption in the EU should adopt a comprehensive approach that considers not only economic factors but also social factors such as education. By addressing these multifaceted factors, the EU can foster greater renewable energy consumption throughout its member states.

Examining the drivers of renewable energy consumption in the BRICS nations, it was found that CO2 emissions and gross fixed capital formation have a significant and negative impact on the demand for renewable energy (Sachan, et al., 2023). This highlights the importance of implementing policies focused on reducing CO2 emissions

and increasing investment in renewable energy infrastructure to promote sustainable energy use in these countries. Understanding these drivers is crucial for developing effective policies that encourage the adoption of renewable energy sources in the BRICS nations.

In the United States, factors influencing the adoption of renewable energy in the residential sector were investigated (Jiang, et al., 2022). The study revealed that income, education level, age, home ownership status, and regional climate conditions significantly impact the adoption of renewable energy in U.S. households. Furthermore, there were notable spatial variations in renewable energy adoption across different regions of the country. Policymakers can leverage these findings to target specific demographic groups or regions with tailored policies and incentives aimed at increasing renewable energy adoption. Despite data limitations, the study's methodology offers a user-friendly and widely applicable approach for adoption in other countries.

Evidence from non-parametric panel methods in G7 economies identified economic growth, energy prices, technological innovation, and effective environmental policies as significant determinants of renewable energy adoption (Wu, et al., 2023). Policymakers should prioritize the implementation of effective environmental policies and invest in technological innovation to promote renewable energy. Meanwhile, businesses should focus on research and development to enhance their competitiveness in the renewable energy market. By leveraging these drivers, G7 economies can further enhance their renewable energy adoption and contribute to sustainable development.

The role of government policies in private investment in renewable energy was examined, highlighting the impact of subsidies for fossil fuels and regulatory uncertainty (Azhgaliyeva, et al., 2023). Policymakers play a crucial role in creating stable and predictable regulatory environments that encourage private investment in renewable energy. Moreover, alternative sources of financing such as corporate research and development (R&D), private equity, and venture capital are underutilized and can be promoted to drive investment in renewable energy projects. By addressing barriers and diversifying financing options, policymakers can foster increased private investment in renewable energy.

In the context of renewable energy development, a systematic review and meta-analysis underscored the significance of political, economic, technological, and social factors (Wang, et al., 2023). Policymakers should focus on implementing market-oriented

regulations, providing direct financial subsidies, and establishing feed-in tariffs to promote the development of renewable energy. Additionally, efforts should be made to improve energy security by reducing net energy imports. This comprehensive approach recognizes the interplay between various factors and emphasizes the need for coordinated efforts across different sectors to drive renewable energy development.

In conclusion, the drivers of renewable energy adoption are multifaceted and vary across different contexts. Factors such as corporate sustainability goals, cost reduction, and leadership aspirations motivate corporate renewable procurement. Social factors like education and economic factors influence renewable energy consumption in the EU. The BRICS nations require policies targeting CO2 emissions reduction and increased investment in renewable energy infrastructure. In the U.S., demographic and regional characteristics play a significant role in the adoption of renewable energy. The G7 economies emphasize economic growth, energy prices, technological innovation, and effective environmental policies. Government policies, regulatory stability, and alternative financing sources are critical for private investment in renewable energy. Finally, political, economic, technological, and social factors collectively shape renewable energy development. By understanding these drivers, policymakers can design tailored strategies and initiatives to accelerate the adoption of renewable energy, ultimately contributing to a sustainable and clean energy future.

2.8 Factors Affecting Renewable Energy Adoption

Several studies have reported on the various factors affecting renewable energy adoption. However, some were found to have one or more of the following limitations. First, many studies have focused solely on a single RE source such as solar energy adoption and overlooked other RE sources such as biomass and geothermal. The power sector has consumed the largest share of RE, and solar energy has been the fastest-growing electricity source. However, the power sector only accounted for 17% of global energy consumption while heating and cooling made up 51% in 2017 that cannot be overlooked. Beyond this structural limitation, which is largely technological, a comprehensive demand based renewable energy assessment is yet to be reported. Meanwhile, the multidimensional factors which influence the adoption of renewable energy on a generic level include political, economic, technological, social and environmental.

2.8.1 Political Factors

Government ideology is another political factor that potentially affects the environmental quality and the stringency of energy policies. Potrafke (2010) investigates the hypothesis (among others) that market oriented and right-wing governments have been more active at deregulating product markets, among them, the market for energy. His empirical estimates show that right-wing governments do in fact promote deregulation of the energy market. Also, the concentration of the government majority seems to positively affect market deregulation, while the institutional constraints, captured by the comprehensive Henisz index, appear not to play a major role. Chang and Berdiev (2011) as well as Biresselioglu and Karaibrahimoglu (2012) focus on the effects of government ideology and of other political factors on the energy market alone. Their results confirm that left-wing governments favour regulation in the energy sector, with the fragmentation of government again playing a partly offsetting role. More stringent institutional constraints seem to favour the deregulation of the sector. On the other hand, market-oriented, right-wing governments endorse energy deregulation, although the link between environmental policy and government ideology in this case appears less evident than for left-wing governments. Both studies look at government ideology only, disregarding other political dimensions that may have an impact on energy policy decisions. That is likely to prove a serious neglect, as Neumayer (2003), for instance, makes the interesting point that left-wing governments may find themselves in an ambivalent position vis à vis the protection of the environment. That is because policy decisions aimed at protecting the environment can be costly in terms of employment levels. Employment concerns may be particularly influential in policy decisions in countries that adopt corporate governance methods. In such a case a conflict arises in the political objectives of left-wing parties when they run the government. Neumayer's (2003) empirical analysis indeed confirms such ambivalence

To sum up, all these studies concur in pointing out those various indicators of the quality of governance, of the pervasiveness of interest groups, of the type of institutional system in place, as well as of the ideology of governments are all potentially relevant factors in shaping environmental and energy policies even though none of these studies specifically refers to RE. At the same time, all these studies

share three drawbacks. First, they insist on a single type of political economy determinant, i.e., either the quality of governance or political ideology. Second, none of them compares the relative importance of the political drivers of RE deployment with alternative types of conditioning factors, like economic, energy and environmental indicators. Third, although some of these studies exploit panel data, most of them fail to explore the dynamic properties of the estimated relationships, treating them to be either contemporaneous or equilibrium ones.

We try to overcome these shortcomings by:

(a) considering a more comprehensive set of political determinants.

(b) comparing the explanatory power of the political drivers with that of the standard economic, energy and environmental factors.

(c) providing a thorough examination of the dynamic properties of the estimated relationships, checking for their stochastic properties, the significance of different lag structures, trends and time dummies.

2.8.2 Economic Considerations

Although there is extensive literature on the impact of socioeconomic variables on renewable energy (RE), such as the works of Sadorsky (2009a, 2009b), Payne (2012), Salim and Rafiq (2012), Lean and Smyth (2013), Smyth (2013), Apergis and Payne (2015), Marques and Fuinhas (2011), Omri and Nguyen (2014), Omri et al. (2015), and Liu et al. (2019), the role of technological factors in renewable energy production remains underexplored. This gap in the literature justifies the inclusion of additional drivers, such as high technology exports, in the present analysis.

Furthermore, to the best of existing knowledge, this study is the first to compare the impacts of renewable energy driving factors based on development stage. A country's energy mix depends on balancing income levels and environmental considerations, both of which are closely linked to its development stage. This approach enables an examination of how different levels of development influence the effects of RE determinants and confirms discrepancies between two income groups.

Most previous studies indicate that increases in per capita GDP and per capita CO_2 emissions drive per capita renewable energy production in the long run. These studies suggest that per capita GDP positively affects renewable energy production, while the impact of fossil fuel prices and per capita CO_2 emissions can be either positive or

negative. The analysis is conducted at the income group level, following the World Bank Development Indicators classification. Within each group, countries with higher levels of RE production have been selected based on data availability.

2.8.3 Technological Factors

Technology advances reduce costs and increase penetration of renewables in many countries. Ongoing technological innovation is critical for a least-cost transition to modern, efficient, low-carbon energy systems. Energy systems are comprised not only of supply and demand technologies, but of infrastructures that connect them. Enabling technologies help to foster a greater uptake of renewable energy in all sectors. Although, electricity systems are often the focus of discussions about technological change and innovation (Barnsley and Brown 2015). The IEA (2017) has indicated that

There is an important potential convergence of electricity systems with digital and information technologies. Digital infrastructure will be a key enabler to a smarter and more responsive electricity system. However, based on reports of UNCTAD, nontechnological factors, such as the institutional and regulatory environment, are also a crucial part of the technological innovation story. Technologies that share the potential to facilitate and advance the deployment and use of renewable energy include (REN21 and others 2017):

- End-use technologies (e.g., electric vehicles and heat pumps).
- Energy storage (e.g., pumped storage; home, commercial or grid-scale batteries; thermal storage).
- Demand-side energy management technologies (e.g., energy management systems in buildings; interruptible industrial load).
- Energy supply and delivery management technologies (e.g., advanced distribution network management and systems control options).

None of these technology groups has been developed for the specific purpose of facilitating wider deployment of renewable energy, but these technologies present significant opportunities to bring additional benefits by creating new markets for renewable energy in buildings, industry, and transport. For example, electrification of vehicles not only reduces local air pollution, but also allows for rapidly growing renewable power technologies to displace fossil fuels in a sector where renewables other than biofuels previously were barred from entry. Air quality is enhanced further,

along with other benefits of expanded renewable's deployment. Overall, enabling technologies comprise both the physical infrastructure and the automation technology required to support, for example, greater systems integration, data collection and dissemination of system resources, and effective and efficient demand response. This can enhance the function and efficiency of energy systems and thereby facilitate greater deployment and use of renewable energy (REN21 and others 2017).

It is widely believed that technological progress in any nation is paramount if renewable energy use is to be promoted and implemented. Improved technologies are vital for the process of generating renewable energy, which may result in less external cost and thus less environmental pollution (Alam and Murad 2020). An analysis by Alam and Murad (Alam and Murad 2020) reveals that technological progress significantly influences renewable energy use over the long term in OECD countries. Since most OECD countries are in fact high income, enjoy a high level of technological progress and deeply involved in international trade, their access to and utilization of improved technological resources for generating renewable energy are relatively easier than any other nations. Studies also argued that technological progress is crucial for improving energy efficiency (Fisher-Vanden et al. 2004; Hang and Tu 2007; Zhou, Levine, and Price 2010). That said, technological progress is crucial for achieving energy efficiency, which in turn promotes the use of renewable energy. Irandoust (Irandoust 2016) examined the relationship between renewable energy consumption, technological innovation, economic growth, and CO2 emissions in the four Nordic countries (Denmark, Finland, Norway, and Sweden) for the period 1975 - 2012. The results show unidirectional causality running from technological innovation to renewable energy.

2.8.4 Social and Behavioural Factors

The successful implementation of RE is dependent not only on energy and economic policies and strategies, technical and infrastructure factors, but also on social factors such as the dissemination of information and social acceptance. Numerous non-technical barriers can block the deployment of technically sound and cost-effective technologies, including lack of information, consumer indifference and lack of immediate benefit (Barnsley and Brown 2015). In a study published in 2013, Viardot (Viardot 2013) identifies several possible constraints to renewable energy use which includes technological constraints, physical constraints, financial and legal constraints and finally ontological and social constraints. Involvement of local committees and

NGOs for RE deployment is particularly important for garnering societal acceptance and usage of technologies that are perceived as new and unfamiliar (Barnsley and Brown 2015). Training and Human capacity building is also required for largescale production of RE. Setting up a network for specialized capacity in the energy sector is critical, especially for design, operation and management of continually advancing technologies (Barnsley and Brown 2015). The lack of data on social factors makes it almost impossible to appraise the impact of it on RE production.

2.8.5 Environmental Factors

2.8.5.1 CO2 emission and renewable energy

Carbon dioxide, chlorofluorocarbons, methane, nitric acid, and ozone are greenhouse gases associated with climate change. These gases play a major role in environmental degradation. Carbon dioxide emissions per capita are used as an indicator of environmental factors, as CO_2 is the most common greenhouse gas and has been subject to significant policy pressure, leading to several political measures and regulatory guidelines (Marques & Fuinhas, 2011).

Global energy demand is projected to expand by 30% between 2016 and 2040 (Outlook, 2015). This increase in energy consumption is accompanied by rising CO_2 emissions and growing concerns over global warming. The development of energy systems has historically been, and will continue to be, significantly influenced by environmental considerations. Any serious effort to mitigate global warming and environmental degradation must prioritize the decarbonization of the global energy system. There is no singular approach to achieving this goal, but a critical step involves reducing dependence on fossil fuels, which is expected to lead to an increase in renewable energy production. Identifying how renewable energy consumption relates to CO2 emissions is a debatable issue. On the one hand, higher CO2 per capita worsening the environmental conditions, exert political pressure to develop cleaner energy and thus creates demand for a cleaner environment and encourages usage of renewable energy, as emphasized in Omri and Nguyen (Omri and Nguyen 2014) and Nguyen and Kakinaki (Nguyen and Kakinaka 2019), thus a positive relation between renewable energy production and CO2 emission is expected. On the other hand, the prevalence of renewable energy with green technology mitigates environmental problems of carbon emissions, which implies the negative association of renewable energy consumption

and CO2 emissions. These two effects have been reported in the literature (e.g. Sadorsky (Sadorsky 2009b), Marques and Fuinhas (Marques and Fuinhas 2011), and Nguyen and Kakinaki (Nguyen and Kakinaka 2019). If the second effect prevails, then a negative impact is observed. Given the argument that renewable energy and the adoption of green technology tend to be more emphasized and prevalent in advanced countries, the negative relationship dominates the positive relationship in high-income countries, but it is dominated by the positive relationship in less developed countries (Nguyen and Kakinaka 2019). A policy framework that inclusively addresses issues like air quality issues, acid rain, global warming and climate change with local, regional, national and international solutions in the energy sector and environmental conditions will impact developed and developing countries alike. Several studies have examined the effect of pollutant emissions on renewable energy consumption (e.g. Sadorsky (Sadorsky 2009b), Salim and Rafiq (Salim and Rafiq 2012), Omri et al. (Omri et al. 2015)). Most of these studies show a positive impact of CO2 emissions on renewable energy consumption. For example, Sadorsky (Sadorsky 2009b) investigates the determinants of renewable energy for the G7 countries and shows that increases in per capita CO2 emissions are a major force to drive per capita renewable energy consumption in the long run. By considering six major emerging countries, Salim and Rafiq (Salim and Rafiq 2012) find evidence of a short-run bidirectional casual relation between CO2 emissions and renewable consumption.

Apergis and Payne (Apergis and Payne 2015) investigate causal dynamics associated with renewable energy consumption per capita for a panel of 11 South American countries over the period 1980 to 2010. They find that in the short run, an increase in carbon dioxide emissions per capita increases renewable energy consumption per capita while an increase in renewable energy consumption per capita reduces carbon dioxide emissions per capita. Nguyen and kakinaki (Nguyen and Kakinaka 2019) examine the relationship between renewable energy consumption and carbon emissions associated with the development stage by applying a panel cointegration analysis to 107 countries during the period from 1990 to 2013. The analysis shows the clear differences between the groups of low-, middle-, and high-income countries. Renewable energy consumption is negatively associated with carbon emissions for high-income countries and middle-income countries, while the relationship is opposite for low-income countries. Omri and Nguyen (Omri and Nguyen 2014) apply dynamic panel data analysis to identify determinants of renewable energy consumption in 64 countries

during the period of 1990 - 2011 and reveal that CO_2 emissions are an important factor to promote renewable energy demand, while oil price has a negative impact only in middle income countries. Irandoust (Irandoust 2016) finds a unidirectional causality running from renewable energy to CO_2 emissions for Denmark and Finland and a bidirectional causality between these variables for Sweden and Norway.

2.9 Challenges of Renewable Energy Adoption

The implementation of renewable energy projects faces numerous barriers that hinder their development and employment. In Iran, a mixed-method approach identified 13 main barriers, including economic and financial issues, lack of public awareness and education, and inadequate policies and regulations (Oryani, et al., 2021). The country's political and economic situation, such as limited access to international financing due to economic sanctions, further complicates the implementation of renewable energy projects. To address these barriers, stakeholders, including policymakers, researchers, and private sector actors, need to collaborate and design effective strategies that promote renewable energy in Iran.

In India, the barriers to renewable energy growth were identified and prioritized using the Modified Delphi and Analytic Hierarchy Process methods (Pathak, et al., 2022). The study identified 20 significant barriers, including lack of government support, high capital costs, and inadequate infrastructure. To overcome these barriers, policymakers and stakeholders should focus on targeted policy interventions, such as financial incentives and regulatory frameworks, to promote sustainable energy growth in India. By addressing these barriers, India can create an enabling environment for renewable energy development.

Political and regulatory barriers were identified as significant hurdles to renewable energy adoption, with corruption and nepotism being critical sub-barriers (Asante, et al., 2020). However, potential solutions were proposed, such as implementing renewable energy standards, grid connection quotas, and simplifying certification procedures. The study recommended a bottom-up approach for inclusive and sustainable renewable energy policy formulation. By addressing the political and regulatory barriers, countries can create a conducive environment for renewable energy adoption and ensure its long-term sustainability.

In Africa, the success of renewable energy has been limited by various barriers, including a poor institutional framework and infrastructure, high initial capital costs, weak dissemination strategies, lack of skilled manpower, poor baseline information, and weak maintenance services (Ouedraogo, et al., 2019). Bridging the financing gap and overcoming these barriers requires renewed efforts in current approaches, as well as the exploration of new approaches. Africa needs to focus on strengthening its institutional framework, enhancing knowledge transfer, and attracting investment to unlock the full potential of renewable energy.

Within the European Union, collective renewable energy prosumers face significant regulatory challenges in 10 countries (Inês, et al., 2020). Difficulties in legally setting up renewable energy communities and a lack of incentives for joint projects hinder the growth of collective renewable energy initiatives. However, some countries like France, Germany, the Netherlands, and the United Kingdom have more favorable regulatory frameworks. Policymakers should consider implementing more supportive regulations to encourage the development of collective renewable energy prosumers throughout the EU.

The above discussions provide overview of some of the common barriers to renewable energy adoption, including:

- Variability of resources: Renewable energy resources, such as wind and solar, are variable and intermittent, which can make it difficult to integrate them into the grid and ensure a stable supply of electricity.
- High upfront costs: The initial investment required to install renewable energy systems can be high, which can make it difficult for individuals or organizations to adopt them.
- Lack of awareness: Many people may not be aware of the benefits of renewable energy or may not understand how to use it effectively.
- Grid availability: In some areas, the grid infrastructure may not be sufficient to support the integration of renewable energy systems.
- Government policies: Government policies can either support or hinder the adoption of renewable energy, depending on factors such as subsidies, tax incentives, and regulations.
- Institutional support: The lack of institutional support, such as financing

mechanisms or technical assistance, can also be a barrier to renewable energy adoption.

- Social acceptance: The social acceptance of renewable energy solutions can also be a barrier, as some people may be resistant to change or may not see the value in adopting new technologies.

In conclusion, barriers to renewable energy penetration and development are multifaceted and vary across different contexts. Economic and financial issues, lack of public awareness, inadequate policies and regulations, and political and regulatory hurdles are commonly identified barriers. However, potential solutions and strategies exist, including targeted policy interventions, simplified procedures, and supportive regulatory frameworks. By addressing these barriers, stakeholders and policymakers can create an enabling environment that promotes renewable energy adoption and development, ultimately contributing to a sustainable and clean energy future.

2.9.1 Challenges of Renewable Energy Adoption in Nigeria

The following provide some insights into the barriers to renewable energy adoption in Nigeria. Some of the key barriers include:

- High Initial Costs
- Policy and Regulatory Barriers
- Limited Grid Integration
- Fossil Fuel Industry Resistance
- Lack of Awareness and Education

1) Lack of institutional support: According to (Igirigi, 2019), the lack of institutional support, such as financing mechanisms or technical assistance, is a major barrier to renewable energy adoption in Nigeria. This can make it difficult for individuals or organizations to access the resources they need to invest in renewable energy solutions.

2) Grid availability: Igirigi (2019) notes that the grid infrastructure in Nigeria may not be sufficient to support the integration of renewable energy systems. This can make it difficult to connect renewable energy systems to the grid and ensure a stable supply of electricity.

3) High upfront costs also note that the initial investment required to install renewable energy systems can be high, which can make it difficult for individuals or

organizations to adopt them.

4) Lack of clear plans: According to (Igirigi, 2019), there is a lack of clear plans to address the issue of efficiently matching supply and demand from renewable energy systems in Nigeria. This can make it difficult to integrate renewable energy into the grid and ensure a stable supply of electricity.
5) Fuel for domestic cooking: Igirigi, (2019) notes that the sources of fuel for domestic cooking in low-income rural communities in Nigeria are largely cantered on firewood, charcoal, and kerosene, each of which are associated with health hazards and CO2 pollution. This can make it difficult to shift to cleaner and more sustainable energy sources for cooking.
6) Government policies: Igirigi (2019) notes that government policies can either support or hinder the adoption of renewable energy in Nigeria. The lack of supportive policies, such as subsidies or tax incentives, can be a barrier to renewable energy adoption. It is important to note that these barriers can interact with each other and with the drivers of renewable energy development. Addressing these barriers will require a coordinated effort from various stakeholders, including government, private sector, and civil society organizations.

2.10 Why Renewable Energy Projects Fail

Public projects in SSA countries generally come with high expectations and a lot of hype (Borup et al. 2006). With regards to expectations, public RE projects are often designed to provide solutions to problems that confront the public. Thus, the initiation of numerous RE projects comes with expectations to provide people with access to electricity to power their homes, hospitals, streetlights and other energy-dependent facilities. In most cases, these expectations are shared by both the implementing agencies (government) and beneficiaries (people). On the other hand, hype often follows these expectations. In SSA, the media is very quick to disseminate information on public RE projects. Also, politicians, administrators and other bureaucrats involved in public RE projects are interested in claiming credit for initiating the projects. These levels of hype and expectation are not peculiar to SSA countries but common to countries around the world (Borup et al. 2006; Ruef and Markard 2010; Verbong, Geels, and Raven 2008). However, the experiences and performance of RE projects after the hype and expectation differ from country to country. Within SSA countries, we identify five basic kinds of RE project failures:

- Shelved RE projects.
- Stalled RE projects.
- Appropriate RE projects.
- Malfunctioning RE projects; and
- Nonfunctioning RE projects.

The shelved projects are those that have been planned but not implemented. Some RE projects are painstakingly planned and intensely hyped but never get implemented. An example is the so-called largest solar project in Africa to be implemented in Ghana (Energy 2015) which, until now, is still yet to take off, if not already abandoned.

There are also those projects (stalled projects) which although take-off, get stalled and never reach completion. For these kinds of failed projects, implementation is incomplete.

Furthermore, some RE projects get appropriated (appropriated projects) in such a way that their implementation succeeds but deviates from the original plans and intents. Most appropriate projects come by due to imminent threats of failure that planned projects experience. Hence, they usually take on a scale smaller than the original project. Other appropriate projects may result from lack of appropriate technology for original projects.

Malfunctioning projects are those projects that have already been implemented but are defective. This may result from either technical or non-technical factors. RE projects may malfunction due to technical breakdowns or due to turbulent socio-economic circumstances in their context that affect their proper functioning. Malfunctioning projects are those that are not completely broken but only function on irregular basis.

Finally, nonfunctioning projects are broken down and cease to be of any use. This is rather common in SSA countries. For example, it is not uncommon to see solar systems installed but not functioning (Anon n.d.-b; Sebitosi and Pillay 2007). Reasons for failure of RE projects in SSA are diverse. In addition, a multitude of factors can combine to result in a project's failure. Nevertheless, many of the causes of RE project failures lie in project management processes and practices. Different challenges emerge at different stages of the project management process that contribute to RE project failures.

2.10.1 Renewable Energy Project Failure in Developing Countries and in Nigeria

In this section, we present an in-depth analysis associated with understanding why RE projects fail in Sub-Saharan Africa. Foremost, we begin by highlighting in Fig. 1 the focus on the failures of these projects and their interconnection with the participating stakeholders that have been presented in existing studies and actual projects (Ikejemba et al. 2017). In Figure 2.1, the interconnection between stakeholders (financing government, implementing organization, public) and the issues connected to each of them has been indicated. With the government awarding the project, one issue that affects the overall management of an RE project is the specific political agenda that the government harbours. This affects the process by which the project is awarded to the implementing organization and as such the issues of planning, implementation and maintenance are not clearly defined and enforced. This results in an unsustainable implemented project that creates negative mannerism towards the adoption and acceptance of renewable energy projects by the public. In addition, this affects the relationship between the implementing organization and the local communities. The following sections discuss the issues in-depth and subsequently provide solutions to the problems and the interconnections.

2.10.1.1 Political agenda

We cannot rule politics out of public RE projects in SSA countries. Political influence is pervasive in projects and usually translates into authority and decision-making power embodied in public sector officials (Mbachu and Nkado 2007). Conflicts of interest are common in RE projects where political interests are not synchronous with project goals. We deduced political agenda to have both constructive and destructive effects on potential projects. Constructive political agenda prompted attempts to establish efficient management systems, mobilize and allocate resources for successful implementation of projects. Nonetheless, some politicians exploit public RE projects to attain or further their political goals which, in most cases, are divergent and contradict project goals (Ika 2012). Obviously, this modus operandi negatively affects the sustainable implementation of RE projects in SSA. Some project managers we interviewed expressed that "to some politicians, RE projects are nothing more than symbols of their efforts to 'bring development

to the doorstep of the people'". This expression underscores the symbolic importance of RE projects. Most politicians in SSA bear the perception that RE projects must demonstrate their party's fulfilment of campaign promises or support their pleas to beneficiaries for re-election. For this reason, the significance of a public RE project transcends its basic functions such as lighting streets, powering homes, hospitals, and schools. Because RE projects possess more symbolic importance than functional importance to politicians in SSA, less importance is given to proper implementation. The projects are only as good as they help them to convince voters and win elections. Majority of the project managers agree that politicians are a major distraction to their professional practice. "They pointed out the existence of substantial political wrangling and cynicism in most RE projects". Analogous to the proverb "when two elephants fight, it is the grass that suffers", different political parties (elephants) with opposing interests, openly (or clandestinely) use public projects (grass) to get at their opponents. According to some managers e "it is not always the success of the project which matters to politicians. Instead, they seek conditions of projects (successful or failed) which corroborate their own competence and/or the incompetence of their opponents". These responses from dialogues inform us that the combination of political agenda with RE projects may initially suggest a win-win situation which leads to mutual benefits between politicians and the public, but such is not the case because of the difference in strategic outlook between public interests and political interests. Whilst the public is interested in projects that solve their energy and energy-related problems in a long-term manner, politicians are interested in enticing the public to elect them. Thus, the influential but short-term, exploitative, and divergent political agenda in public RE projects contributes to their failure. In most SSA countries, public projects are implemented not entirely on rational strategic reasons for the so-called greater public good (Devine-Wright 2005). Most of the RE projects found amid many political innuendos, fail.

2.10.1.2 Process of awarding projects

The process of awarding contracts for RE projects links with the influence of politics in public RE projects as discussed above. In some SSA countries, legal procedures have been established to ensure that the awarding of contracts is objective, transparent and free of nepotism or favouritism. For example, Ghana has

a functioning Public Procurement Process where legal tenders for government projects are advertised through mass media. The public procurement practices are expected to be anonymous, and contracts awarded meritoriously. Despite the existence of a compressive procurement process, corruption still occurs (Osei-Tutu, Badu, and Owusu-Manu 2010).

In Nigeria, several project developers indicated that "the awarding of contracts is not meritorious or based on competence and ability to carry out the project. Instead, it is based on personal ties." Further analysis was conducted on the process of awarding contracts, outlining the authority structure involved in project disbursement. The diagram below illustrates the flow among parties in the contract awarding process in most of the research areas examined in this study. The figure has been constructed by the authors based on reported fraudulently awarded projects as well as private communications with project developers (Okoduwa, 2011; Okogba, 2021; Salihu, 2012).

The management of projects should be the responsibility of a participating stakeholder. In Nigeria for example, so many small solar projects have been implemented around the country ranging from solar boreholes to thousands of streetlights. Despite the potential of these projects, most of them have been left to deteriorate (Omisore 2011). This situation has created a negative attitude towards the acceptance of sustainable and clean energy usage within the minds of the masses, making it difficult for developing governments to adopt the technology and contribute to the slow implementation of projects.

2.10.1.3 Stakeholder co-operation

We identified three major stakeholders in public RE projects in SSA: government, project developers and the public herewith known as the beneficiaries. The amount of political wrangling, nepotism, and opacity in the awarding of public contracts affects the level of trust that the stakeholders involved in RE projects share among one another (Muriithi and Crawford 2003). Research has shown that the management of public sector projects falls short of efficiency which links with inefficient project governance methods (Ika 2012; Patanakul et al. 2016). Stakeholder participation is considered an important part of implementing and governing projects. Hence, Public-Private Partnership (PPP) implementation

strategies are often preferred, especially in developed countries (Alvial-Palavicino et al. 2011). Further dialogues show that most public projects in SSA are neither jointly owned nor under the management of properly co-opted PPP management bodies. Rather, ownership is contested among stakeholders in some projects and outright denied by stakeholders in others. For example, in some projects we ethnographically observed, it was not clear which stakeholder(s) owned and had direct responsibility over the projects. Some project developers attributed this occurrence to the application of generic implementation models from the top government level which pays little or no attention to peculiarities in the project implementation areas. Furthermore, some project managers stated e "We see a lot of potential in stakeholder cooperation. At best, cooperation makes everyone responsible and brings all hands-on board which can facilitate project performance. However, cooperation exists in principle but not in practice". The shadiness in distribution of responsibility among stakeholders makes it difficult to determine whether they consider their engagement a privilege or burden. We observed that success or failure of a project is the simple yardstick for determining the competence or incompetence of project managers. This is problematic because it excludes other stakeholders. Consequently, most stakeholders are insulated from any direct responsibility for failure. This is unlike private RE projects where all stakeholders have much to lose or gain.

2.10.1.4 Planning/implementation

Amongst other reasons for the failure of RE projects in Sub-Saharan Africa is the planning of the project and its implementation. It is difficult to measure the actual time the implementing organizations spend on creating an effective plan but based on the nature of the failed projects and private discussions with project implementers, it is effortless to assume that an ineffective and an inadequate plan was executed as also indicated in the paper by Ikejemba et al. (Ikejemba et al. 2017). Burke et al. (Burke et al. 2001) investigate the success and failures of implementing new systems based on human behaviour. They indicate that the success of any implementation project has little to no attribution to technology. Thus, this indicates that the failures of RE projects are more attributed to the inability of all stakeholders. It is important to make sure that approval is received from all participating stakeholders, distinctively defining the roles of all parties involved,

knowing how resolutions will be reached in the project and comprehending how expected outcomes will affect the success of the project. Whilst the potential definition of project success is based on, for example, patronage, economic spin-off, public acceptance and appreciation, most literature bases large projects' success on time and cost aspects (Shenhar et al. 2001).

This differs when the focus is on RE projects in Sub-Saharan Africa because the success of a project is based on its ability to deliver the expected outcome. If this is not achieved, it simultaneously affects the maintenance of the projects and further deteriorates which causes a negative surge within the public perception of accepting the technology and projects associated with it. An example of implementation failure can be drawn from the project implemented in Lagos; Nigeria (Omisore 2011) also considered in this study. Its failure is attributed to the planning and implementation and follow-up maintenance on the system. Thus, we propose that projects that are being implemented should possess a clear definition of ownership of the project and the entity responsible for the project maintenance. Solutions towards the issue analysed are presented under proposed solutions in Section 4.

2.10.1.5 Maintenance

One other determined reason for the failures of renewable energy projects in Sub-Saharan Africa is the maintenance of the projects after their implementation (Alvial-Palavicino et al. 2011; Ikejemba et al. 2017). This is a problem that is attributed to the overall planning and implementation of the project. A compelling correlation must exist between physical maintenance and the stakeholder implementing the maintenance. However, in the projects analysed in this study neither was a maintenance plan available nor was maintenance carried out on most of the implemented projects, making it effortless for the projects to deteriorate. Maintaining renewable energy projects entails mainly the inspection, the cleaning, and the performance monitoring of the whole system. Of all the projects inspected no monitoring systems were installed. This includes the recently implemented projects. Thus, stipulating the fact that even the new projects may be doomed to fail soon. Nevertheless, this is just one of the reasons under the aspect of maintenance that results in failure of renewable energy projects in Sub-Saharan Africa. "The principal reason for failure under maintenance is the selection of incompetent organizations to implement, manage and maintain renewable energy projects" e

Participating in project developer. Findings from direct interactions with the local community and implementing organizations indicate that there is no clear distinction regarding responsibility for system maintenance. This whole situation traces back to the starting point on how organizations are selected, and the projects awarded. Further dialogues with project developers indicated that e "the designation of responsibilities towards maintenance is said to stem from financial government as this is not discussed prior to the implementation of the project and is not included in budget for the project".

2.10.1.6 Public acceptance and inclusion

Another important finding from existing articles (Ikejemba et al. 2017) and further analysis on the reasons why solar projects fail in Sub-Saharan Africa is the absence of public acceptance and the non-inclusion of the public as stakeholders within the overall project. The public acceptance of renewable energy technologies is convincingly correlated to the inclusion of the corresponding community in implementing renewable energy projects. Practical ideas exist on how local communities should be involved in the implementation of renewable energy projects (Alvial-Palavicino et al. 2011). However, it is arduous to comprehend why these recommendations have not been taken into consideration prior to the implementation of the projects analysed in this study and other implemented projects. Engaging with the locals in one of the villages where a solar borehole water system was implemented indicated that, although the villagers were used as labourers towards the implementation of the project, immediately after the implementation of the project, no real dialogue was executed between the project developers and the local community.

Public acceptance of renewable energy projects in Sub-Saharan Africa is low compared to other parts of the world (Deichmann et al. 2011). This can be attributed to multiple issues such as:

(i) The financing government failing to firmly accept the technology and shortcoming in the aspect of awareness creation towards its adoption and implementation,

(ii) The high level of ignorance amongst the people with respect to RE and finally

(iii) The failure of the implementing organization to unerringly include the local community through a combination of training and resource provision (Ikejemba et al. 2017).

If the local community does not accept the technology or is not included as stakeholder in the implemented projects, the sustainability of such projects is at towering risk. When projects experience problems or unplanned downtime, the locals aren't equipped with the necessary skills and thus are unable to address the problems. Now that we have discussed the key causes of failure, we are investigating in the next section how to achieve adequate sustainable management of renewable energy projects in SSA.

2.10.1.7 The Structural and Infrastructural Reasons for Failure

In a study on the major reason for failure of most solar street lighting projects in Nigeria (Asiegbu 2012), it was indicated that most of these projects fail due to system sizing whereby the output of the panels fails to match the battery size for effective charging, therefore causing the battery to deteriorate within a couple of months. In some cases, the opposite was recorded, where the load of the batteries was higher than their output capacity. It is evidently clear from the dialogue that most of the implementing organizations studied in this report are mainly focused on the profit of the business and in turn lose sight of the sustainability of the system and its effect on the future generation to adopt the technology.

2.11 Renewable Energy Project Management

2.11.1 Project Conceptualisation and Design

The World Bank reckons that energy poverty affects over 840 million people globally (World Bank 2019). Estimation further indicates that over 2.7 billion people worldwide do lack access to clean cooking energy alone with many of these people residing in developing countries. In Africa, over 573 million people presently live without access to electricity which constitutes approximately 80% of the entire continent's population (World Bank 2019). The inadequate supply and access to clean and sustainable energy have not only stifled the continent's economic growth or intensified health risks but also resulted in an over-reliance on the forest for fuelwood. The latter contributes to others environmental challenges as most of the populace relies on biomass to meet energy needs (Hafner et al. 2018).

2.11.2 Project Feasibility Assessment

In Africa, energy demand moved from 91 TW-hours in 2010 to 163 in 2020 and is projected to reach 463 TW-hours by 2040 (IRENA, 2021). The concern with this projection is that the Africa's contribution to greenhouse gas emissions is likely to rise because the usage of unclean fuel is widespread across continent (Antwi and Ley 2021; Ehimen et al. 2023). One of the strategies policymakers in Africa can employ to address this situation is the adoption of RE sources that most often on its part necessitate huge investments for their proper functioning. Successful financing of innovation in RE requires a better understanding of the relationship between different types of finance and their willingness to invest in RE (IRENA 2022). In this respect, global renewable energy investment reached USD 322 billion in 2018 and is expected to reach USD 800 billion by 2050. Between 2013 and 2018, public sector financing represented only 14% of the total financing while the private sector took responsibility of the highest chunk of finance. On the global investment in renewable energy, while on average, countries in East Asia and Pacific attracted on average 32% of renewable energy investments between 2013 and 2018, those in Central Asia, Eastern Europe, Latin America and the Caribbean, Middle East and North Africa, South Asia, and Sub- Saharan Africa attracted only 15% (i.e., USD 45 billion) in the same period (IRENA, 2020). These disparities across differences in finance in renewable energy have been mainly due to the sources of finance of each country. Schumpeter (1939) placed finance at the centre of his theory of innovation–a theory that limits itself to banks as the only source of finance. Recent literature has, however, emphasised the role of other sources of financing (Mazzucato and Semieniuk 2018). These could be through the public sector (Mazzucato, 2013), the private sector, or other innovation agencies (Mazzucato and Penna, 2016). Besides, one of the sources of finance that developing countries have continued to benefit from is external financing. External financing comes through aid, foreign direct investments, or remittances. These sources of finance are regrouped under the well-known concept of financial globalization. Globalization has been argued to be a motor of RE diffusion (Kim 2018). According to these authors, globalization spurs economic growth, through knowledge diffusion, innovation, global value chain participation, and infrastructural development (Asongu, Meniago, and Salahodjaev

2022). Globalization is thus, for the most partly linked to increasing industrial productivity as a result and increase in energy demand. This in consequence will increase investments in RE sources to meet up with the extra energy demand. In recent years, economic growth in Africa has mostly been driven by the presence of high foreign capital in the form of foreign direct investments (Poku 2016). According to the World Bank (2020), external financial flows into Africa have been on a steady increase, with foreign investment in renewable energy amounting to US$ 40 billion between 2003 and 2019. In this growth of FDI, Italy invested most in the renewable energy sector with the value of its investment in the sector between 2003 and 2019 amounting to about US$7900 million, followed by France (US$5000 million) and the United Kingdom (US$ 4800 million). In fact, in Sub-Saharan Africa (SSA), FDI in general rose from 6.8578 billion USD in 2000 to US$32.222 billion in 2018. In the same period, workers' remittances witnessed a sharp increase, rising from US$4.801 billion in 2000 right up to US$48.169 Billion in 2018 while official development assistance (ODA) increased from US$13.058 billion to US$50.478 billion. These continued inflows have prompted research on the effect of financial globalization on the economy in Africa.

2.11.3 Implementation

Notwithstanding, one of the distinctive approaches amongst the numerous alternatives and strategies considered to electrify the continent of Africa is the greater use of renewable energies due to their multiple benefits and availability on the continent (IRENA 2022). Renewable energy adaptation as enshrined in the Sustainable Development Goal (SDG) 7, has the propensity to help achieve several other SDGs. This includes quality education, poverty alleviation, good health, sustainable cities and communities, water security, responsible consumption and production, and decent job creation. The impact of renewable energy on climate change adaptation, gender mainstreaming and sustainable growth and development are also innumerable (UN Energy 2022a). Case studies from developing countries like Pakistan, Nepal, India and Kenya, shows that renewable energy sources are already helping small villages, homes and businesses to access electricity for income-generating activities, culminating into improved socio-economic living standards of the users (Arif Hasan 2023). It will, however, require an annual investment of about $45billion to $49billion to reach universal access by 2030 in sub-Saharan Africa alone (Nicolas, Samson, and Rozenberg 2019). Although this investment is likely to change considering the impact of the

COVID-19 pandemic on the global economic outlook (IEA 2020), within the framework of the African Union Agenda 2063, there is a sheer commitment through various programmes and projects to provide efficient, modern and reliable cost-effective renewable energy sources for domestic and commercial use. The African Development Bank's New Deal on Energy for Africa (NDEA), and Sustainable Energy Fund for Africa (SEFA), amongst others, for example, all seek to help African countries achieve universal energy access to energy through the latest off-grid and technological solutions (IEA 2023). Notwithstanding these flagship initiatives and policies, energy access and penetration remain woefully inadequate on the continent. In Niger, for instance, energy access rate stands at 12.93% despite many governmental and non-governmental policies and interventions to bridge the wide energy access gap in the country. Inadequate access to finance, standards and quality assurance, technical and technological barriers and limited policy interventions are amongst numerous concerns raised by stakeholders in Niger and across many parts of Africa as impeding energy access (Brew-Hammond 2010; Chaurey et al. 2012; Ehimen et al. 2023; Hafner et al. 2018). Studies also indicate that approaches in initiating energy projects and technology transfer, especially in rural areas of Africa, are fraught with improper engagement and holistic stakeholder consultations (UN 2011a). There is also the perception that the diffusion of technologies from developed countries to developing countries, for example, is done with limited evaluation on its impact on the host country or community (Pueyo et al. 2012). Bel and Joseph (Bel and Joseph 2018) and Pueyo et al. (Pueyo et al. 2012) allude to the fact that there is a usual lack of social, cultural and institutional consideration in innovation and technology transfer of which the energy sector is not immune. Notably, most state-led, finance-driven models of technology deployment which prescribe cost and support for alternative energies have proven to carry a high tendency for failure due to inadequate local-based involvement, participation and acceptance in the project life cycle process (Newell and Bulkeley 2017). For many, a renewable energy project in Africa is about finding empty land and fixing solar panels to provide light for the people because they lack electricity (Ikejemba et al. 2017).

2.11.4 Maintenance and Management

The proposed solutions are derived from comprehensive virtual analysis, interviews with stakeholders, existing literature, and practical experiences in Sub-Saharan Africa

(SSA). These solutions are designed to address the issues raised above in a manner that allows for adoption by project managers, government agencies, and private organizations involved in renewable energy (RE) projects in SSA. The proposed solutions are presented and discussed under the following key themes: Transparency, Ownership, Shared Responsibility, and Community Involvement.

2.11.5 Transparency

Transparency is a critical aspect of projects in general (Zhang 2005), and renewable energy. Transparency is not merely the absence of opacity, but also the active pursuit of clarity in how public projects are designed and implemented. In our recommendation, the requirements for attaining transparency in public projects are captured in the following points:

- Defragmenting administrative and bureaucratic procedures in public projects
- Implementing checks and balances in stakeholder relationships
- Prioritizing public interests over other interests

Defragmenting administrative and bureaucratic procedures in public projects is important to ensure that projects are planned and implemented sustainably. The bias of current research on RE projects has been identified, where researchers tend to focus on technical aspects of projects while neglecting administrative aspects (Polatidis and Haralambopoulos 2007). It is observed that most RE project managers have a blind side when it comes to the administrative processes that lead to the initiation of the projects they manage. Based on dialogues, findings indicate that in most SSA countries, project managers are outsiders to how public projects are assigned because they are involved mainly at the implementation stage rather than at the planning stage of projects. In some countries, the process of awarding contracts is fragmented and involves the participation of different government bodies. The involvement of these different bodies is not particularly problematic because it offers the platform for applying checks and balances on one another. However, the overlap of the roles of bodies involved in the awarding of contracts inclines them towards compromising standard procedures. We recommend that relationships be streamlined and clearly delineated to avoid overlapping and, thereby, promote transparency. In addition, it is important that checks and control should be conducted on these bodies or organizations participating in promoting

transparency in awarding renewable energy projects in Sub-Saharan Africa, to avoid any sort of corruption or nepotism.

This should, however, be done in a seamless manner to avoid any unwanted bureaucratic situation, that could potentially lead to loss of time and unwarranted discussions that in turn lead to projects not being implemented or delayed unnecessarily. Enforcing checks and balances is a crucial mechanism for promoting transparency in most democratic processes. Similarly, checks and balances in public RE projects are necessary to ensure transparency. In most SSA countries, checks and balances are unidirectional, occurring from top to bottom. This allows higher level officials to monitor and control the actions of their subordinates without the opportunity for subordinates to monitor and control the acts of superiors. Here, we propose that a bi-directional or multi-directional approach be adopted to allow people from the bottom to be able to hold top-level officials responsible. In this way, the interests of the public stakeholders are highly considered. Moreover, the interests of the locals are guaranteed to be considered since they are participating as stakeholders. The focus should be on the established goals of public projects and, accordingly, prioritize public interests over private, political or financial interests.

2.11.6 Ownership

Ownership is deemed a critically important component of factors that facilitate project success, as several other researchers have also noted (Brent and Kruger 2009; Urmee, Harries, and Schlapfer 2009; Wüstenhagen, Wolsink, and Bürer 2007). However, findings indicate a lack of clarity regarding the degree to which stakeholders have authorized ownership of most RE projects. For example, in a particular project, perspectives on ownership may range from shared ownership to government ownership or public ownership. It is even more common for stakeholders to deny ownership in the event of a malfunctioning project to evade responsibility for maintenance. In recognition of this challenge, the following recommendation is proposed to contribute to assigning ownership and, in effect, responsibility for public renewable energy projects:

Disambiguate ownership of public renewable energy projects at the project design stage: A common trend among the projects in Sub-Saharan African countries assessed is ambiguity regarding the ownership of public projects. Consequently, we recommend

that every public project should actively pursue the disambiguation of ownership of public projects. To this end, the question "who owns this public renewable energy project?" merits a clear answer. If ownership is established from the point a project is conceived, it will translate into a clear idea of designation of responsibilities during implementation and management. Some researchers and practitioners advocate the importance of community ownership and the role of community engagement (Alvial-Palavicino et al. 2011). However, community ownership comes with limitations. Projects locally owned cannot withstand the rigors of infighting and in some cases sabotage. This is evident in some of the cases we studied and cited in some of the reports. As such, we recommend that the body responsible for implementing the project e which in most public projects is the government itself e should own the project. Where ownership is shared, the ownership should be clearly communicated to other stakeholders. For public RE projects in Sub-Saharan African countries, we recommend that the project developers take ownership of the projects and thereby secure the responsibility over the functioning of the project.

However, it is important that next to the institutional transparency discussed, process transparency in awarding projects is enforced. In that way government bodies can enforce rules that implementing organizations must adhere to and accept responsibility of any drawback that may arise towards the ownership and or failure of the project. If transparency is negatively influenced, difficulty would arise in the enforcement of rules towards the sustainable management of the corresponding renewable energy projects. Therefore, clear project ownership functions only if transparency is considered.

2.11.7 Shared responsibility

In practice, all public projects involve multiple stakeholders (Alvial-Palavicino et al. 2011; Asiegbu 2012; Chaurey et al. 2012). Common interests unite these stakeholders. We mentioned the need to provide and improve the public services as a common reason for the implementation of most public RE projects in SSA.

The different stakeholders should therefore share the responsibility of promoting sustainable management of public projects for the public good. Here, we present three key factors to consider in ensuring that this shared responsibility is realized:

- Establish and maintain communication amongst stakeholders
- Collectively ensure that project infrastructure is safe and protected

- Monitor and ensure effective project management

It is essential that stakeholders share the responsibility for establishing and maintaining good communication in public renewable energy projects in Sub-Saharan Africa. This is in response to the observation in the cases of failed projects where communication was either entirely broken or incoherent amongst stakeholders. In some projects, communication deteriorated with the progression of time whilst in other failed projects, the public beneficiaries were hit with obstacles in efforts to communicate problems to government representatives. We recommend that channels for communication should be constantly refreshed, which would result in an efficient problem-solving process. Maintaining a good communication line also contributes to hedging administrative and bureaucratic processes of bottlenecks. Protecting project infrastructure is a key recommendation in this paper.

Public renewable energy projects are huge investment projects, and it is appalling to learn about vandalism, intentional damage and sabotage of these projects in some Sub-Saharan African countries. This suggests negligence of the public in ensuring the physical safety and protection of renewable energy projects. When the public and other stakeholders do not actively ensure that the infrastructure is protected, all other efforts aimed at ensuring sustainability are pointless. It is imperative that the public should have the responsibility to protect the infrastructures. A great sense of ownership must be felt by the benefiting recipients. All the recommendations discussed so far culminate into "responsible project management" (RPM). In this scenario, RPM requires that all stakeholders act in the interest of maintaining renewable energy projects instead of destroying them or allowing them to fail. It indicates that the active involvement of all project stakeholders is only beneficial to sustaining projects. Hence, we propose that stakeholders involved in public renewable energy projects be responsible towards the implemented or planned project and contribute to its management for sustainability. RPM integrates the essentials of sustainable project management and requires that all stakeholders act in the interest of maintaining RE projects instead of destroying them. It is important that the implementing organization accepts responsibility towards the management of shared responsibilities of the corresponding renewable energy project being implemented. In addition, the implementing government should endeavour to create awareness on the acceptance and dissemination of the technology to the local communities.

2.11.8 Community involvement

One of the potential solutions to the failures and unsustainable management of renewable energy projects in Sub-Saharan Africa is the involvement of the corresponding local community. Several studies (Alvial-Palavicino et al. 2011; Rogers et al. 2008; Terrapon-Pfaff et al. 2014; Walker 2008; Walker et al. 2010) have discussed the importance of involving the local community as stakeholders in renewable energy projects. However, this has both benefits and drawbacks (Schnitzer et al. 2014). Several case studies were presented that indicated the success of community involvement. Nevertheless, in some cases the sharing of responsibilities resulted in operational inefficiencies and sometimes the community members were uncooperative. However, other projects were sustainable, and success soared through the prioritization of planning, training and community-building from the commencement of the project. Building trust between all stakeholders involved in the project is the most important aspect of involving the local community in a potentially successful project. A study has shown that trust is an important element when one aims to achieve change in the implementation of RE projects (Walker et al. 2010). Trust between the implementing organization and local beneficiaries is an element that can assist projects to meet their potential and for the corresponding local community to believe and participate fully as stakeholders in the process of project development. Alvial- Palavicino et al. (Alvial-Palavicino et al. 2011) presents a methodology that involves three different stages that include the building of trust with the local community, construction with the locals and finally, ensuring sustainability of the implemented projects via the engagement of the local community into renewable energy projects. The technique presented is expected to be applicable to rural communities in developing countries, where suppositions about technological relations differ from traditional ones in urban communities. However, a limitation in this is the time required to engage all participating stakeholders, an endeavor that may not be applicable for all types of RE projects and regions in SSA.

2.12 Theoretical Framework

2.13.1 Stakeholder theory of renewable energy adoption

This study employs Stakeholder Theory as its primary theoretical framework for analyzing the adoption of renewable energy in Nigeria (Figure 2.1). The stakeholder theory is a notion of organisational management and business ethics that focuses on issues of morals and values in managing an organisation. It was originally proposed and elaborated by Freeman (1984). It identifies and patterns the groups that are stakeholders of a corporation as well as describes and suggests devices by which corporation's management can accord proper matter to the interests of those groups. In the shareholder view of the firm (the traditional view of the firm in terms of responsibilities), the shareholders or stockholders are the owners of the company, and the firm has an obligatory and primary duty of trust to pursue their interests and needs, to multiply and intensify value for them. The stakeholder theory, however, argues that there are other parties (including governments, political groups, trade associations, communities, financiers, suppliers, employees, and customers) encompassed in the aims and aspirations of the firm (Fassin, 2012). Sometimes even competitors are counted as stakeholders, their eminence resulting from their ability to determine and shape the firm and its other ethically justifiable stakeholders. The nature of what is a stakeholder is highly contested, with hundreds of definitions standing in the literature (Miles, 2012).

The stakeholder view of strategy is an influential theory of the corporation, assimilating both the resource-based view and the market-based view of the firm, as well as adding a socio-political dimension. The stakeholder view of the firm is used to delineate the identifiable stakeholders of a firm (the normative theory of stakeholder identification) and to examine the conditions under which the contingent parties and variables should be treated as stakeholders (the descriptive theory of stakeholder salience). These two issues structure the avant-garde study of the stakeholder theory. The stakeholder theory asserts that a company should create and distribute value to many stakeholders depending on the support and cooperation of the stakeholders themselves. The survival of a company is conditional on the benefits the stakeholders receive from the company, and it is the full responsibility of the company to provide these benefits (Freeman et al., 2006). The stakeholder theory encourages businesses to heed all their stakeholders. This implies fair treatment, consideration and respect of all

the stakeholders of the firm. This theory urges and fosters transparency between the company and its stakeholders (Frooman, 1999; Frooman and Murrell, 2005; Elijido-Ten et al., 2010; Freeman et al., 2006).

In the context of renewable energy adoption, Stakeholder Theory is particularly relevant because renewable energy projects involve a diverse array of stakeholders—government policymakers, private investors, technology providers, regulatory agencies, local communities, and non-governmental organizations (NGOs) each with distinct, and at times conflicting, priorities (Sovacool and Geels, 2016). Governments play a crucial role in setting regulatory frameworks and providing financial incentives to encourage investment (IRENA, 2021). Businesses contribute technological advancements and capital investment, while local communities, as end-users, significantly influence the feasibility and long-term sustainability of renewable energy projects through their acceptance, trust, or resistance (Devine-Wright, 2007; Sovacool et al., 2018).

There are numerous key characteristics of stakeholder theory that need to be considered. These include:

1. **Stakeholder Inclusivity**: Stakeholder theory posits that organizations should diligently consider the interests and concerns of all stakeholders, as opposed to focusing solely on the profit-maximizing desires of shareholders. In the context of renewable energy adoption at the Katsina Wind Farm, this implies that the interests of employees, customers, suppliers, and the local community must be carefully weighed and considered.
2. **Sustainable Business Model**: Central to the tenets of stakeholder theory is the idea of value creation for all stakeholders. In the Katsina Wind Farm project, this entails moving beyond conventional profit-centric thinking and exploring how renewable energy adoption can engender benefits for diverse stakeholders. For instance, investing in renewable energy sources like solar and wind power not only reduces carbon footprints but also contributes to a cleaner environment for customers and the community at large. This can foster increased customer loyalty and a positive brand reputation, subsequently enhancing shareholder value through increased profits.

Stakeholder Theory provides a structured approach to examining how these different actors interact within the renewable energy sector and how their interests align or

conflict. It enables the identification of barriers and enablers in energy policy implementation, financing mechanisms, and societal acceptance. A core tenet of the theory emphasizes that effective stakeholder engagement enhances project success by reducing resistance, ensuring equitable distribution of benefits, and fostering long-term sustainability (Reed, 2008; Li et al., 2020). Thus, applying Stakeholder Theory to this study allows for a deeper analysis of stakeholder power dynamics, competing interests, and institutional frameworks that shape Nigeria's renewable energy landscape (Sovacool and Brisbois, 2019).

Moreover, this study integrates Stakeholder Theory to address the research gap identified in section 1.3.2. Previous studies on renewable energy adoption in Nigeria have largely overlooked the interplay of stakeholder relationships in determining project success or failure (Ogunbiyi, 2022). By incorporating this theoretical framework, the study will examine how multi-stakeholder collaboration, inclusive policy design, and participatory governance can enhance the success of renewable energy initiatives (Baker et al., 2019; REN21, 2022).

Furthermore, the study will explore how policy misalignment, lack of community involvement, and investor uncertainty affect the renewable energy transition. Empirical research suggests that policies developed without active stakeholder engagement often result in resistance from affected communities and ineffective policy execution (Devine-Wright, 2011; Sovacool, 2014). This study, therefore, positions Stakeholder Theory as a tool for identifying best practices in governance, fostering policy coherence, and ensuring equitable benefits from renewable energy deployment (Reed et al., 2009; Li et al., 2020).

By applying Stakeholder Theory to this research, the study aims to bridge the existing knowledge gap and contribute to a more effective transition to renewable energy in Nigeria. It underscores the importance of a multi-dimensional perspective, where governments, investors, businesses, and communities work collaboratively to shape a sustainable, inclusive, and resilient energy future (Sovacool et al., 2018; IEA, 2020). Through this approach, the research seeks to develop a more comprehensive and stakeholder-driven roadmap for Nigeria's renewable energy sector, ensuring long-term economic, social, and environmental sustainability (Baker et al., 2019; Akinbami, 2022).

Figure 2.1: Stakeholder theory diagram

The Stakeholder Theory diagram (Figure 2.1) illustrates the complex network of interactions among key stakeholders in the renewable energy sector. At the core of the diagram is the renewable energy project, surrounded by various stakeholders, each exerting influence on decision-making, policy implementation, and project sustainability. Governments and regulatory bodies play a crucial role in establishing policies, providing incentives, and ensuring compliance with environmental and energy regulations. Private investors and financial institutions contribute capital and financing mechanisms, which are essential for project feasibility and scalability. Technology providers and research institutions drive innovation, supporting the development of efficient, cost-effective, and scalable renewable energy solutions. Local communities and consumers are integral to project acceptance and long-term sustainability, influencing demand and social legitimacy. Non-governmental organizations (NGOs) and advocacy groups provide oversight, lobbying for policies that promote sustainable and equitable energy transitions.

By visually mapping these stakeholder interactions, the diagram underscores the interdependence of economic, political, technological, and social forces in shaping Nigeria's renewable energy landscape. The inclusion of multi-directional relationships highlights the need for collaboration and coordination among stakeholders to overcome barriers to renewable energy adoption. Understanding these stakeholder dynamics is essential for designing inclusive policies, fostering stakeholder engagement, and ensuring the long-term success of renewable energy initiatives.

2.13.2 Cyclical Conceptual Framework: Empirical Interaction Perspective

The cyclical conceptual framework presents an interactive systems-based view of renewable energy adoption, highlighting the dynamic feedback loops that characterise stakeholder engagement and contextual adaptation in the Nigerian energy landscape.

At the center of the model are stakeholders, government agencies, private developers, academic institutions, civil society, and local communities—who both influence and are influenced by four interlinked contextual factors: Policy, Economic, Technological, and Social (Figure 2.2). These elements form a continuous cycle of interaction rather than a linear progression. For example, policy shifts impact financial flows, which in turn affect technology deployment and shape public perceptions.

This interactive framework is particularly useful in capturing the adaptive and often non-linear nature of project implementation in complex environments. It reflects the learning processes embedded in the case study projects, where iterative feedback from stakeholder experiences contributes to improved governance, institutional capacity, and community acceptance.

Moreover, the cyclical model emphasizes the role of institutional learning and stakeholder reflexivity in sustaining project outcomes. As renewable energy initiatives evolve, lessons from implementation challenges are internalized, reshaping subsequent strategies and reinforcing systemic resilience.

This framework complements the linear model by portraying how theoretical constructions translate into lived experience and evolve over time. It aligns with participatory and adaptive governance models that are increasingly advocated in the literature on sustainable development and energy transitions (Sovacool et al., 2020).

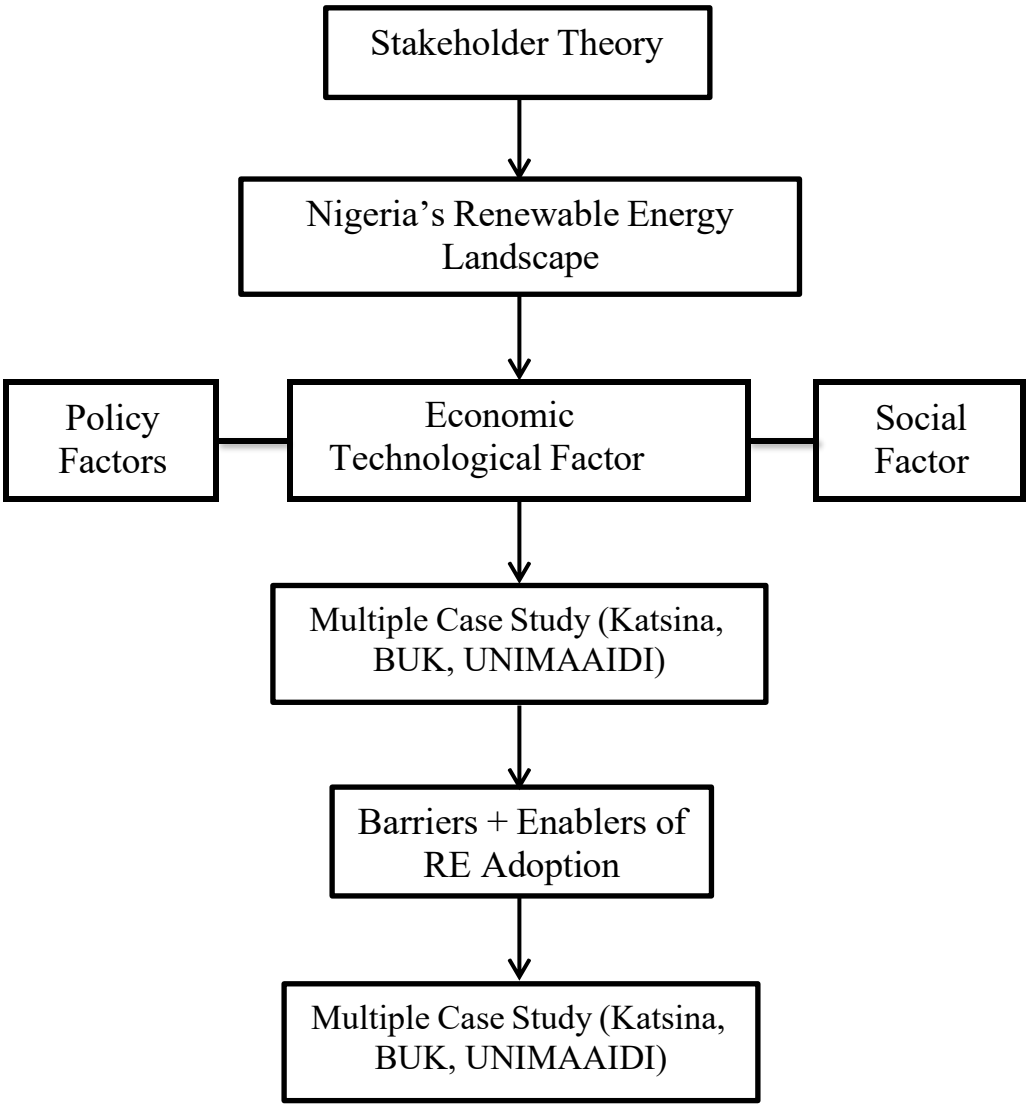

Figure 2.2: Conceptual Framework: Empirical Interaction Perspective

2.12.2Implications for Organizational Management

Stakeholder theory engenders substantial implications for the management of organizations. It suggests a paradigm shift, urging managers to transcend the myopic pursuit of short-term profit maximization. Instead, it advocates for a broader perspective that considers the interests of all stakeholders when making decisions and formulating strategies. In the context of the Katsina Wind Farm project, this means that stakeholders such as the local community, suppliers, and employees should be integral to the decision-making process concerning renewable energy adoption. The goal is to create enduring value that not only benefits shareholders but also aligns with the interests of all stakeholders, ultimately fostering a more sustainable and harmonious business model (Ackermann, et al., 2011).

In summary, Stakeholder Theory serves as the foundational framework for understanding and examining the dynamics of renewable energy adoption at the Katsina Wind Farm project. It underscores the imperative of inclusive stakeholder engagement, value creation for all, and a shift towards long-term sustainability in organizational management.

2.13 The Research Gaps in the Literature

Previous research on renewable energy adoption in Nigeria has largely focused on technical, economic, and policy-level constraints but has paid insufficient attention to the dynamics of stakeholder engagement, trust-building, and multi-actor governance (Ogunbiyi, 2022; Ebhota and Tabakov, 2022). Many policy failures can be traced to a lack of inclusive stakeholder participation, inadequate consultation with local communities, and insufficient coordination between government agencies and private investors. This study addresses these gaps by adopting a multi-stakeholder, case-study approach informed by Stakeholder Theory.

Despite growing global recognition of the urgent need for energy transitions, existing literature on renewable energy adoption in developing countries, particularly Nigeria, reveals significant limitations in scope, focus, and methodology. The body of research to date has been dominated by techno-economic analyses, with much emphasis placed on the financial feasibility, technological deployment, and policy recommendations for renewable energy integration (Ellabban et al., 2014; Lund, 2007). While such studies provide valuable insights, they often approach the issue from isolated perspectives, failing to address the systemic and multi-dimensional nature of the barriers impeding renewable energy development in complex national contexts like Nigeria (IRENA, 2021; IEA, 2020).

One of the most prominent gaps in the literature is the insufficient exploration of stakeholder dynamics in the design, implementation, and sustainability of renewable energy projects. Most studies tend to focus on high-level policy prescriptions and macroeconomic assessments, overlooking the nuanced interactions among key actors such as government agencies, private investors, community members, and civil society organisations (Ogunbiyi, 2022; REN21, 2022). The failure to understand how these stakeholders engage, collaborate, or conflict has led to a fragmented understanding of energy governance, resulting in policy interventions that are often disconnected from

on-the-ground realities (IEA, 2021; IRENA, 2019). A more stakeholder-focused perspective, grounded in empirical research, is thus needed to address these governance complexities and inform more inclusive and sustainable renewable energy strategies.

Moreover, the literature reveals a dearth of research on social acceptance, public awareness, and behavioural dimensions of renewable energy adoption in Nigeria. While economic and technical constraints are frequently cited (He et al., 2023), few studies examine how cultural values, misinformation, trust in institutions, and community involvement shape public attitudes toward renewable energy technologies (GIZ, 2021; Sovacool & Griffiths, 2020). International evidence suggests that social legitimacy and local ownership are critical to the success of renewable energy projects, especially in rural or underdeveloped regions (Akinbami, 2022; Adegbite et al., 2020). However, in the Nigerian context, these factors remain under-researched, leaving policymakers without the necessary insights to design effective communication, engagement, and awareness strategies.

Another critical gap lies in the lack of empirical, case-based investigations of renewable energy project outcomes in Nigeria. Many studies offer theoretical models or high-level policy recommendations, but there is a scarcity of evidence-based research that evaluates the real-world performance, challenges, and stakeholder experiences associated with specific projects (Ebhota & Tabakov, 2022). Lessons from countries such as Kenya and South Africa show the value of case study research in diagnosing implementation barriers and developing context-specific solutions (Baker et al., 2019). Yet, similar efforts in Nigeria remain limited. Consequently, the literature does not sufficiently inform evidence-based policymaking or allow for a systematic assessment of what works, what fails, and why, in Nigeria's renewable energy space (NESP, 2020; IEA, 2021).

In summary, the research gap in the literature on renewable energy adoption in Nigeria is threefold: the neglect of stakeholder engagement as a critical factor in project success; the marginalisation of socio-cultural and behavioural factors in adoption studies; and the absence of in-depth, empirical case study analyses. These gaps underscore the need for an interdisciplinary and qualitative research approach that considers the institutional, political, technical, and social dynamics of energy transitions. By addressing these underexplored areas, the present study makes a substantive contribution to the field and offers practical insights for improving renewable energy deployment in Nigeria and

other developing contexts.

2.13.1 Relevance to Research Questions

Stakeholder Theory directly informs the study's research questions by providing a conceptual lens through which the interactions, conflicts, and collaborations among different actors can be understood:

- **RQ1** (Impact of economic, political, technological, and social factors): Stakeholder Theory helps dissect how different actors are affected by and respond to these dimensions.
- **RQ2** (Social attitudes and perceptions): The theory emphasizes the role of community engagement and social legitimacy in shaping project outcomes.
- **RQ3** (Challenges in project implementation): Understanding power asymmetries and communication gaps among stakeholders reveals why projects succeed or fail.
- **RQ4** (Lessons for future initiatives): The theory provides principles for fostering inclusivity, transparency, and collaborative governance, which can be applied to future project planning.

By integrating these theoretical insights, the study aims to contribute a more nuanced, stakeholder-driven model for renewable energy adoption in Nigeria, especially within rural and underserved communities.

Given the diverse and interconnected roles of stakeholders in the renewable energy sector, a well-defined research approach is necessary to examine the barriers and opportunities within Nigeria's energy transition. The next section outlines the research aims and objectives, detailing the specific areas this study seeks to investigate and the contributions it intends to make toward policy development, investment strategies, and technological advancements in renewable energy adoption.

2.13 Main Findings from Previous Studies that Influenced This Research

Previous research on renewable energy adoption has provided critical insights that have shaped the conceptual and empirical direction of this study. One of the most frequently cited findings across literature is the multifaceted nature of barriers to renewable energy implementation in developing countries, particularly in sub-Saharan Africa. These

include financial constraints, policy inconsistencies, technological limitations, stakeholder misalignment, and socio-political instability. These recurring themes informed the need for a multidimensional analysis of Nigeria's renewable energy landscape, with a focus on economic, institutional, technical, and governance factors.

Several scholars have pointed to the inadequacy of financial infrastructure as a primary barrier to large-scale renewable energy deployment. For instance, Akinbami (2022) observed that the lack of long-term financing instruments, currency volatility, and reliance on imported technology significantly increase project risk and cost. This is further corroborated by IRENA (2021), which notes that countries with underdeveloped local manufacturing and high import dependency tend to experience stalled implementation timelines. These studies influenced the selection of case study sites—such as Katsina Wind Farm and the solar projects at BUK and UNIMAID—where financial and logistical barriers were clearly manifest.

From a governance and policy standpoint, several authors have highlighted the gap between policy formulation and execution. For example, Akuru and Okoro (2011) found that Nigeria's Renewable Energy Master Plan lacks robust enforcement mechanisms, resulting in poor stakeholder coordination and weak regulatory compliance. Similarly, GIZ (2021) demonstrated that inter-agency rivalry and institutional overlap hinder effective implementation of decentralised energy projects. These findings reinforced the need to explore political and regulatory dimensions in this study, especially considering Nigeria's complex federal structure and bureaucratic inefficiencies.

The literature also demonstrates that stakeholder engagement is often marginalised in energy policy planning, particularly in rural and peri-urban regions. Scholars such as Sovacool and Brisbois (2019) argue that socio-technical transitions fail when they do not account for the interests and agency of affected communities. In the Nigerian context, Adegbite et al. (2020) reported that the absence of participatory consultation in projects like the Lagos Independent Power Plant led to widespread local opposition. These insights directly shaped the research's application of Stakeholder Theory as a guiding framework, prioritising the voices of local communities, regulators, investors, and engineers.

Technological development has also been critically evaluated in prior studies. He, Kammen and Wang (2023) identified the lack of technical expertise and maintenance

infrastructure as a consistent impediment to sustainability in African renewable energy projects. Lund (2007) and Ellabban et al. (2014) similarly emphasised the importance of technology transfer and skills development to ensure project longevity. These findings prompted this study's focus on technology as both a constraint and a catalyst for capacity building in Nigeria's renewable energy sector.

In addition, comparative studies such as Baker, Newell and Phillips (2019) provided evidence that successful energy transitions in South Africa and Kenya were underpinned by integrated approaches that aligned political, financial, and technical strategies. The absence of such integrative frameworks in Nigeria suggested a critical research gap, which this study aims to address through case study analysis and cross-sectoral engagement.

Collectively, these prior findings established the groundwork for this research by identifying underexplored areas such as implementation gaps, political accountability, and institutional weakness in renewable energy governance. The insights derived from these studies not only justified the use of a qualitative, multiple-case study approach but also informed the selection of theoretical models—namely Stakeholder Theory and Institutional Theory—as the analytical foundation for interpreting data.

2.15 Summary

This chapter has provided a comprehensive review of the existing literature on renewable energy adoption, highlighting the economic, political, technological, and social factors that influence its development. The review has demonstrated that while Nigeria possesses vast renewable energy potential, its integration into the national energy mix remains limited due to multiple systemic and structural barriers. Key themes emerging from the literature indicate that financial constraints, policy inconsistencies, technological deficiencies, and public perception challenges are among the primary obstacles hindering large-scale renewable energy deployment.

The chapter first examined economic factors, identifying the high initial capital costs, limited access to financing, and dependency on imported renewable energy components as significant deterrents to investment. The review revealed that while international financial institutions and development agencies provide funding for renewable energy projects, domestic financial mechanisms remain weak, limiting long-term sustainability. Political and regulatory challenges were also explored, with findings indicating that inconsistent policies, bureaucratic inefficiencies, and regulatory

uncertainty deter both local and foreign investment. The lack of enforcement mechanisms further exacerbates these challenges, leading to project delays and inefficiencies in implementation.

On the technological front, the literature highlighted Nigeria's outdated grid infrastructure and lack of research funding as key constraints to renewable energy integration. Limited local expertise and reliance on foreign technology have slowed the development of innovative, context-specific renewable energy solutions. Furthermore, challenges related to grid stability, energy storage, and transmission losses remain unresolved, posing technical barriers to widespread adoption. In addition, social and cultural factors were reviewed, demonstrating that misinformation, low public awareness, and cultural resistance to alternative energy sources contribute to slow adoption rates. The literature suggests that without targeted public education campaigns and community-driven initiatives, renewable energy will continue to face societal resistance, particularly in rural areas.

A critical gap identified in the literature is the lack of interdisciplinary studies that assess the interplay of economic, political, technological, and social dimensions in renewable energy adoption. Many previous studies have examined these factors in isolation, failing to capture their interdependencies. Additionally, there has been insufficient empirical research on stakeholder engagement and the role of public perception in shaping renewable energy transitions. This study aims to bridge these gaps by adopting a holistic, stakeholder-driven approach, integrating case studies and qualitative insights to provide a more comprehensive understanding of Nigeria's renewable energy landscape.

In conclusion, this chapter has synthesized key debates and findings in the literature, outlining the existing knowledge base and identifying critical research gaps. The insights gained provide the foundation for the next chapter, which will present the methodological approach adopted in this study. Chapter 3 will outline the research design, data collection methods, and analytical framework employed to investigate the barriers and opportunities for renewable energy adoption in Nigeria, ensuring a robust and empirical contribution to this field.

CHAPTER 3 - RESEARCH METHODOLOGY

3.1 Introduction

Research methodology serves as a strategic blueprint, a coordinated plan of action, a systematic process, and a structured design that guides the selection of specific methods and their subsequent application to attain desired outcomes (Crotty, 1998). It encompasses a comprehensive sequence involving data gathering, rigorous analysis, and meaningful interpretation, as outlined by Creswell (2011). In the context of this research, the methodology is tailored to precisely address the research objectives and research questions formulated following the literature review.

In determining the most suitable research approach, the guidance of scholars such as Meredith et al. (1989), Newman and Benz (1998), and Creswell (2009, 2011) is sought. They propose that an effective methodology should strive to integrate both quantitative and qualitative research paradigms. However, in alignment with the principles of qualitative research, this study adopts a methodological purism approach, relying exclusively on qualitative methodologies. This decision is based on the nature of the research questions and the depth of understanding sought in analysing renewable energy adoption in Nigeria through three selected case studies: Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project.

Qualitative research is particularly well-suited for exploring complex, context-dependent phenomena, as is the case in studying renewable energy adoption in Nigeria. By focusing solely on qualitative methods, this study explores the complexities of the subject matter, allowing for rich, in-depth exploration and the capture of nuanced insights (Denzin & Lincoln, 2011). The study aims to examine the economic, political, technological, and social dimensions influencing the adoption of renewable energy projects, with an emphasis on stakeholder interactions and perceptions.

While methodological triangulation, which integrates quantitative and qualitative methods, is valuable in many research contexts (Yin, 2014), the primary objective of this study is to gain a holistic understanding of the factors influencing renewable energy adoption in Nigeria. Given that renewable energy transitions are shaped by diverse, interconnected factors, qualitative research methods such as case studies, in-depth

interviews, and document analysis provide the best means of uncovering underlying motivations, barriers, and perceptions among key stakeholders.

This study employs case study methodology as its primary research strategy, focusing on three key renewable energy projects in Nigeria:

1. **Katsina Wind Farm:** One of Nigeria's first large-scale wind energy projects, this case provides insights into the challenges of implementing wind energy infrastructure in a developing economy.
2. **Bayero University Kano (BUK) Solar Project:** A university-based solar energy initiative, offering a perspective on how renewable energy can support academic institutions and decentralized energy systems.
3. **University of Maiduguri (UNIMAID) Solar Project:** A solar energy project in a conflict-prone region, highlighting the role of renewable energy in enhancing energy security and resilience.

By examining multiple case studies, this research aims to generate comparative insights, drawing lessons that can inform future renewable energy policy, investment strategies, and community engagement models.

This chapter elaborates on the philosophical underpinnings of the study, providing justification for the selected research paradigm and detailing the empirical methodologies used for data collection and analysis. The subsequent sections will discuss research philosophy, case study methodology, data collection methods (including interviews and document analysis), sampling strategy, ethical considerations, and data analysis techniques. Through this approach, the study ensures methodological consistency and rigor, enabling a comprehensive understanding of Nigeria's renewable energy landscape.

By adhering exclusively to qualitative research methods, this study maintains methodological coherence, capturing the rich narratives and contextual nuances that quantitative methods might not fully address. Ultimately, this research provides an in-depth qualitative analysis that contributes valuable insights to the field of renewable energy adoption in Nigeria, with implications for policy development, institutional decision-making, and stakeholder engagement.

3.2 Research Philosophy

The research philosophy of a study defines the fundamental assumptions about reality (ontology), the nature of knowledge (epistemology), and the role of values in research (axiology) (Guba and Lincoln, 1994; Geyi, 2021; Saunders, et al., 2019). These philosophical foundations influence the selection of research methods and determine how data is collected, analysed, and interpreted (Bryman, 2016). Given the multi-dimensional nature of renewable energy adoption, shaped by economic, political, technological, and social factors, choosing an appropriate research philosophy is essential for ensuring coherence between the study's objectives, methodological approach, and data analysis.

This study explores the challenges and opportunities of renewable energy adoption in Nigeria through an in-depth analysis of three case studies: Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project. These projects involve multiple stakeholders, including government agencies, investors, local communities, and technology providers, whose interactions influence policy effectiveness, project success, and public acceptance. Understanding how these stakeholders engage with renewable energy initiatives requires a research philosophy that emphasizes context, meaning, and social interactions. As such, this study adopts an interpretivist research philosophy within a constructivist ontological stance, prioritizing qualitative inquiry to capture diverse stakeholder perspectives and institutional dynamics (Creswell and Poth, 2018).

3.2.1 Ontology and Epistemology

Ontology concerns the nature of reality, questioning whether it exists independently of human perception or is socially constructed (Crotty, 1998; Geyi, 2021; Saunders et al., 2019). This study adopts a constructivist ontology, which posits that reality is subjective, context- dependent, and shaped by social interactions (Guba & Lincoln, 1994; Bryman, 2016). The adoption of renewable energy in Nigeria is not merely a technical issue but is influenced by regulatory frameworks, stakeholder perceptions, institutional constraints, and cultural attitudes. Since each stakeholder group—including government agencies, private investors, NGOs, and local communities—perceives and experiences renewable energy differently, a qualitative approach is

necessary to uncover these diverse perspectives (Neuman, 2000).

Epistemology, on the other hand, concerns how knowledge is acquired and validated (Galliers, 1991). This study adopts an interpretivist epistemology, recognizing that knowledge is socially constructed and best understood through qualitative engagement with stakeholders (Creswell, 2013). Unlike positivist approaches that emphasize objective measurement and statistical generalization, interpretivism prioritizes depth over breadth, making it particularly relevant for analysing policy failures, stakeholder interactions, and institutional challenges in Nigeria's renewable energy sector (Saunders et al., 2019).

3.2.2 Positivism vs. Interpretivism

Two dominant research paradigms—positivism and interpretivism—offer contrasting approaches to inquiry (Collis and Hussey, 2021). Positivism assumes that reality is objective and measurable, relying on quantitative methods, experimental control, and statistical generalization (Levin, 1988; Geyi, 2021; Remenyi et al., 1998). While positivist approaches are commonly used in energy-related research, such as electricity demand modelling or wind energy efficiency analysis, they do not fully capture the socio-political and institutional barriers affecting renewable energy adoption (Giddens, 1991).

In contrast, interpretivism recognizes that reality is subjective and context-dependent, requiring qualitative methodologies such as case studies, interviews, and thematic analysis (Creswell and Poth, 2018). This paradigm is highly relevant for this study, as renewable energy adoption in Nigeria is influenced by multiple social actors, regulatory dynamics, and institutional frameworks that cannot be meaningfully captured through quantitative techniques alone (Yin, 2018).

3.2.3 Justification for the Choice of Interpretivism

The selection of interpretivism as the guiding research philosophy is based on several key considerations. First, renewable energy adoption in Nigeria is not merely a technical transition but is shaped by complex regulatory, financial, social, and political interactions (Sovacool, 2020). By adopting an interpretivist approach, this study explores the lived experiences of stakeholders involved in the three case study projects,

capturing how policy misalignments, financial constraints, and socio-political factors influence project success. Second, given that this research is grounded in Stakeholder Theory, an interpretivist paradigm aligns with the need to understand the roles, interests, and interactions among multiple stakeholders (Freeman, Harrison and Zyglidopoulos, 2018). The adoption of renewable energy technologies involves diverse actors, including government agencies, investors, non-governmental organizations (NGOs), and local communities, each with distinct motivations and expectations.

Third, interpretivism is well-suited to qualitative inquiry, allowing this study to generate context-specific insights rather than seeking universal generalizations (Bryman, 2016). Each of the three case studies presents unique opportunities and challenges. For instance, the Katsina Wind Farm has faced regulatory and technical hurdles, while the BUK and UNIMAID Solar Projects highlight institutional and security-related barriers that impact project sustainability. An interpretivist stance ensures that these contextual factors are fully explored, allowing for a richer and more nuanced analysis. Fourth, this research is designed to generate policy-relevant insights, capturing stakeholder narratives, policy failures, and institutional gaps that affect renewable energy implementation. The findings will be particularly valuable for government agencies, private investors, and development organizations seeking to strengthen Nigeria's renewable energy policies (Newell, Phillips and Pueyo, 2021). Finally, case study methodology (Yin, 2018) aligns with interpretivism, as it provides a comparative analysis of different renewable energy projects across varied socio-political contexts.

In summary, this study adopts an interpretivist research philosophy, underpinned by a constructivist ontological stance and subjective epistemology. This philosophical positioning aligns with the qualitative research approach employed in the study and is best suited for examining stakeholder perspectives, policy frameworks, and socio-economic influences on renewable energy adoption in Nigeria. By analysing three distinct case studies—Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project—this study generates contextually grounded insights that inform energy policy, investment strategies, and stakeholder engagement practices. Furthermore, by using an interpretive paradigm, this research captures the nuanced interactions between regulatory bodies, financial institutions, and local communities, providing valuable contributions to both theoretical and practical discussions on sustainable energy

transitions (Denzin & Lincoln, 2018).

The next section discusses the research strategy, outlining the case study methodology and the data collection techniques employed to achieve the research objectives.

3.3 Research Strategy

The research strategy defines the overarching plan that guides data collection, analysis, and interpretation, ensuring alignment with research objectives (Saunders et al. 2019; Geyi, 2021). A well-structured research strategy is essential for ensuring coherence and rigor, particularly when addressing complex, multidimensional phenomena such as renewable energy adoption in Nigeria. Given the study's emphasis on understanding the challenges and opportunities of renewable energy projects, an empirical, qualitative, and case study-based approach is adopted to provide a rich, contextualized analysis.

3.3.1 Empirical Research Approach

Research strategies are broadly categorized as empirical or non-empirical (Avison et al., 2008). While non-empirical approaches rely on conceptual reasoning, empirical research involves systematic collection of data to examine real-world phenomena (Creswell and Poth, 2018; Geyi, 2021). Given the exploratory nature of this study, an empirical approach is most appropriate, as it allows for an in-depth understanding of stakeholder perspectives, policy influences, and institutional challenges affecting renewable energy adoption in Nigeria.

Empirical research can be either quantitative, qualitative, or mixed methods (Neuman, 2014). Quantitative approaches focus on measurable variables, statistical analysis, and hypothesis testing, making them well-suited for large-scale generalization (Bryman, 2016). However, this study adopts a qualitative approach, given its emphasis on contextual analysis and the exploration of subjective experiences related to renewable energy projects in Nigeria.

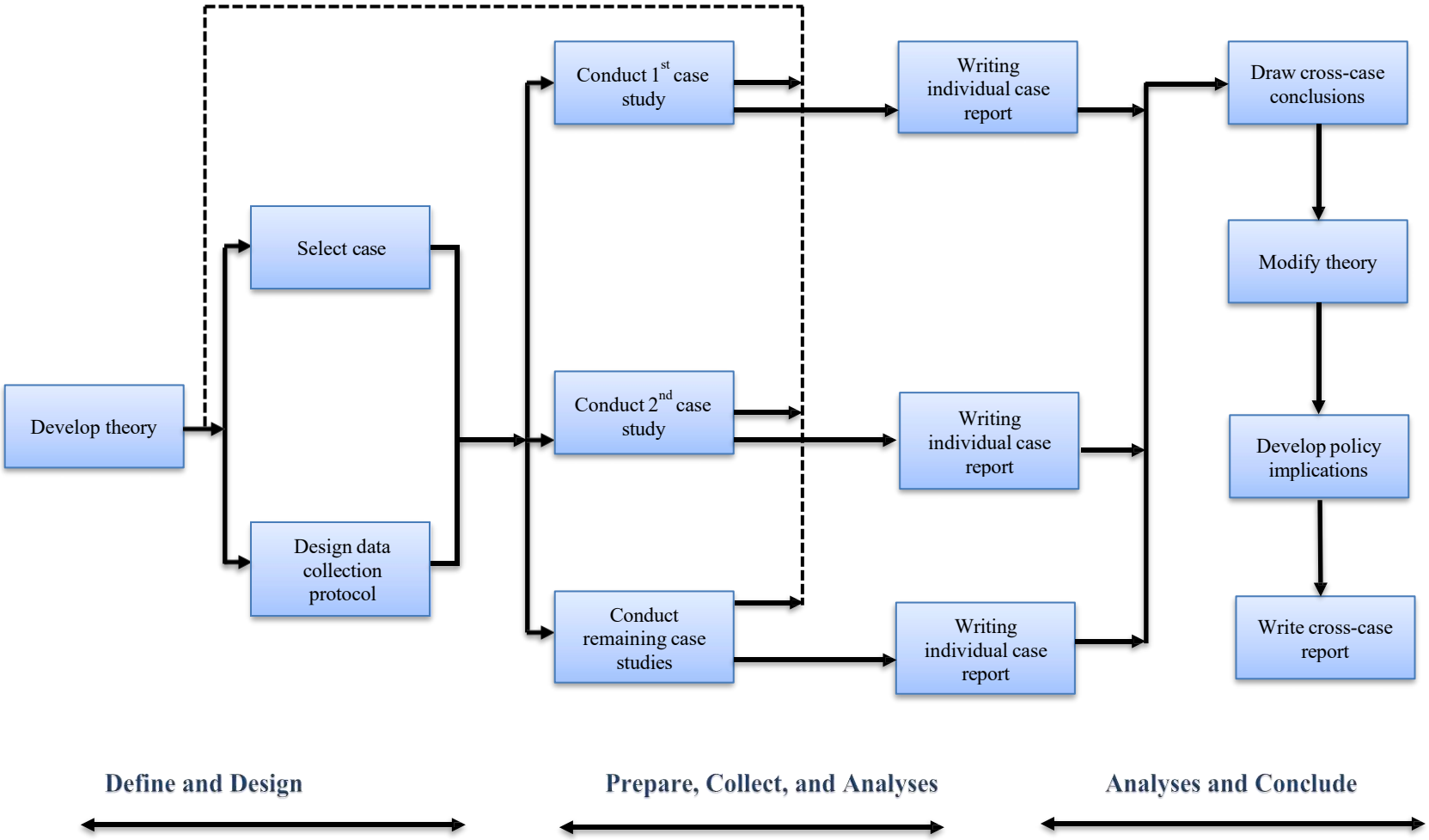

Figure 3.1 Multiple case study procedure

3.3.2 Case Study Approach

A case study methodology is employed, which allows for an in-depth examination of contemporary phenomena within their real-life contexts (Yin, 2018). This approach is particularly relevant given the need to explore the complex socio-economic, political, and technical factors influencing renewable energy adoption. The study examines three major renewable energy projects in Nigeria: Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project.

Each case study represents a distinct renewable energy initiative, offering valuable insights into project success factors, challenges, and stakeholder dynamics. As shown in figure 3.1 above, a multiple-case study approach strengthens the reliability of findings by allowing for cross-case comparisons, highlighting recurring themes, policy gaps, and best practices (Stake, 1995).

3.3.3 Rationale and Justification for Case Study Selection.

The selection of appropriate case studies is a foundational component of qualitative research design, particularly within the context of multiple-case study methodology. Case studies must be strategically chosen to illuminate the phenomenon under investigation, generate rich empirical data, and facilitate theoretical generalisation (Yin, 2018; Stake, 2005). In this research, three renewable energy projects were purposively selected to explore the institutional, technical, and stakeholder-related dynamics affecting renewable energy adoption in Nigeria: The Katsina Wind Farm, the Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project.

Case study methodology is especially well-suited to addressing "how" and "why" questions in settings where the researcher has limited control over real-world events and where the boundaries between the phenomenon and its context are blurred (Yin, 2018). Renewable energy adoption in Nigeria is a multifaceted, context-sensitive process shaped by diverse actors, governance structures, socio-political constraints, and technological environments. The selected cases provide an empirically grounded lens through which to examine these interlocking factors, offering both within-case depth and cross-case comparability.

The selection was guided by four criteria: technological diversity, geographical spread, institutional affiliation, and alignment with key thematic concerns in literature. Together, these cases represent a cross-section of Nigeria's renewable energy landscape, spanning different scales (utility and institutional), technologies (wind and solar), regions (north-west, north-

central, and north-east), and implementation contexts (state-led and university-led).

The Katsina Wind Farm was selected as one of Nigeria's earliest grid-connected wind energy initiatives, led by the federal government. It provides an important opportunity to evaluate the operational challenges and sustainability issues associated with large-scale public infrastructure in a low-resource environment. Challenges observed in the projects such as prolonged delays, equipment failures, and minimal community engagement—exemplify many of the systemic issues identified in the literature on energy infrastructure in developing countries (Sachs et al., 2019; Ebhota and Tabakov, 2022). Furthermore, the project reflects tensions between state-driven development and the increasing involvement of private capital and international donors in the renewable energy sector (Akinbami, 2022).

The BUK Solar Project was selected due to its distinctive role as a university-based renewable energy system operating within an academic urban environment. As a mid-sized institutional project, it highlights the interplay between energy infrastructure and capacity-building within tertiary education. Unlike larger utility-scale installations, the BUK system was designed to meet specific institutional energy demands while simultaneously functioning as a site for training, research, and skills development (IRENA, 2020). This case offers valuable insights into how renewable energy projects can support institutional autonomy and serve as innovation hubs, contributing to broader goals of sustainable development and human capital formation (GIZ, 2021; UNESCO, 2021).

The UNIMAID Solar Project was selected for its unique characteristics as a large-scale, decentralised solar initiative implemented in a conflict-affected and off-grid region of Nigeria. The project presents an opportunity to explore how renewable energy can be leveraged to address energy insecurity in fragile environments, particularly where conventional grid extension is unfeasible. In such settings, energy access is deeply intertwined with institutional resilience, post-conflict recovery, and humanitarian service provision. The UNIMAID case aligns with emerging research that underscores the transformative potential of decentralised renewables in advancing social equity, regional stability, and local empowerment in crisis-prone contexts (Okafor, Adekunle and Okeowo, 2020; Sovacool et al., 2021; Karekezi and Kithyoma, 2005).

Collectively, these three case studies embody a strategic and theoretically grounded selection. Their variation enhances the external validity of the findings while enabling rich analytical insights into the contextual factors shaping renewable energy adoption. They also align closely with the study's use of Stakeholder Theory and Institutional Theory, which emphasise the role

of actor relationships, institutional frameworks, and governance environments in shaping socio-technical transitions (Freeman, Harrison and Zyglidopoulos, 2010; Scott, 2001). By investigating these diverse yet thematically interconnected cases, the study seeks to contribute both to theory development and to policy and practice in the renewable energy sector in Nigeria and beyond.

3.3.4 Strategic Relevance and National Importance

Each of the selected projects holds strategic significance in Nigeria's national renewable energy agenda. The Katsina Wind Farm, for example, is Nigeria's first and only utility-scale wind energy project. Initiated in the early 2000s and backed by foreign partnerships, it was meant to serve as a pioneering model for large-scale renewable electricity generation. However, its prolonged delays, partial implementation, and ultimate underperformance have rendered it a symbol of policy disjuncture and project mismanagement (Ogunbiyi, 2021; Okafor, Egbue & Umar, 2020). It provides a valuable case for investigating how governance inefficiencies, stakeholder disengagement, and technical misalignment contribute to project failure.

In contrast, the BUK Solar Project is a university-led initiative designed to meet campus energy needs while promoting solar research and technical innovation. As a decentralised and institutionally managed project, BUK offers a successful model of how renewable energy systems can be implemented effectively outside the centralised grid framework. It enables the exploration of enabling factors such as academic leadership, internal funding, and institutional autonomy (Acheampong, Erku-Kutan & Abor, 2021; Sovacool & Brisbois, 2019).

The UNIMAID Solar Project is in North-East Nigeria, a region affected by armed conflict and displacement. The project not only provides power to the university but also contributes to post-conflict recovery, community resilience, and humanitarian support (IRENA, 2021). It presents a unique opportunity to examine how renewable energy can be leveraged for peacebuilding and service delivery in fragile contexts, highlighting issues of energy security, infrastructure protection, and stakeholder coordination in high-risk areas (IEA, 2022; He, Kammen & Wang, 2023).

These three cases, therefore, represent diverse renewable energy typologies—wind and solar; state-led, academic-led, and donor-supported; partially failed, moderately successful, and contextually adaptive. The variation enhances the explanatory scope of the research and provides fertile ground for cross-case comparison (Yin, 2018; Thomas, 2011).

3.3.5 Theoretical Sampling and Analytical Generalisation

The selection process follows a purposive sampling strategy, aligned with theoretical replication logic as described by Yin (2018). Rather than seeking statistical representativeness, the focus here is on selecting cases that can support analytical generalization, that is, the ability to draw theoretical insights from empirical findings (Flyvbjerg, 2006; Stake, 2005). The contrast between successful and unsuccessful cases is intentional, allowing the researcher to test rival explanations and develop robust analytical propositions about stakeholder influence, policy implementation, and institutional learning.

Each case was selected to reflect maximum variation sampling (Patton, 2002), where key contextual dimensions—geographic location, institutional ownership, funding structure, and technological system—differ significantly. Such variation strengthens the internal logic of comparative analysis and allows for the identification of recurring patterns across distinct project environments (Creswell & Poth, 2018; Gerring, 2007).

Furthermore, the selected cases are information-rich and data-accessible. Stakeholders were identifiable and available for interviews; relevant documents were retrievable from institutional repositories or online platforms; and visual access was possible via virtual tours, photographs, and project videos. These practical factors enhanced the feasibility and reliability of each case, enabling comprehensive and triangulated data collection (Bowen, 2009; Denzin & Lincoln, 2018).

3.3.6 Relevance to Research Objectives and Contribution to Knowledge

The three selected cases align with the central research objective: to understand the barriers, opportunities, and stakeholder dynamics affecting renewable energy adoption in Nigeria. They offer fertile ground for investigating key dimensions of the research questions, including stakeholder engagement, institutional coordination, policy coherence, and socio-technical system integration.

The comparative insights drawn from these cases address a key gap in the literature—namely, the lack of empirically grounded, context-sensitive, and stakeholder-informed studies on renewable energy implementation in sub-Saharan Africa. The findings will also inform policy design, investment strategy, and institutional reform efforts aimed at improving the scalability and sustainability of clean energy initiatives in Nigeria (REN21, 2022; Lund, 2007).

3.3.7 Inductive Research Approach

Research strategies can follow deductive or inductive reasoning (Hussey and Hussey, 1997). Deductive research tests existing theories through empirical validation, whereas inductive research generates theories based on data analysis (Saunders et al., 2019). This study follows an inductive approach, allowing themes and patterns to emerge organically from qualitative data rather than being constrained by pre-existing theoretical frameworks.

An inductive strategy is well suited for understanding stakeholder perspectives on renewable energy adoption, exploring socio-political and regulatory barriers affecting renewable energy projects, and developing insights into institutional frameworks shaping renewable energy transitions. By employing an inductive approach, this study captures rich, context-specific insights that would be difficult to obtain through hypothesis-driven quantitative methodologies.

3.3.8 Justification for the Research Strategy

The research strategy chosen for this study is justified by several key considerations. The transition to renewable energy in Nigeria is not merely a technical process but involves economic, political, and socio-cultural challenges (Sovacool, 2020). A qualitative case study approach enables a holistic analysis of these interdependent factors by engaging with stakeholders and capturing their lived experiences. Since stakeholder perspectives vary across different projects and locations, the case study approach is particularly valuable in identifying patterns, policy misalignments, and localized barriers.

The exploratory nature of this study necessitates a research strategy that allows for flexibility in uncovering new insights. Given the limited empirical research on stakeholder engagement in Nigeria's renewable energy sector, a qualitative approach provides the methodological openness required to capture emerging themes that might otherwise be overlooked (Creswell and Poth, 2018). By focusing on in-depth qualitative inquiry, the study ensures that findings are not constrained by predefined variables but instead reflect the realities of renewable energy stakeholders in Nigeria.

Stakeholder Theory serves as the theoretical foundation of this study, emphasizing the

role of multiple actors in shaping energy transitions. The case study methodology aligns well with this theoretical lens, facilitating a nuanced analysis of government agencies, investors, local communities, and energy providers (Freeman, Harrison and Zyglidopoulos, 2018). An interpretivist epistemology further strengthens this approach by allowing for an in-depth exploration of stakeholder perceptions and interactions, which are critical in understanding the socio-political dimensions of renewable energy adoption.

The selection of three case studies—Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project—ensures that the research captures a diverse range of institutional, geographical, and socio-political contexts. Katsina Wind Farm, for example, presents significant regulatory and technical hurdles, whereas the BUK and UNIMAID Solar Projects highlight the impact of institutional and security-related challenges on renewable energy adoption. Comparing these cases provides a broader understanding of how different renewable energy initiatives navigate policy, financing, and stakeholder engagement issues.

Furthermore, the study aims to generate policy-relevant insights that can inform future energy policies, investment strategies, and community engagement models. The qualitative case study methodology enables the research to contribute to ongoing policy discussions by capturing stakeholder narratives, policy failures, and institutional gaps. Findings from this study will be particularly useful for government agencies, private investors, and development organizations seeking to enhance Nigeria's renewable energy policies (Newell, Phillips and Pueyo, 2021).

This research adopts an empirical, qualitative, and inductive approach, utilizing a case study methodology to explore the challenges and opportunities of renewable energy adoption in Nigeria. The study focuses on three case studies, Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project, to provide a comparative, stakeholder-driven analysis of institutional frameworks, policy gaps, and socio-technical challenges affecting renewable energy initiatives. This research strategy ensures a rich, contextually grounded investigation, contributing valuable insights to both academic discourse and policy development in Nigeria's renewable energy sector.

3.4 Research Design

A research design provides a structured framework that guides the collection, analysis, and interpretation of data to ensure a systematic and coherent approach to addressing research questions (Yin, 2018). In qualitative research, the design can take different forms, including exploratory, descriptive, and explanatory research (Saunders, Lewis & Thornhill, 2019). These classifications are not mutually exclusive, and a study can incorporate elements from all three to achieve a comprehensive analysis.

Exploratory research involves extensive literature reviews, focus group discussions, or preliminary interviews to identify key variables and themes that require further investigation (Pizam, 1994). Descriptive research seeks to provide a detailed account of observed phenomena without generalizing beyond the cases under study. Explanatory or confirmatory research focuses on uncovering relationships between qualitative variables, making it particularly useful in theory development (Saunders et al., 2019).

This study adopts an exploratory and descriptive case study approach to examine the challenges and opportunities in renewable energy adoption in Nigeria. The study is structured around three case studies: Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project. These case studies provide a rich empirical foundation for analysing stakeholder engagement, policy effectiveness, and institutional barriers.

The research design is structured into key phases: (i) development and implementation of case studies, (ii) formulation of a qualitative data analysis framework, and (iii) validation of qualitative data analysis techniques using systematic coding and thematic analysis (Miles, Huberman & Saldaña, 2014).

3.4.7 Philosophical Underpinnings

Qualitative research is guided by a constructivist epistemology, which acknowledges that reality is socially constructed through interactions, perceptions, and experiences (Creswell & Poth, 2018). This perspective is particularly relevant for understanding how different stakeholders in Nigeria's renewable energy sector interpret and respond to policy, financial, and infrastructural challenges.

The interpretivist paradigm is well suited to this study, as it allows the researcher to capture the subjective meanings, values, and perspectives of stakeholders involved in the three case study projects (Bryman, 2016). This aligns with Stakeholder Theory, which emphasizes the interconnected roles of multiple actors—including government agencies, investors, communities, and technical experts—in shaping renewable energy adoption (Freeman, Harrison & Zyglidopoulos, 2018).

By employing a multiple-case study approach, the research gains deeper insights into how different renewable energy projects navigate institutional, financial, and policy barriers, thus contributing to a more nuanced understanding of the sector's dynamics in Nigeria.

3.4.8 Data Collection Methods

This study adopts a multi-method qualitative approach to data collection, combining semi-structured interviews, participant observation, and document analysis. These methods were selected not only for their capacity to capture the multifaceted dynamics of renewable energy adoption in Nigeria but also to enable data triangulation, which enhances the reliability, validity, and richness of the research findings (Denzin & Lincoln, 2018; Creswell & Poth, 2018). Given the complexity of the socio-political, technical, and institutional environments in which energy transitions occur, especially in developing countries like Nigeria, this methodological strategy provides a robust framework for understanding stakeholder experiences, project implementation outcomes, and the interplay of governance mechanisms.

3.4.8.1 In-depth Interviews:

The primary method of data collection in this study is semi-structured interviews, which are widely recognized for their capacity to generate rich, contextual, and nuanced data (Adams, 2015; Rubin & Rubin, 2012). Semi-structured interviews allow researchers to explore participant experiences in depth, while retaining flexibility to probe emergent themes that are not predetermined by the researcher (Kvale & Brinkmann, 2015). This is particularly important in research settings where lived experience, institutional constraints, and localized knowledge are central to understanding complex phenomena such as the challenges and opportunities involved in renewable energy project implementation.

In this study, semi-structured interviews were conducted with key stakeholders from

three major renewable energy projects in Nigeria: the Katsina Wind Farm, the BUK Solar Project, and the UNIMAID Solar Project. Participants were purposefully selected based on their involvement in project design, implementation, regulation, or community interaction, and included government officials, project managers, technical experts, academic researchers, and local community representatives. The purposive sampling strategy was informed by the Stakeholder Theory framework (Freeman, 1984; Mitchell et al., 1997), ensuring a diverse range of perspectives and stakeholder categories.

Interviews were guided by a semi-structured protocol comprising twelve core questions. These questions were designed to elicit insights into key thematic areas including project implementation strategies; institutional and regulatory barriers; stakeholder engagement and collaboration; policy alignment and misalignment; technical feasibility and maintenance issues; and social acceptance of renewable energy technologies. Interviews were conducted virtually (via Zoom) due to geographical and logistical constraints, with each session lasting approximately 20 to 25 minutes. This duration provided sufficient time for guided questioning, clarification, and follow-up probes to explore unexpected but relevant insights. In line with best practice, interviews were audio-recorded (with participant consent) and later transcribed verbatim to preserve detail and support systematic analysis (Rowley, 2012; Qu & Dumay, 2011).

The use of semi-structured interviews in this context was particularly valuable for unpacking the power dynamics, institutional practices, and operational realities underpinning renewable energy deployment in Nigeria—many of which are not easily observable or documented. Participants often shared candid reflections, critiques, and institutional histories that illuminated not only the technical or policy dimensions of the projects, but also the social and political context in which they were embedded.

3.4.8.2 Participant Observation:

While traditional field-based observation was constrained by external factors, the study incorporated virtual site observation through a combination of project images, satellite footage, official project videos, and user-generated media from stakeholders and institutions. The goal of observational research in this study was to provide contextual and visual validation of the data collected through interviews and documents. Observational methods,

even when adapted to virtual contexts, can offer valuable insights into spatial arrangements, infrastructure conditions, visual representations of progress or abandonment, and community interactions with energy installations (Denzin & Lincoln, 2018; Flick, 2018).

The observational component allowed the researcher to assess visual indicators of project functionality, such as the physical state of turbines, solar panels, and control facilities, as well as signs of neglect or incomplete implementation. Observations were recorded in reflexive field notes, with attention given to comparing these impressions against stakeholder narratives. For instance, in cases where interviewees reported equipment vandalism or inadequate maintenance, observation helped corroborate or complicate these claims.

Although limited in scope, this virtual observation added empirical depth to the case studies and supported triangulation by enabling comparison between reported experiences and visible realities.

3.4.8.3 Document Analysis:

The third data collection method used in this study was document analysis, which involved a systematic review of relevant documents related to the three case study projects. Document analysis is a valuable qualitative tool for understanding the historical, policy, institutional, and technical context in which projects are developed and managed (Bowen, 2009). Unlike interviews, which rely on subjective interpretation, documents provide official records, policy rationales, financial plans, and technical specifications that reveal the broader governance and organizational landscape.

In this study, a wide range of documents were reviewed, including but not limited to project feasibility studies; federal and state-level energy policy documents; implementation timelines; evaluation reports; regulatory frameworks issued by the Nigerian Electricity Regulatory Commission (NERC); and technical manuals or presentations shared by project coordinators. These documents were obtained from public repositories, institutional websites, and participant contributions.

Document analysis was particularly useful in identifying policy discontinuities, funding gaps, regulatory ambiguities, and technological limitations. For example, inconsistencies between stated policy goals and actual implementation practices were noted by comparing strategic policy plans with project progress reports. The documents also provided timelines, data sets, and policy benchmarks that could be

compared against stakeholder interview accounts to test the credibility and coherence of the findings.

Each document was subjected to qualitative content analysis, involving coding for recurring themes, institutional language, implicit assumptions, and silences (i.e., what was omitted or downplayed). Documents were treated as both artefacts of policy intent and sources of institutional culture, enabling a multidimensional interpretation that complemented the interview data.

By integrating semi-structured interviews, virtual participant observation, and document analysis, this study ensured a comprehensive, triangulated, and methodologically rigorous examination of renewable energy project implementation in Nigeria. Each method was selected not only for its empirical utility but also for its alignment with the study's interpretivist epistemology, stakeholder-oriented theoretical framework, and case study methodology. The combined use of these methods allowed for a nuanced understanding of stakeholder perspectives, institutional processes, and governance challenges, thereby enriching the validity, depth, and relevance of the study's findings.

3.4.9 Managing Challenges and Limitations During Data Collection

The data collection phase of this research encountered several practical and methodological challenges, which were carefully managed to ensure the integrity and completeness of the qualitative dataset. These challenges arose due to contextual realities of conducting research in Nigeria's renewable energy sector, particularly in remote or conflict-prone areas, and were addressed using strategies rooted in qualitative best practices.

One significant limitation was the geographical inaccessibility of some field sites, particularly the University of Maiduguri (UNIMAID) Solar Project in Nigeria's North-East region, which has experienced prolonged instability due to insurgency. Given security concerns and travel restrictions, physical site visits were not always feasible. In response, the study adopted virtual observation techniques and remote interviews using digital platforms such as Zoom. This approach aligns with adaptive fieldwork strategies in conflict-affected regions, where technology can serve as a substitute for in-person interaction while still maintaining qualitative depth (Block and Erskine, 2012; Lo Iacono, Symonds and Brown, 2016). Participants were briefed extensively beforehand, and digital consent was obtained in accordance with ethical guidelines.

Another limitation involved participant availability and scheduling difficulties, particularly among high-level stakeholders such as government officials and project managers, who often face time constraints. This challenge was mitigated through flexible scheduling, repeated follow-ups, and the use of WhatsApp and email for asynchronous communication. Such digital flexibility has been shown to improve participation rates in qualitative research where time or location constraints exist (Deakin and Wakefield, 2014).

The study also encountered issues of participant hesitation and sensitivity, particularly when discussing politically charged topics such as policy failure, corruption, or project mismanagement. To address this, interviews were conducted with a non-confrontational and empathetic approach, allowing participants to steer the direction of the conversation and decline questions they found uncomfortable. Building rapport and ensuring anonymity and confidentiality were essential for establishing trust (King and Horrocks, 2010). Additionally, questions were phrased in a neutral and open-ended manner to avoid leading responses and to reduce perceived judgment (Bryman, 2016).

Technological barriers, such as poor internet connectivity during virtual interviews posed occasional interruptions. These were addressed by offering alternative formats, such as voice-only calls, and by rescheduling sessions when necessary. Interviews were also audio-recorded (with consent) and backed up securely to prevent data loss, aligning with best practices for remote qualitative data collection (Archibald et al., 2019).

Lastly, the process of document retrieval posed some limitations, especially for accessing internal reports, feasibility studies, or unpublished policy documents related to the case studies. Where official access was restricted, the study supplemented missing data by consulting publicly available regulatory frameworks, project white papers, and third-party assessments. Triangulation with interview data ensured that even when full documentation was not obtainable, the reliability of the data remained strong (Bowen, 2009).

Through these adaptive measures, the research was able to navigate the complex realities of fieldwork in developing and crisis-prone contexts, while upholding methodological rigour, ethical compliance, and data quality.

3.4.10 Sampling Strategy

In qualitative research, purposive sampling is used to select participants who possess direct knowledge and experience of renewable energy adoption in Nigeria (Creswell & Poth, 2018). This study targets individuals representing key stakeholder groups, including government officials from the Rural Electrification Agency (REA) and Ministry of Power, project managers and engineers involved in the three case studies, local community leaders and residents affected by these projects, and private sector investors and renewable energy developers engaged in project financing and implementation.

To ensure diversity in perspectives, the study adopts maximum variation sampling, selecting participants with varying roles, experiences, and institutional affiliations (Palinkas et al., 2015). This strategy enhances the credibility and richness of the qualitative dataset. The sample size is determined by the principle of data saturation, ensuring that interviews continue until no new themes emerge. This approach ensures that the study captures a comprehensive and multi-faceted understanding of renewable energy adoption in Nigeria.

3.4.11 Data Analysis Strategy

The collected qualitative data undergoes thematic analysis, a systematic approach to identifying, analysing, and reporting patterns (themes) within the dataset (Braun & Clarke, 2006). The process begins with data familiarization, where interview recordings are transcribed, observation notes reviewed, and documentary evidence organized. Following this, initial coding is conducted to identify recurring keywords, phrases, and concepts relevant to renewable energy adoption challenges. These codes are then grouped into broader themes, such as policy barriers, financial constraints, and community engagement.

A cross-case comparison is performed to contrast findings from the three case studies, identifying commonalities and project-specific challenges. The validation and interpretation stage ensures credibility and consistency through triangulation, comparing findings across multiple data sources. To enhance transparency and rigor, NVivo software is used for data management and coding (Bazeley & Jackson, 2013), ensuring that the analysis is systematic, reproducible, and well-documented.

This study employs a qualitative, multiple-case study design to explore the challenges

and opportunities in renewable energy adoption in Nigeria. By focusing on three case studies—Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project—the research provides a comparative analysis of stakeholder interactions, policy constraints, and technical challenges.

A multi-method data collection strategy (interviews, participant observation, and document analysis) ensures a rich, triangulated dataset, while purposive sampling allows for the inclusion of diverse stakeholder perspectives. Thematic analysis, supported by NVivo software, provides a systematic approach to identifying key themes and insights.

This research design ensures that findings are empirically grounded, contextually relevant, and methodologically rigorous, thereby contributing to both academic discourse and policy formulation in Nigeria's renewable energy sector.

3.5 Leveraging Stakeholder Theory for Qualitative Data Collection

Stakeholder Theory provides a robust analytical framework for examining the interactions, roles, and influences of various actors involved in renewable energy adoption (Freeman, Harrison & Zyglidopoulos, 2018). Given the complex socio-technical and institutional dynamics that shape the success of renewable energy projects, a stakeholder-driven qualitative research approach is essential for capturing the nuanced perspectives of key actors (Mitchell, Agle & Wood, 1997).

In this research, Stakeholder Theory is leveraged to inform the methodological approach, guiding the selection of data sources and ensuring a comprehensive understanding of renewable energy adoption in Nigeria. The study examines three case studies—Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project—to analyse how stakeholder interactions, policy frameworks, and institutional mechanisms influence project implementation and sustainability.

The qualitative data collection process incorporates multiple methods, including virtual site visits, in-depth interviews, document analysis, and stakeholder mapping, ensuring a triangulated approach that enhances validity and reliability (Denzin & Lincoln, 2018). This approach aligns with interpretivist epistemology, emphasizing the socially constructed nature of knowledge and the importance of understanding stakeholder

experiences in context (Saunders, Lewis & Thornhill, 2019).

3.5.1 Qualitative Data Collection

A multi-method qualitative approach is adopted to ensure rich, in-depth data collection. The following methods are employed to capture diverse stakeholder perspectives across the three case study projects.

3.5.1.1 **Virtual Site Visits and Observations**: The research involves virtual site visits to Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project to gain first-hand insights into the operational realities of renewable energy adoption. Observational techniques allow the researcher to document technical infrastructure, stakeholder interactions, and project-specific challenges (Creswell & Poth, 2018). Ethnographic engagement with project stakeholders provides contextualized insights into real-world barriers to renewable energy expansion (Bryman, 2016).

3.5.1.2 **Semi-Structured Interviews**: Interviews serve as the primary data collection method. Semi-structured interviews are conducted with key stakeholders, including government policymakers and regulators, renewable energy project managers, private sector investors, financial institutions, and local community members. These interviews explore themes such as stakeholder engagement, policy effectiveness, project financing, and technical barriers (Rowley, 2012). The study employs a set of twelve core interview questions, designed to elicit responses that align with the research objectives and allow for probing to clarify emerging themes. Interviews last approximately twenty to twenty-five minutes and are conducted virtually via Zoom, depending on participant availability. The semi-structured format ensures flexibility while allowing for consistency in data collection. Through open-ended questioning, participants articulate their experiences and perceptions, contributing to a deeper understanding of renewable energy project implementation (Adams, 2015). The interactive nature of the interview process enhances data quality by allowing the researcher to clarify responses and explore stakeholder motivations and concerns in depth (Qu & Dumay, 2011).

3.5.1.3 **Document Analysis**: Document analysis complements primary data collection by examining government reports, project feasibility studies, regulatory policies, and industry publications related to renewable energy adoption in Nigeria (Bowen, 2009). This method provides a historical and policy-oriented perspective, helping to contextualize findings within broader institutional frameworks (Flick, 2018). Reviewing policy documents also enables the identification of gaps in regulatory mechanisms and policy implementation that impact project success.

3.5.1.4 **Stakeholder Mapping and Engagement Analysis**: Stakeholder mapping is employed to systematically categorize and analyse the influence of different actors in renewable energy projects (Reed et al., 2009). This process identifies key decision-makers, power asymmetries, and collaboration networks, ensuring that the study captures the complex governance dynamics surrounding renewable energy initiatives (Newell, Phillips & Pueyo, 2021). Understanding these relationships is essential for assessing the effectiveness of stakeholder engagement strategies and policy interventions.

3.5.2 Data Validation and Triangulation

In qualitative research, the validity and credibility of findings do not derive from statistical generalizability, but from the depth, richness, and trustworthiness of the evidence and interpretations. To enhance the rigour, reliability, and credibility of this study's findings, the research employs a robust triangulation strategy—a cornerstone of qualitative validity that involves cross-verifying information from multiple sources, methods, and perspectives (Denzin, 2012; Flick, 2018). Triangulation reduces the influence of researcher bias, improves interpretive coherence, and facilitates a more nuanced understanding of complex social phenomena, particularly in case study research involving diverse stakeholders and institutional processes (Yin, 2018).

This study adopts a triangulated framework integrating methodological triangulation, data source triangulation, theoretical triangulation, and participant validation (member checking). These strategies are applied consistently across the analysis of semi-structured interviews and documentary sources, ensuring internal consistency and analytical depth.

3.5.2.1 Methodological Triangulation

Methodological triangulation refers to the use of multiple data collection methods to examine the same phenomenon (Patton, 2002). In this study, triangulation was achieved through the integration of semi-structured interviews, document analysis, virtual site observation, and stakeholder mapping. This multimethod approach enabled the researcher to collect overlapping and complementary data on stakeholder experiences, institutional behaviour, policy frameworks, and project implementation outcomes.

For instance, insights gathered from interviews with government officials regarding bureaucratic delays were cross validated with documentary evidence, such as project feasibility reports and policy implementation timelines. Where participants referred to technical challenges or community pushback, these accounts were compared against observed project conditions (via virtual site assessments) and textual records of stakeholder consultations, regulatory interventions, or media coverage.

By combining data derived from different modalities, methodological triangulation enhanced the robustness of findings and mitigated overreliance on any single data source.

3.5.2.2 Data Source Triangulation

Data source triangulation involves collecting information from multiple participant groups or institutional sources to assess the consistency of perspectives and reveal possible contradictions (Creswell & Poth, 2018). In this study, interviews were conducted with a diverse range of stakeholders across three renewable energy projects: government officials, engineers, energy consultants, investors, and members of local communities.

Each group offered distinct vantage points, often reflecting their positionality within the energy ecosystem. For example, whereas regulators emphasized policy compliance and institutional mandates, community members highlighted issues of marginalization, lack of participation, and unmet energy expectations. Data source triangulation enabled the researcher to identify thematic convergence and divergence, contributing to a richer and more contextualised interpretation of stakeholder dynamics and project performance.

Importantly, documents from multiple institutional origins (e.g., REA, NERC, international donor agencies, and private developers) were also compared to validating or challenging the narratives shared in interviews. This cross-source comparison strengthened the empirical foundations of the study and ensured analytical balance.

3.5.2.3 Theoretical Triangulation

Theoretical triangulation involves using more than one theoretical perspective to interpret the data (Denzin & Lincoln, 2018). While Stakeholder Theory forms the central analytical lens in this research—focusing on stakeholder identification, power dynamics, and legitimacy, this is complemented by insights from Institutional Theory, which highlights formal rules, informal norms, and governance challenges (North, 1990), and aspects of Political Economy Analysis, which inform the analysis of influence, interest, and power asymmetries.

This pluralistic approach allowed the researcher to move beyond a single-dimensional reading of stakeholder relationships and explore how institutional fragmentation, elite capture, and resource dependencies shaped renewable energy adoption outcomes. Theoretical triangulation also facilitated a more interdisciplinary and multi-scalar interpretation of policy discourse, regulatory behavior, and investment patterns.

3.5.3 Application of Triangulation in Interview and Document Analysis

In analysing semi-structured interviews, triangulation was operationalized by:

i. Comparing responses from participants occupying different roles in the same project.

ii. Cross-referencing individual accounts with official records, third-party evaluations, and global benchmarks (e.g., IEA, IRENA reports).

iii. Revisiting earlier interviews when new themes emerged, ensuring that emerging insights were validated across the dataset.

In document analysis, triangulation was applied by:

i. Comparing documents issued by different institutions (e.g., ministry-level policy documents vs. donor project reports) to identify alignment or contradictions.

ii. Cross-checking document claims against stakeholder experiences and observed project realities.

iii. Analysing language use, framing, and omissions to detect biases, assumptions, or gaps in institutional narratives (Bowen, 2009; Flick, 2018).

This bidirectional triangulation between interviews and documents ensured that findings were contextualised, verified, and empirically grounded.

3.5.4 Member Checking and Comparative Benchmarking

In addition to triangulation, member checking was conducted with selected key informants to ensure the accuracy and integrity of data interpretation. After the initial coding and thematic synthesis, summaries of findings were shared with a subset of participants to verify that their views were accurately represented and to provide an opportunity for correction or elaboration (Creswell, 2013). This process strengthened the credibility and confirmability of the analysis by introducing stakeholder feedback into the interpretation phase.

Furthermore, the study employed comparative benchmarking using the best global practices and insights from international energy organisations, including the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA). These comparisons helped situate Nigeria's renewable energy challenges within broader international trends, highlighting where domestic gaps align with or diverge from global norms (IRENA, 2021; IEA, 2022). This comparative validation adds another layer of triangulation by linking local data to global frameworks.

In summary, this study employs a comprehensive triangulation strategy to ensure that its findings are valid, credible, and theoretically robust. Through the integration of multiple data sources, methods, and perspectives—combined with reflexivity and participant validation—the research constructs a nuanced and empirically grounded account of renewable energy adoption in Nigeria. This methodological rigour enhances not only the quality of the data but also the legitimacy of the study's conclusions and policy recommendations.

3.5.5 Characterization of Research Data: Stakeholder Theory Perspective

Applying Stakeholder Theory, the research categorizes and analyses data sources to capture the multi-actor dynamics influencing renewable energy adoption in Nigeria (Freeman, 1984). The framework considers primary stakeholders, including government regulators, investors, and project developers, who play a direct role in decision-making and implementation. Secondary stakeholders, such as non-governmental organizations (NGOs), advocacy groups, and local community leaders, influence renewable energy policies and project acceptance through public engagement and lobbying efforts. Institutional intermediaries, including universities, research institutions, and multilateral development agencies, contribute expertise and technical knowledge, shaping policy formulation and capacity-building initiatives. By structuring data collection through a stakeholder-oriented lens, the research ensures a comprehensive and participatory understanding of Nigeria's renewable energy sector (Mitchell, Agle & Wood, 1997).

3.5.6 Identification of Renewable Energy Stakeholders in Nigeria: Historical Evolution

The evolution of renewable energy governance in Nigeria reflects shifting institutional and regulatory landscapes (Akinbami, 2022). Electricity generation was first introduced in Nigeria in 1896, followed by the establishment of the National Electric Power Authority (NEPA) in 1929. In 2000, power sector reforms initiated the transition toward privatization and regulatory restructuring, leading to the creation of the Nigerian Electricity Regulatory Commission (NERC) in 2005. Further restructuring in 2010 saw the formation of the Nigerian Bulk Electricity Trading Plc (NBET), which became responsible for facilitating market transactions between electricity generators and distribution companies. By 2013, the Nigerian government privatized electricity generation and distribution, retaining control over transmission infrastructure through the Transmission Company of Nigeria (TCN).

Currently, Nigeria's electricity landscape consists of one transmission company, six generation companies, and eleven distribution companies. The regulatory framework is governed by NERC, while REA plays a pivotal role in rural electrification initiatives. The growing involvement of private sector actors, international investors, and development agencies further shapes Nigeria's renewable energy trajectory. Figures 3.1 and 3.2 illustrate the structure of renewable energy governance in Nigeria, mapping key

stakeholder interactions.

Incorporating Stakeholder Theory into the research methodology ensures that the multi-dimensional factors shaping renewable energy adoption in Nigeria are adequately captured. By employing qualitative research methods such as site visits, interviews, document analysis, and stakeholder mapping, the study generates rich, context-driven insights into the policy, financial, and technological barriers facing Nigeria's renewable energy sector. This stakeholder-driven approach enhances the study's theoretical depth while offering practical insights for policymakers, investors, and project developers navigating Nigeria's renewable energy transition.

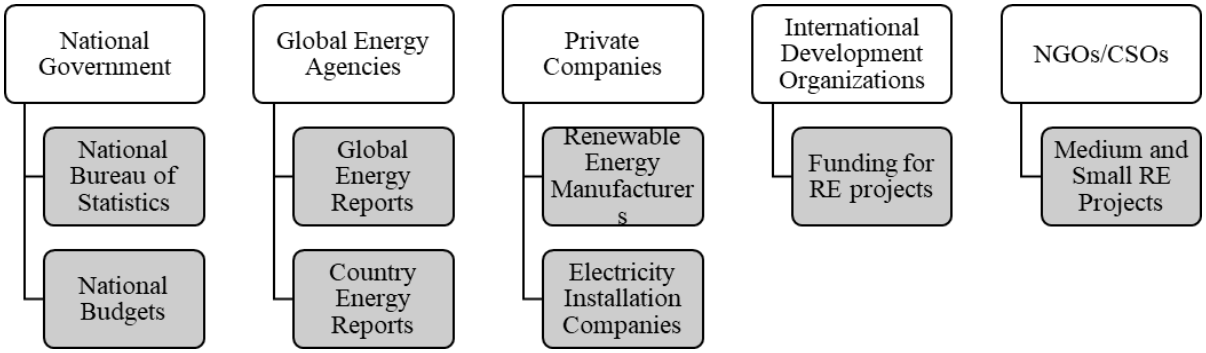

Figure 3.1: Sources of Available Research Data

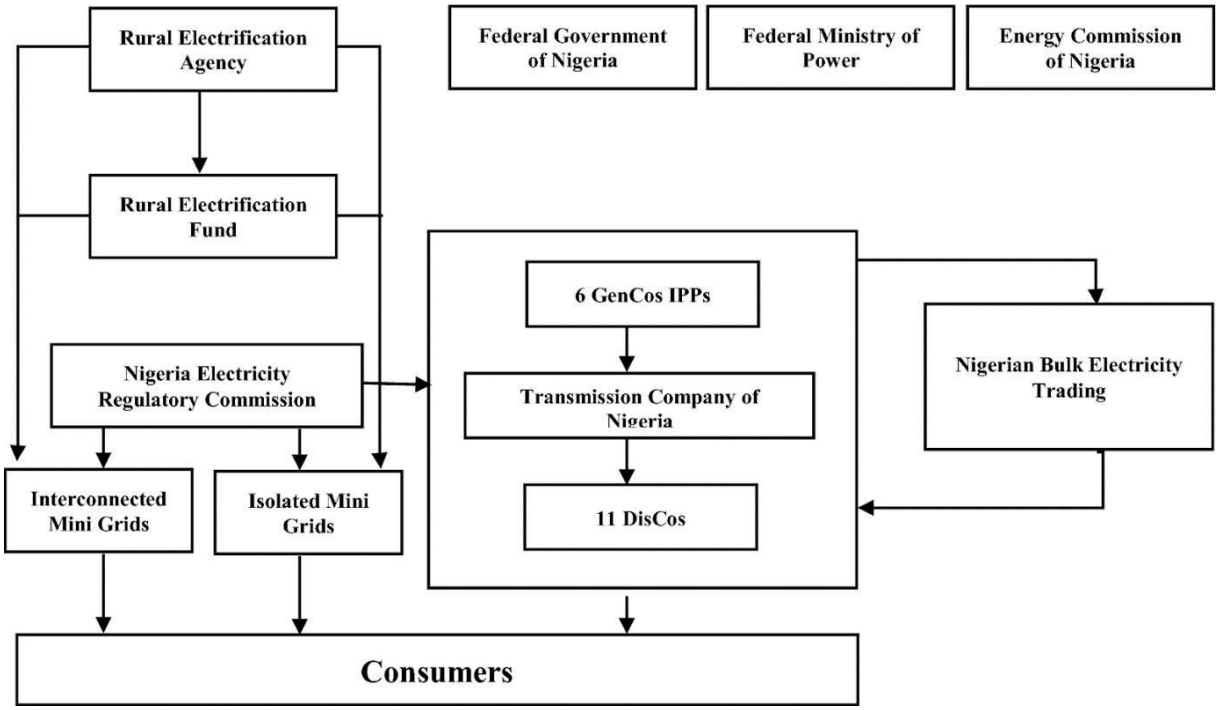

Figure 3.2: Renewable Energy Stakeholders within the Nigerian Electricity Structure (Source: (Adeyanju et al., 2020))

3.6. Ethical Considerations

Ethical considerations are a cornerstone of rigorous and responsible research, particularly when studies involve human participants. Ethics guides the researcher in ensuring that research is conducted with integrity, fairness, transparency, and respect for participants' rights and well-being (Bryman, 2016). In qualitative research, which involves in-depth interviews, subjective narratives, and potentially sensitive topics, ethical principles must be actively embedded throughout the research lifecycle (Tracy, 2010; BSA, 2017).

This study strictly complied with both institutional and international ethical standards. Ethical approval was granted by the University of Central Lancashire's Ethics Review Committee prior to fieldwork commencement. The research also followed the ethical codes of the British Sociological Association (BSA, 2017), the UK General Data Protection Regulation (GDPR, 2018), and the Belmont Report (1979), which collectively outline the principles of beneficence, non-maleficence, autonomy, and justice (Beauchamp & Childress, 2019).

3.6.1 Informed Consent and Voluntary Participation

Informed consent is central to ethical research as it upholds the principle of autonomy and respects individuals' right to self-determination (Creswell & Poth, 2018). In this study, all participants were provided with a detailed Participant Information Sheet (PIS) explaining the study's aims, scope, methods, potential risks, data use, and confidentiality protocols. The PIS was written in clear, accessible language to ensure understanding across various educational backgrounds.

Participants were given sufficient time to read the document, ask questions, and consult third parties if they wished. Only after fully understanding the content did they sign a Consent Form, confirming voluntary participation. For online interviews (via Zoom), verbal consent was digitally recorded and reconfirmed at the start of the session in line with best practices for remote research ethics (Markham & Buchanan, 2012).

Participants were further reminded of their right to withdraw at any point without giving reasons, and without any consequence. This provision was reaffirmed before, during, and after the interviews. Additionally, they were given the option to skip questions they felt uncomfortable answering, thereby ensuring that participation

remained non-coercive and fully voluntary (Saunders, Lewis & Thornhill, 2019).

3.6.2 Anonymity, Confidentiality, and Data Protection

Protecting the identity and personal data of participants is a fundamental ethical obligation in qualitative research (Wiles et al., 2008). This study followed strict procedures to ensure both anonymity and confidentiality.

Participants' names, job titles, institutions, and other potentially identifying details were pseudonymised using alphanumeric codes, and interview transcripts were redacted to prevent deductive disclosure. For example, references to specific geographic locations or policy incidents were either generalized or excluded to further protect identities.

All data, including audio files, transcripts, consent forms, and metadata—were securely stored on an encrypted, password-protected university-approved server. The researcher was the sole person with access to raw data. Data storage and handling fully complied with the GDPR (2018), which mandates lawful, transparent, and secure processing of personal data (ICO, 2019).

Where quotes were used in the final thesis, they were carefully selected and sometimes slightly rephrased to preserve participant confidentiality without distorting meaning (Bazeley, 2013). No direct identifiers were included, and efforts were made to ensure that no individual or institution could be recognized from the data, even indirectly.

3.6.3 Avoidance of Harm and Researcher Reflexivity

The study was designed with the principle of non-maleficence in mind, ensuring that no physical, psychological, emotional, or reputational harm came to any participant (Orb, Eisenhauer & Wynaden, 2001). The subject matter focused on renewable energy challenges in Nigeria had the potential to raise politically sensitive or institutionally critical perspectives. Therefore, all interview questions were open-ended, neutrally phrased, and piloted beforehand to avoid leading or provocative language.

Participants were given the freedom to stop the interview at any time or to decline to answer any question. The researcher also remained vigilant to verbal and non-verbal cues indicating discomfort, and interviews were paused or rescheduled where necessary. This approach was intended to create a psychologically safe environment conducive to honest and open dialogue (Denzin & Lincoln, 2018).

Moreover, researcher reflexivity was employed throughout the research process. Given the researcher's background as a Nigerian national with academic and professional exposure to the energy sector, there was a potential for subjective interpretations. To mitigate this, a reflexive diary was kept, recording reflections on positionality, emerging biases, and methodological decisions (Finlay, 2002). These reflections were periodically discussed with supervisors to ensure objectivity and transparency.

3.6.4 Conflict of Interest and Transparency

Transparency about conflicts of interest is vital in maintaining trust and research integrity (Bell & Bryman, 2007). At the beginning of each interview, the researchers disclosed their funding support from the Petroleum Technology Development Fund (PTDF) and clarified that the study was independent and not affiliated with any government agency or private company involved in the energy sector.

Participants were also informed that their contributions would be used strictly for academic purposes and that no commercial or political use would be made of their responses. This disclosure fostered openness and accountability, ensuring that participants could trust the research process and its outcomes.

No direct affiliations, financial incentives, or personal relationships with any of the renewable energy projects studied existed that could bias the data collection, analysis, or reporting. All sources of support, including financial and institutional, are transparently disclosed in this thesis, in line with the university's code of research conduct.

3.6.5 Ethical Oversight and Compliance

Ethical compliance did not end with ethics approval; rather, it was maintained throughout the research lifecycle. An ethics log was maintained, documenting interactions with participants, decisions taken to address ethical dilemmas, and data access controls. This ensured ongoing adherence to the ethical principles of beneficence, justice, and respect for people (Beauchamp & Childress, 2019).

Data will be retained securely for five years post-submission, following the University of Central Lancashire's research data retention policy. After this period, all raw data, including audio files and transcripts, will be permanently deleted using secure deletion protocols.

Any future publications or conference presentations arising from this research will maintain full confidentiality among participants. No identifying information will be revealed in any form of dissemination.

In summary, ethical considerations were comprehensively embedded into the design, conduct, and dissemination of this research. Measures were taken to uphold participant autonomy through informed consent, protect personal data through confidentiality and GDPR compliance, and minimize harm through sensitive interviewing and reflexive practices. Transparency regarding institutional support and conflict of interest enhanced the trustworthiness of the research, while ongoing ethical oversight ensured sustained compliance throughout the project.

These ethical safeguards not only protected participant welfare but also enhanced the methodological rigour and credibility of the research, contributing to its value as an academically sound and ethically responsible investigation into renewable energy adoption in Nigeria.

3.7 Reliability and Validity in Qualitative Research

In qualitative research, ensuring reliability and validity—often referred to as trustworthiness—is essential to uphold the credibility, rigor, and replicability of the study's findings (Lincoln & Guba, 1985). This research addresses these dimensions through a combination of well-established techniques, including triangulation, member checking, detailed audit trails, reflexivity, and transparency in data management.

Reliability, in qualitative research, pertains to the consistency and dependability of the research process and the extent to which it can be replicated under similar conditions (Silverman, 2021). Although replication is not always the aim of qualitative inquiry, this study ensures process reliability by applying a structured case study protocol (Yin, 2018). Data collection instruments—such as the interview guides—were pre-tested to ensure consistency in questioning across all participants and case study sites.

Validity, on the other hand, refers to the accuracy and truthfulness of the findings as they relate to the realities and perspectives of the participants (Creswell & Poth, 2018). To enhance credibility, the research employed prolonged engagement with each case, conducting multiple interviews with key stakeholders, and spending sufficient time interpreting project documents and observations. Triangulation—the use of multiple data sources (interviews, documents, observations)—enabled cross-

verification of data, thus reducing the risk of systematic bias and increasing interpretive validity (Denzin, 2012).

Further, member checking was employed to enhance the accuracy of data interpretation. Key participants were given summaries of their interview transcripts and the opportunity to verify or challenge the interpretations drawn from their inputs. This process reduces the likelihood of researcher misrepresentation and supports co-construction of meaning between the researcher and participants (Birt et al., 2016).

To ensure transferability, thick description was adopted. This involves providing detailed accounts of the research context, participant backgrounds, and institutional settings so that readers can assess the relevance of the findings to other contexts (Tracy, 2010). The use of maximum variation sampling also ensured the inclusion of diverse perspectives, enhancing the breadth of the findings and their potential applicability to other settings.

To establish confirmability, a reflexive journal was maintained throughout the data collection and analysis phases. This journal documented the researcher's decisions, biases, and interactions, helping to distinguish between participants' perspectives and the researcher's interpretations (Finlay, 2002). Additionally, the coding framework used in thematic analysis was systematically documented and implemented using NVivo software, allowing for an auditable trail of the analytical process (Bazeley & Jackson, 2013).

Dependability was supported by maintaining a comprehensive methodological audit trail. This includes detailed documentation of interview schedules, transcription protocols, coding schemes, and memo writing during the analytical process. By making these processes transparent and traceable, the study ensures that other researchers can follow and understand the research pathway taken (Nowell et al., 2017).

In conclusion, the reliability and validity of this research are firmly grounded in qualitative best practices. Through methodological transparency, triangulation, reflexivity, and rigorous data analysis procedures, the study adheres to the highest standards of qualitative inquiry, ensuring that the findings are robust, trustworthy, and meaningful in the context of renewable energy adoption in Nigeria.

3.8 Summary

This chapter has provided a comprehensive discussion of the research methodology adopted in this study, which is grounded in qualitative research methods and underpinned by Stakeholder Theory. The methodological choices have been guided by the need to explore the complex and multi-faceted challenges of renewable energy adoption in Nigeria, particularly through case studies of the Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project. The chapter outlined the philosophical foundations of the study, emphasising an interpretivist epistemology and an inductive research approach, which allow for a deeper understanding of stakeholder experiences, policy interactions, and institutional constraints.

A case study strategy was adopted as the most appropriate methodological framework, given its ability to provide rich, contextualized insights into the social, political, economic, and technological barriers influencing renewable energy projects. Through this approach, multiple sources of data including in-depth interviews, participant observations, and document analysis were triangulated to ensure the credibility and reliability of findings. The study's empirical research design was structured to systematically investigate the challenges, opportunities, and policy dynamics associated with renewable energy implementation in Nigeria.

The research design section outlined the data collection methods, detailing the use of semi-structured interviews as the primary method of engagement with government officials, energy policymakers, private investors, community representatives, and renewable energy experts. These interviews were guided by a set of core thematic questions, allowing for flexibility while ensuring consistency across case studies. To further enhance the robustness of data interpretation, participant observations and document analysis were integrated to capture institutional frameworks, regulatory documents, and previous project reports.

Sampling in this study followed a purposive sampling strategy, ensuring that participants were selected based on their direct involvement in renewable energy projects. This approach allowed for the inclusion of diverse perspectives while maintaining thematic saturation in qualitative data collection. The data analysis framework was structured around a thematic analysis approach, enabling the identification of emergent patterns and theoretical constructs relevant to renewable

energy adoption in Nigeria.

Ethical considerations played a central role in shaping the research process. The study adhered to institutional ethical guidelines, with a strong emphasis on informed consent, anonymity, and data security. Participants were fully briefed on the objectives and implications of the study, and mechanisms were put in place to protect their confidentiality in accordance with General Data Protection Regulation (GDPR) principles. Furthermore, the researcher-maintained reflexivity throughout the study, acknowledging potential biases and ensuring an ethical and responsible engagement with research participants.

By leveraging Stakeholder Theory, the study ensured a structured framework for identifying key actors in Nigeria's renewable energy landscape, their interests, and the power dynamics that shape policy implementation. This theoretical lens enabled the study to assess the role of government agencies, private investors, local communities, and regulatory institutions in facilitating or hindering renewable energy transitions. The integration of historical policy evolution further contextualized the contemporary challenges of renewable energy governance in Nigeria, particularly the implications of privatization, institutional restructuring, and policy fragmentation.

This chapter has also acknowledged potential limitations associated with qualitative research, including subjectivity, researcher positionality, and the challenge of generalizability. However, the rigor of the study was strengthened through methodological triangulation, reflexive analysis, and data validation processes, ensuring credibility, dependability, and transferability of findings.

In summary, Chapter 3 has provided the strategic blueprint that guides the empirical investigation of this research. By adopting a qualitative, case study-driven, and inductive approach, the study seeks to generate policy-relevant insights into the barriers and opportunities shaping Nigeria's renewable energy sector. The methodological rigor embedded in this research ensures that findings will contribute to academic discourse, inform policymaking, and provide practical recommendations for enhancing the success and scalability of renewable energy initiatives in Nigeria.

The subsequent chapters will present the empirical case study findings, cross-case analysis, and theoretical reflections, further demonstrating how the chosen

methodology facilitates an in-depth understanding of renewable energy adoption in Nigeria.

CHAPTER 4 – CASE STUDIES

4.1 Introduction

This chapter provides a comprehensive examination of three distinct case studies focusing on renewable energy adoption in Nigeria. The selected cases—the Katsina Wind Farm, the Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project—serve as illustrative examples of the opportunities and challenges associated with implementing sustainable energy solutions in diverse contexts within the country. These case studies represent different facets of renewable energy deployment, encompassing wind energy and solar photovoltaic (PV) systems, and their implications for large-scale energy transition.

Renewable energy adoption is critical for addressing Nigeria's pressing energy challenges, including over-reliance on fossil fuels, insufficient grid coverage, and the growing demand for sustainable energy solutions. Despite the nation’s abundant renewable energy resources, particularly in solar and wind energy, the rate of adoption remains limited due to a range of systemic barriers. This study employs Robert K. Yin's methodological approach to case study research to provide a structured and nuanced exploration of these barriers and potential pathways for improvement.

The purpose of this chapter is to explore the contextual, technical, and organizational aspects of these projects, as well as their broader implications for Nigeria's energy landscape. By focusing on the real-world implementation of renewable energy technologies, the chapter aims to identify the drivers, constraints, and critical success factors that have shaped these initiatives.

4.1.1 Overview of the selected case studies

The use of a case study approach is particularly apt for this research, as it allows for an in-depth investigation of complex phenomena within their real-life settings. Following Yin’s framework, the case studies are designed to answer the "how" and "why" questions related to renewable energy adoption in Nigeria, offering rich, empirical insights that extend beyond surface-level observations. This methodology not only captures the intricacies of each project but also facilitates cross-case analysis to identify recurring themes and unique deviations. Case studies provide the opportunity to examine the interplay between economic, political, technological, and social factors in shaping project outcomes. For instance, the Katsina Wind Farm offers valuable insights

into the challenges of integrating wind energy into Nigeria's power sector, while the solar projects at BUK and UNIMAID shed light on the application of solar PV systems in educational institutions with varying levels of grid access and security concerns.

The first case study, the Katsina Wind Farm, represents Nigeria's pioneering attempt to integrate wind energy into the national grid. Initiated in 2005, the project faced multiple challenges, including regulatory bottlenecks, funding delays, and technical capacity constraints. Despite these obstacles, the project underscores the potential of wind energy to complement the country's energy mix.

The second case study focuses on the Bayero University Kano Solar Project, a 7.1 MW hybrid solar PV installation designed to address the unreliable grid power supply and reduce dependence on diesel generators. As one of Nigeria's flagship renewable energy projects in higher education, it highlights the role of solar energy in promoting sustainability within academic institutions.

The third case study examines the University of Maiduguri Solar Project, part of the federal government's Energizing Education Programme. Located in a conflict-prone region, this project presents unique logistical and security challenges but also demonstrates the transformative potential of renewable energy in fostering inclusivity and resilience.

4.2 Business Environment and the Industrial Context

Nigeria is endowed with abundant renewable energy resources, including solar, wind, biomass, and small hydropower. Despite this, the energy sector remains heavily reliant on fossil fuels, with gas-fired plants accounting for over 80% of electricity generation (International Energy Agency [IEA], 2021). This dependence, coupled with insufficient and unreliable energy supply, has left nearly 85 million Nigerians—approximately 43% of the population—without access to grid electricity, particularly in rural areas (World Bank, 2020). This stark energy deficit has intensified interest in renewable energy as a viable solution to bridge the gap.

Currently, the renewable energy sector in Nigeria contributes marginally to the national energy mix. According to the International Renewable Energy Agency (IRENA, 2021), renewables account for only about 0.9% of the country's total energy supply, despite

Nigeria's vast solar and wind energy potential. The Nigerian Energy Support Programme (NESP, 2018) underscores the slow integration of renewables, citing challenges such as infrastructural deficits, inadequate funding, and policy execution gaps as significant barriers.

Solar energy has emerged as a leading renewable energy option due to Nigeria's location within the Sun Belt, which ensures high solar radiation levels throughout the year. Similarly, wind energy has shown potential in regions like Katsina, where favorable wind speeds make it suitable for large-scale generation (NESP, 2020). However, unlocking this potential requires addressing systemic barriers, including regulatory delays, financing limitations, and insufficient technical expertise, which have historically slowed renewable energy adoption in the country.

4.2.1 Policy Landscape and Regulatory Framework

The Nigerian government has introduced several policy initiatives aimed at promoting renewable energy. Key among these is the Renewable Energy Master Plan (REMP), first introduced in 2005 and revised in 2012, which outlines strategies for increasing renewable energy's share in the national energy mix (Nigerian Energy Support Programme [NESP], 2018). Additionally, the National Renewable Energy and Energy Efficiency Policy (NREEEP) sets ambitious targets for renewable energy deployment, including achieving 30% renewable energy by 2030 (International Renewable Energy Agency [IRENA], 2021).

Programs such as the Energizing Education Programme (EEP) and the Rural Electrification Strategy and Implementation Plan (RESIP) have been critical in driving renewable energy adoption in universities and rural communities (World Bank, 2020). These initiatives aim to deploy solar and hybrid systems in educational institutions and off-grid areas, improving access to electricity while reducing dependence on fossil fuels. For instance, the EEP has facilitated the installation of solar hybrid systems in several Nigerian universities, including the University of Maiduguri and Bayero University Kano, significantly enhancing energy reliability and efficiency (NESP, 2020).

However, the regulatory environment poses significant challenges. Delays in securing permits, lack of streamlined approval processes, and inconsistencies in policy implementation hinder project execution (GIZ, 2020). Furthermore, the absence of

robust incentives, such as tax breaks and subsidies for renewable energy components, have limited private sector participation and investment (International Energy Agency [IEA], 2021). Addressing these regulatory and policy gaps is critical to accelerating the adoption of renewable energy in Nigeria.

4.2.2 Economic and Financial Context

The economic context of Nigeria is marked by volatility, influenced by fluctuations in global oil prices, currency devaluation, and high inflation rates. These economic conditions directly impact on the renewable energy sector by increasing the cost of importing components such as solar panels, wind turbines, and battery storage systems (International Renewable Energy Agency [IRENA], 2021). Furthermore, the high upfront costs of renewable energy projects often deter investment, particularly in a country where access to affordable financing is limited (Nigerian Economic Summit Group [NESG], 2020).

International funding agencies, such as the World Bank and the African Development Bank (AfDB), have played a significant role in bridging this financial gap. For instance, the World Bank's $350 million support for the Energizing Education Programme (EEP) has been instrumental in implementing large-scale solar projects across Nigerian universities, including the University of Maiduguri and Bayero University Kano (World Bank, 2020). Similarly, blended financing models combining public and private sector investments have emerged as viable solutions to address financial constraints (GIZ, 2020). These models have helped to reduce reliance on singular funding sources and ensure financial sustainability for renewable energy initiatives in Nigeria.

4.2.3 Social and Cultural Factors

Social attitudes and awareness of renewable energy significantly influence its adoption in Nigeria. While urban areas have shown increasing acceptance of renewable energy technologies, rural communities often remain skeptical, primarily due to limited awareness and exposure (International Renewable Energy Agency [IRENA], 2021). Cultural factors, including resistance to change and trust issues with government-led initiatives, further complicate adoption in rural areas (Nigerian Energy Support Programme [NESP], 2020).

Community engagement has proven to be a critical success factor in overcoming these barriers. For instance, the Katsina Wind Farm project emphasized community consultations during its planning and implementation phases to address local concerns about land use and environmental impact (GIZ, 2020). Similarly, the University of Maiduguri (UNIMAID) Solar Project successfully incorporated stakeholder involvement, which helped mitigate scepticism and fostered trust among residents and stakeholders (World Bank, 2020).

Additionally, capacity-building initiatives, such as training programs for local technicians and engineers, have enhanced community participation and ownership (Nigerian Economic Summit Group [NESG], 2020). These programs not only improve technical skills but also ensure the sustainability of renewable energy projects by enabling local communities to manage and maintain the systems effectively.

4.2.4 Technological Landscape

Technological advancements play a pivotal role in renewable energy adoption. Nigeria has witnessed the introduction of innovative solutions such as hybrid solar PV systems, smart inverters, and real-time monitoring technologies, which have been particularly effective in addressing challenges like intermittent power supply, system maintenance, and performance optimization (GIZ, 2020). For example, projects under the Energizing Education Programme (EEP) have integrated hybrid solar systems with advanced battery storage to ensure uninterrupted electricity supply to universities and teaching hospitals (World Bank, 2020).

However, the lack of local manufacturing capabilities for renewable energy components remains a significant hurdle. The dependence on imports for critical components such as solar panels, wind turbines, and battery systems not only increases costs but also exposes projects to supply chain disruptions, as highlighted by the Nigerian Energy Support Programme (NESP, 2020). These disruptions became particularly evident during the COVID-19 pandemic, which affected the timely delivery of imported components (IRENA, 2021).

Building local capacity for manufacturing and technical expertise is essential for scaling renewable energy solutions. According to the Nigerian Economic Summit Group (NESG, 2020), initiatives to establish local production facilities and invest in skills

development can significantly reduce costs and enhance the sustainability of renewable energy projects in Nigeria.

4.2.5 Environmental and Geographic Context

Nigeria's diverse geography presents both opportunities and challenges for renewable energy projects. Regions such as the northern states, including Katsina, experience high wind speeds, making them ideal for wind energy generation, as evidenced by the Katsina Wind Farm project (GIZ, 2020). Similarly, solar radiation levels are abundant and consistent across the country, making solar power viable for both grid-connected and off-grid applications (IRENA, 2021). The Renewable Energy Master Plan identifies the northern and central regions as hotspots for renewable energy investments due to their favourable climatic conditions (NESP, 2018).

However, environmental challenges such as desertification in the north and coastal erosion in the south can hinder project implementation and long-term sustainability. Desertification, for instance, exacerbates dust accumulation on solar panels, reducing efficiency and increasing maintenance requirements (NESG, 2020). Similarly, coastal erosion poses risks to infrastructure stability in southern regions, complicating deployment in these areas.

Environmental regulations, such as mandatory Environmental Impact Assessments (EIAs), are designed to ensure compliance with sustainability standards and minimize adverse environmental impacts. However, the bureaucratic nature of these processes often leads to delays, as noted by the Nigerian Energy Support Programme (NESP, 2020). Streamlining these regulatory procedures and adopting a more proactive approach to environmental challenges will be critical for accelerating renewable energy adoption.

4.2.6 Industry Challenges and Opportunities

The renewable energy sector in Nigeria faces several systemic challenges. One of the primary issues is regulatory delays, with lengthy approval processes and bureaucratic hurdles hindering timely project implementation. For instance, the Nigerian Energy Support Programme (NESP, 2018) notes that inefficiencies in obtaining permits and clearances can delay projects by months or even years. Financial constraints also pose significant barriers, as limited access to affordable financing deters private sector investment and slows down project rollouts (World Bank, 2020).

A critical issue is the shortage of technical expertise, which affects the installation, operation, and maintenance of renewable energy systems. Reports by the International Renewable Energy Agency (IRENA, 2021) emphasize the need for capacity-building initiatives to train local personnel. Additionally, infrastructure deficiencies, including poor road networks and unreliable grid systems, complicate the logistics of transporting renewable energy components, particularly to remote and off-grid areas (NESG, 2020). Despite these challenges, the renewable energy sector offers significant opportunities. Renewable energy solutions have the potential to bridge the energy access gap, particularly in off-grid communities, where nearly 85 million Nigerians lack access to electricity (IEA, 2021). Furthermore, the sector can drive economic development through job creation and the establishment of local manufacturing capabilities for solar panels and wind turbines (GIZ, 2020). Environmental benefits are another key advantage, as transitioning to renewable energy can significantly reduce greenhouse gas emissions and support Nigeria's climate goals under the Paris Agreement (NESP, 2018).

To fully capitalize on these opportunities, there is a need for targeted policy interventions, enhanced financial incentives, and capacity-building initiatives to address existing challenges and unlock the potential of Nigeria's renewable energy sector.

4.2.7 Implications for the Case Studies

The business environment and industrial context described above provide a critical backdrop for understanding the case studies presented in this chapter. Each project—Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project—operates within the constraints and opportunities of Nigeria's renewable energy sector. The challenges of regulatory delays, financial constraints, and technological integration observed in the broader industry are mirrored in these case studies. For instance, the Nigerian Energy Support Programme (NESP, 2018) highlights that delays in obtaining necessary permits often hinder the progress of renewable energy projects, as observed in the Katsina Wind Farm. Similarly, limited access to affordable financing, as noted by the World Bank (2020), has been a recurring issue across all three projects.

The technological integration challenges observed in the broader sector, such as dependence on imported components and limited local manufacturing capacity, are also

reflected in these case studies. Reports by IRENA (2021) emphasize the need for innovative solutions like hybrid systems and real-time monitoring, which have been adopted in projects such as the BUK and UNIMAID Solar Projects.

On the other hand, the case studies also illustrate the sector's significant opportunities. The potential for community engagement and capacity building is evident in the UNIMAID Solar Project, which included training initiatives for STEM students, particularly women, aligning with the goals of the Energizing Education Programme (EEP, 2020). Similarly, leveraging international funding, such as the World Bank's $350 million investment in the EEP, has been instrumental in overcoming financial barriers and scaling projects like the BUK Solar Project.

This context underscores the need for tailored solutions that address Nigeria's unique economic, social, and regulatory environment. As the Nigerian Economic Summit Group (NESG, 2020) notes, aligning renewable energy projects with national and regional priorities is essential to maximize their impact and sustainability. In the subsequent sections, these factors will be explored in detail through the lens of the selected case studies, offering insights into the challenges and successes of renewable energy adoption in Nigeria.

4.3 Case Study Protocol

4.3.1 Overview of the Case Study Methodology

The methodology for this chapter is grounded in Robert K. Yin's case study approach, which emphasizes the exploration of complex real-life phenomena within their specific contexts. This approach allows for the investigation of renewable energy adoption in Nigeria, focusing on its challenges, drivers, and broader implications. Yin's emphasis on the "how" and "why" questions underpin this study's methodology, enabling a nuanced understanding of factors influencing renewable energy projects in the country. The case study protocol adopted for this research ensures methodological rigor and replicability. It provides a framework for data collection, analysis, and interpretation, adhering to established best practices in qualitative research. The protocol includes clearly defined research questions, a structured approach to data collection, and systematic procedures for data analysis, ensuring the validity and reliability of findings.

4.3.2 Research Questions

The following overarching questions guided the case studies:

1. How do economic, political, technological, and social factors impact the adoption and success of renewable energy projects in Nigeria?
2. What are the specific challenges encountered in the Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project?
3. What lessons can be learned from these case studies to inform future renewable energy initiatives in Nigeria?
4. How do social attitudes, perceptions, and awareness about these case studies influence renewable energy adoption in Nigeria?

4.3.3 Case Selection Criteria

The selection of the Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project was based on the following criteria:

- **Relevance:** The projects represent critical renewable energy initiatives in Nigeria, spanning diverse technologies and contexts (wind and solar energy, institutional and regional differences).
- **Impact Potential:** Each project demonstrates the potential to address key energy challenges, including unreliable power supply and over-reliance on fossil fuels.
- **Geographical and Sectoral Diversity:** The projects are located in different regions (Katsina, Kano, and Maiduguri) and address various sectors, such as education, healthcare, and regional electrification.
- **Data Availability:** Access to stakeholders, documents, and project sites was a critical factor in selecting these cases.

4.3.4 Data Collection Procedure

A multi-method data collection strategy was employed, combining semi-structured interviews, document analysis, and field observations. This triangulated approach ensures a comprehensive understanding of each case study.

- **Document Analysis**
    - Key documents analysed included feasibility studies, project reports, policy documents, and contracts.

    - The analysis focused on understanding project objectives, funding mechanisms, technological configurations, and regulatory compliance.
- **Field Observations**
    - Virtual visits to project sites allowed for direct observation of infrastructure, operational processes, and community interactions.
    - Observations provided valuable contextual data and helped validate findings from interviews and documents.
- **Semi-Structured Interviews**
    - Conducted with key stakeholders, including project coordinators, engineers, policymakers, and community representatives.
    - The interviews were guided by a set of predetermined questions but allowed flexibility to explore emergent themes.
    - Participants provided insights into project design, implementation, and outcomes, as well as the challenges faced, and lessons learned.

Developing well-structured questions that align with the research aims is essential, as it forms the foundation for eliciting relevant data. Moreover, incorporating open-ended prompts and follow-up queries enhances the interviewer's ability to explore deeper into participants' experiences and viewpoints, uncovering nuances that might remain hidden with closed-ended inquiries (Rubin & Rubin, 2012). The process of asking the right questions extends beyond the initial query; it involves active listening, empathy, and flexibility to adapt the interview flow based on the participant's responses (Kvale & Brinkmann, 2015). By doing so, qualitative interviews become a dynamic dialogue that not only captures the intended data but also reveals unexpected perspectives and dimensions (Flick, 2018). Ultimately, the skill of asking the right questions in qualitative interviews is akin to unlocking a treasure trove of narratives and insights, allowing researchers to navigate the complexities of their study with precision and depth (Mason, 2018). The following set of questions were asked.

Personal Information

1. How long have you been involved in renewable energy projects?
2. What is your current role in the renewable energy sector, and how long have you been in this position?

3. What previous experience do you have in renewable energy or related fields?

   Rationale: Understanding the background and experience of the participant helps contextualize their perspectives on renewable energy adoption. It also provides insight into their expertise, tenure, and role within the sector.

Project Overview

4. What are the main objectives of the renewable energy project you are involved in?
5. Which key industries or sectors does the project aim to support?
6. How does this project contribute to energy development and electrification goals?

   Rationale: Assessing the project's objectives and target sectors provides insight into its strategic direction and alignment with broader energy goals. This helps determine whether the project is aimed at electrification, economic development, or sustainability efforts.

Experience and Values

7. Can you describe your experience working on renewable energy projects?
8. What are the core values that guide your approach to implementing renewable energy initiatives?

   Rationale: Exploring the participant's experiences and values highlights personal and organizational drivers for renewable energy engagement. It reveals motivations and guiding principles that shape their approach to sustainability.

Knowledge and Perception of Renewable Energy

9. What is your understanding of renewable energy and its importance in energy transition?
10. Are there any specific renewable energy projects you have been involved in or are aware of?
11. What are your thoughts on the progress and adoption of renewable energy in different sectors?

    Rationale: Evaluating knowledge and perceptions helps assess awareness, challenges, and opportunities in renewable energy adoption. Understanding how individuals and organizations view renewable energy informs policy and engagement strategies.

Project Initiation

12. What motivated the initiation of this renewable energy project?
13. Can you walk us through the decision-making process for selecting renewable energy as a solution?
14. What initial challenges did the project face, and how were they addressed?

    Rationale: Examining project initiation provides insights into motivations, decision-making processes, and initial hurdles faced. This helps in understanding the rationale behind selecting renewable energy as a viable solution.

Stakeholder Engagement and Collaboration

15. Who are the key stakeholders involved in the project, and what roles do they play?
16. How is engagement with local communities, employees, and other stakeholders ensured in planning and implementation?
17. What strategies have been used to collaborate with government bodies, private sector entities, and community organizations?

    Rationale: Identifying key stakeholders and engagement strategies reveals collaboration dynamics and potential challenges in project implementation. It also assesses how different groups contribute to or resist renewable energy projects.

Technological Integration and Innovation

18. What renewable energy technologies have been adopted for the project, and why were they chosen?
19. How has innovation been leveraged to overcome technical challenges or enhance project efficiency?
20. What lessons have been learned about integrating renewable energy systems into existing infrastructure?

    Rationale: Investigating technology choices and innovations showcases advancements and solutions for overcoming technical barriers. This section examines how technological improvements impact project efficiency and success.

Financial Viability and Economic Impact

21. How is the financial feasibility and economic viability of the project assessed?
22. What funding mechanisms or investment sources have been utilized to support the initiative?
23. Have there been any notable economic or social impacts as a result of the project?

    Rationale: Assessing financial viability helps understand economic sustainability, investment sources, and socio-economic impacts. It highlights whether the project has long-term economic benefits and how it influences local communities.

Regulatory and Policy Framework

24. How has the regulatory and policy environment influenced the project?
25. Have any regulatory or legal challenges been encountered, and how were they resolved?
26. What policy changes would you recommend to further support renewable energy initiatives?

    Rationale: Understanding the influence of regulatory frameworks helps highlight policy enablers and barriers to renewable energy implementation. This is crucial for identifying areas that require policy reform or government intervention.

Funding and Investment Challenges

27. What were the key funding sources for the project? Were there any challenges in securing funding?
28. How did financial constraints impact the progress and completion of the project?

    Rationale: Examining funding challenges provides insight into financial constraints and strategies for securing investment. It highlights difficulties in attracting funding and how they impact project execution.

Economic Viability

29. How was the financial feasibility of the project assessed?
30. Did any economic factors contribute to delays or obstacles in the project?

Rationale: Assessing economic viability ensures an understanding of cost-benefit analyses and market sustainability. This helps determine whether the project is financially feasible in the long run.

Technological and Technical Challenges

31. What renewable energy technologies were selected, and were there any challenges in integrating them?
32. What were the major technical challenges encountered, and how were they addressed?

    Rationale: Exploring technical challenges highlights obstacles in technology selection, integration, and maintenance. It also identifies strategies used to overcome these barriers.

Stakeholder Engagement and Social Factors

33. How were key stakeholders, including employees, communities, and project teams, involved in the initiative?
34. Were there any challenges with stakeholder cooperation or engagement?

    Rationale: Understanding stakeholder engagement provides insights into participation dynamics and potential resistance factors. This helps refine engagement strategies to ensure smooth implementation.

Social Acceptance and Awareness

35. Did the project face any opposition or resistance? How was it addressed?
36. How were the benefits of the project communicated to stakeholders and the wider community?

    Rationale: Examining social acceptance helps identify factors influencing public perception and strategies to enhance adoption. It also assesses resistance to renewable energy initiatives and ways to address concerns.

Project Management and Execution

37. How effective was project management for the initiative?
38. Were project milestones met? If not, what were the reasons for delays?

    Rationale: Assessing project management effectiveness highlights execution efficiency and challenges in meeting milestones.

Lessons Learned and Future Recommendations

39. What are the key lessons learned from challenges or failures encountered in the project?
40. What could have been done differently to ensure project success?
41. What recommendations would you give for future renewable energy projects?
42. What policy or regulatory changes do you think are necessary to support the adoption of renewable energy initiatives?

    Rationale: Examining lessons learned and recommendations provides insights for improving future renewable energy projects and policy frameworks. It ensures that best practices are documented and shared to enhance future initiatives.

4.3.5 Analytical Framework

Data analysis followed a thematic approach, with coding and categorization guided by Yin's case study methodology. The process involved:

- **Data Familiarization:** Transcripts, documents, and field notes were reviewed to identify key themes and patterns.
- **Coding:** Data were systematically coded into categories aligned with the research questions, such as economic factors, regulatory challenges, and community engagement.
- **Cross-Case Synthesis:** Patterns and differences across the three case studies were identified to generate broader insights.

4.3.6 Ethical Considerations

The study adhered to strict ethical guidelines to ensure the integrity of the research and the well-being of participants:

- **Informed Consent:** Participants were briefed on the research objectives, data collection procedures, and their rights, including the right to withdraw at any time.
- **Confidentiality:** Identifiable information was anonymized, and data were stored securely to protect participant privacy.
- **Transparency:** Participants were informed of how the data would be used and were offered the opportunity to review the findings.

4.3.7 Limitations and Challenges

The case study protocol acknowledges several limitations:

- **Generalizability:** Findings are specific to the selected cases and may not be universally applicable to all renewable energy projects in Nigeria.
- **Response Bias:** Stakeholders may present biased views, particularly when discussing challenges or project failures.
- **Data Access:** Gaps in documentation or restricted access to certain stakeholders posed challenges to data collection.

Despite these limitations, the protocol's robust design mitigates potential biases and enhances the reliability of findings.

4.3.8 Application of Yin's Principles

The research aligns with Yin's principles for rigorous case study methodology:

1. **Use of Multiple Sources of Evidence:** The triangulated data collection approach enhances the credibility of findings.
2. **Development of a Case Study Database:** All collected data were systematically organized to facilitate transparency and replicability.
3. **Maintenance of a Chain of Evidence:** A clear link was maintained between research questions, data sources, and findings, ensuring the validity of conclusions.

4.3.9 Structure of the Case Study Presentation

The subsequent sections of this chapter are structured to provide an in-depth exploration of each case study. Each case includes:

- **Background and Objectives:** Overview of the project's origin, goals, and context.
- **Key Findings:** Insights into economic, technological, political, and social factors influencing the project.
- **Outcomes and Lessons Learned:** Analysis of project successes, challenges, and implications for future initiatives.

By adhering to this structured protocol, the chapter aims to deliver a comprehensive and insightful analysis of renewable energy adoption in Nigeria. This systematic

approach ensures the findings are both rigorous and actionable, contributing to the broader understanding of sustainable energy solutions in developing countries.

4.3.10 Categorization of Interview Questions

This study categorizes interview questions and responses under five overarching themes. These questions serve as key thematic areas for examining the experiences, challenges, and insights of stakeholders involved in renewable energy projects. By categorizing the responses into these broad themes, the study provides a structured understanding of the factors influencing the adoption and sustainability of renewable energy initiatives.

Each category explores a distinct dimension of renewable energy implementation, supported by direct quotations from stakeholders who have actively participated in projects across different case studies. These categories are:

1. Understanding Stakeholder Roles and Project Objectives
    - This section examines the roles and responsibilities of various stakeholders, including policymakers, technical experts, university administrators, and private sector investors.
    - It outlines the motivations behind renewable energy projects, their expected outcomes, and the sectors they aim to support.
2. Key Challenges in Renewable Energy Adoption
    - This section explores financial, regulatory, technical, and infrastructural challenges that hinder the success of renewable energy projects.
    - Stakeholder perspectives provide insight into the specific barriers encountered, including funding limitations, government bureaucracy, and grid integration issues.
3. Stakeholder Engagement and Social Perception of Renewable Energy
    - The adoption of renewable energy is not solely dependent on technical feasibility; it also requires social acceptance and active stakeholder participation.
    - This section analyzes engagement strategies, community reactions, and public perceptions of renewable energy initiatives.
4. Financial Viability and Economic Impact of Renewable Energy Projects

- Financial sustainability is a critical factor in determining the long-term success of renewable energy projects.
- This section assesses the funding mechanisms used, economic viability assessments, and the broader economic benefits of these projects.

5. Lessons Learned and Future Recommendations
    - Reflecting on both successes and failures, this section identifies key lessons drawn from past renewable energy initiatives.
    - Stakeholders provide insights into what could have been done differently and offer recommendations for future projects, including policy improvements and financial reforms.

Sections 4.4, 4.5 and 4.6 will present perspectives from the three case studies:

- Katsina Wind Farm
- Bayero University Kano (BUK) Solar Project
- University of Maiduguri (UNIMAID) Solar Project

By structuring the analysis in this way, the study ensures that each critical aspect of renewable energy adoption in Nigeria is explored comprehensively. The inclusion of direct respondent quotations provides first-hand insights into the realities of implementing renewable energy projects, enriching the discussion with lived experiences and practical lessons.

The following sections will now provide an extensive examination of each overarching question, integrating responses from the case studies to highlight patterns, challenges, and recommendations for future energy development in Nigeria.

4.4 The Case Study Project 1: Katsina Wind Farm

The Katsina Wind Farm, initiated in 2005, represents one of Nigeria's earliest large-scale renewable energy projects, designed to harness wind energy for electricity generation. Located in Katsina State, in the northern region of Nigeria, the project was developed to diversify the country’s energy mix and reduce its heavy reliance on fossil fuels. The farm was conceptualized to generate 10 MW of electricity, sufficient to power approximately 27,000 households annually, according to the Nigerian Energy Support Programme (NESP, 2018).

This ambitious initiative was a collaborative effort between the Nigerian government and international partners, including the French Development Agency, which provided technical and financial support. The overarching goals of the project included reducing energy poverty, promoting environmental sustainability, and demonstrating the viability of wind energy in Nigeria. However, despite its potential, the project has faced significant delays and operational challenges, highlighting systemic issues within Nigeria's renewable energy sector. These challenges have prevented the full realization of the farm's potential, limiting its contributions to Nigeria's energy mix. Nevertheless, the Katsina Wind Farm serves as an important case study for future wind energy projects, showcasing both the opportunities and obstacles inherent in renewable energy development in the region.

4.4.1 Key interview questions

This section provides an overview of the key interview questions, which were categorised into five overarching themes (numbered 4.4.1.1 to 4.4.1.5), incorporating direct responses from stakeholders involved in the project.

4.4.1.1 Understanding Stakeholder Roles and Project Objectives

The Katsina Wind Farm was initiated to provide a renewable energy source to supplement the national grid while also serving as a model for future wind energy projects in Nigeria. Stakeholders involved in the project included government agencies, private contractors, technical engineers, and energy policy experts.

Stakeholder Roles and Experience

A project manager involved in the initial planning phase explained:

"I joined the Katsina Wind Farm project six years ago as a technical consultant. Initially, the project was envisioned as a flagship wind energy initiative for Nigeria, meant to demonstrate the feasibility of wind power in our energy mix. My role involved coordinating between the government, local engineers, and international partners supplying the wind turbines." (Katsina Wind Farm Project Manager)

A government official from the Ministry of Power further described the regulatory oversight:

"From a policy perspective, we saw the wind farm as a stepping stone towards reducing our reliance on fossil fuels. My role was to ensure that all necessary approvals were

secured and that the project aligned with Nigeria's broader energy policies." (Ministry of Power Representative)

Project Objectives and Target Sectors

The primary goal of the Katsina Wind Farm was to generate renewable electricity that could be fed into the national grid to improve power reliability in Katsina and surrounding areas.

An engineer involved in the project design explained:

"The wind farm was expected to produce 10 MW of electricity, which would supply power to about 120,000 households in the region. Additionally, it was meant to serve as a research hub for wind energy in Nigeria, encouraging further investment in similar projects." (Katsina Wind Farm Engineer)

A technical officer highlighted the broader economic objectives:

"Beyond providing electricity, the project aimed to create jobs and build local expertise in wind energy technology. We expected it to attract further investments in renewable energy infrastructure across the northern region." (Katsina Wind Farm Technical Officer)

4.4.1.2. Key Challenges in Renewable Energy Adoption

Despite its promise, the Katsina Wind Farm faced numerous obstacles, which significantly delayed its completion and operation.

Financial and Funding Constraints

A financial analyst involved in the project financing shared:

"One of the biggest setbacks was the funding structure. The project received financing from both the Nigerian government and international partners, but there were delays in fund disbursement. This stalled progress for years, leading to cost escalations and logistical challenges." (Katsina Wind Farm Financial Analyst)

A senior official at the Ministry of Finance also noted:

"The lack of continuity in budgetary allocation meant that at several points, construction had to be paused. This not only increased costs but also affected investor confidence in wind energy projects in Nigeria." (Ministry of Finance Representative)

Technical and Infrastructure Challenges

An engineer working on the installation process explained:

"One of the major technical challenges was calibrating the wind turbines to suit the local wind conditions. Since the turbines were imported, we had to modify several components to ensure efficiency, which took additional time and resources." (Katsina Wind Farm Engineer)

A maintenance officer further described the infrastructure constraints:
"Integrating the wind farm into the existing power grid proved to be more difficult than expected. The local transmission infrastructure was not designed for wind-generated electricity, leading to technical adjustments that further delayed the commissioning process." (Katsina Wind Farm Maintenance Officer)

Regulatory and Policy Challenges

A project coordinator highlighted the issue of bureaucratic delays:
"There was a lack of clear regulatory guidelines on wind energy at the time the project started. This meant that securing the necessary permits took longer than expected, and there was confusion over compliance requirements." (Katsina Wind Farm Project Coordinator)

A policy expert from the Ministry of Power added:
"We needed a more coordinated approach from government agencies to streamline the approval process. The delays in regulatory clearances discouraged further investments in wind energy." (Ministry of Power Policy Expert)

4.4.1.3. Stakeholder Engagement and Social Perception of Renewable Energy

Social acceptance and engagement with local communities played a crucial role in the project's progress.

Community Engagement Strategies

A community liaison officer described efforts to involve residents:
"Initially, there was some scepticism from the local population. We held several town hall meetings to explain the benefits of the project, particularly how it would create jobs and provide a stable electricity supply." (Katsina Wind Farm Community Liaison Officer)

Social Perception and Acceptance

Despite engagement efforts, some resistance remained. A project official noted:

"Some community members were concerned about the noise levels from the turbines and whether the land use would affect their agricultural activities. Addressing these concerns required extensive dialogue and reassurance." (Katsina Wind Farm Official)

4.4.1.4 Financial Viability and Economic Impact

The economic feasibility of the project has been a subject of debate, particularly given its long delays and cost overruns.

Economic Impact

A renewable energy economist highlighted the potential benefits:

"If fully operational, the Katsina Wind Farm could significantly reduce reliance on diesel generators in the region, lowering energy costs for businesses and households. Additionally, it has the potential to stimulate local economic activity by attracting related industries." (Renewable Energy Economist)

Funding Challenges and Solutions

A financial consultant suggested alternative funding mechanisms:

"Public-private partnerships could have helped secure more stable funding for the project. Reliance on government funding alone has proven to be a challenge." (Katsina Wind Farm Financial Consultant)

4.4.1.5 Lessons Learned and Future Recommendations

Reflecting on the project, stakeholders highlighted important lessons for future wind energy initiatives.

Key Lessons from the Project

A project engineer emphasized the need for better planning:

"One major lesson is the importance of ensuring stable funding before initiating large-scale renewable projects. Delays in financing can derail even the most well-intended projects." (Katsina Wind Farm Engineer)

A government policy analyst pointed out regulatory shortcomings:

"We need clearer regulations for wind energy projects. A well-defined framework from the beginning would have reduced the delays and confusion over permits." (Government Policy Analyst)

Recommendations for Future Wind Energy Projects

A renewable energy researcher proposed capacity-building initiatives:

"There should be more investment in training local engineers in wind energy technology. Right now, we still depend heavily on foreign expertise, which increases costs and project delays." (Renewable Energy Researcher)

A project manager suggested integrating better community engagement strategies: *"Future projects should involve communities more actively from the onset to minimize resistance and ensure that local needs are addressed."* (Katsina Wind Farm Project Manager)

4.4.2 Project Implementation

The implementation of the Katsina Wind Farm involved several key stages, including feasibility studies, design, procurement of equipment, and installation of wind turbines. Pre-project feasibility studies confirmed Katsina's strong wind potential, with average wind speeds exceeding 5.5 m/s, making the site well-suited for wind energy generation (IRENA, 2021). The wind farm originally consisted of 37 wind turbines, each with a capacity of 275 kW, strategically placed to maximize energy capture and efficiency.

Despite its promising start, the project encountered numerous delays. Construction did not begin until 2010, five years after its initial conceptualization, due to funding challenges and delays in equipment procurement. The situation worsened in 2012 when a foreign contractor was kidnapped, leading to a temporary suspension of activities. This incident highlighted the security risks associated with implementing large-scale infrastructure projects in northern Nigeria. These setbacks significantly prolonged the timeline of the project, ultimately affecting its overall impact. Additionally, difficulties in the procurement and transportation of specialized wind turbine components further slowed progress. Many of these components had to be imported from Europe, making the project highly susceptible to fluctuations in currency exchange rates and international shipping delays. These technical and logistical hurdles, combined with regulatory inefficiencies, resulted in the project missing multiple completion deadlines and experiencing significant cost overruns.

By 2023, the Federal Government (FG) announced that the 10 MW Katsina Wind Farm was finally set for commissioning. According to Engr. Sale Mamman, Minister of Power, the project includes key components such as the engineering, procurement, construction, and installation of 37 wind turbine generators, each with a capacity of 275KW, along with Step-up Transformers (315KVA/33KV/400V), an advanced

SCADA system for real-time monitoring, 2×7.5 MWA transformers and accessories, and two years of operation and maintenance spare parts. These updates were essential to ensure that the facility is operationally efficient and able to supply power to local communities and the national grid.

4.4.3 Impacts

Despite the numerous challenges, the Katsina Wind Farm has made measurable progress and has contributed significantly to the national power grid. By 2016, the farm became partially operational, supplying intermittent power to the national grid. In 2023, the FG announced that the project is fully functional and set for commissioning. With all 37 turbines operational, the facility is expected to increase Nigeria's renewable energy output, reducing dependence on fossil fuels and supporting the nation's clean energy transition goals.

The impact of the Katsina Wind Farm extends beyond just energy supply. One of its major achievements is the reduction of greenhouse gas emissions, as wind energy is a clean and renewable source that does not emit carbon dioxide (CO_2) during power generation. Estimates suggest that the farm will help Nigeria cut down its carbon emissions by over 20,000 metric tons annually, aligning with the country's commitment under the Paris Agreement on Climate Change. This has bolstered Nigeria's standing in the global renewable energy space, showcasing its efforts toward sustainable energy solutions.

Furthermore, the project has had a direct impact on local employment and economic growth. The construction and operational phases of the wind farm created hundreds of direct and indirect jobs, providing employment opportunities for engineers, technicians, security personnel, and administrative staff. Additionally, local suppliers and contractors have benefitted from business opportunities related to logistics, transportation, and maintenance services. The long-term effect of these job opportunities extends to skills development, as workers gain specialized knowledge in wind energy technology, contributing to the growth of Nigeria's renewable energy workforce.

Another significant impact of the Katsina Wind Farm is its contribution to rural electrification and grid stability. The region has historically suffered from power deficits and erratic electricity supply, making industrial and commercial activities

difficult. The inclusion of wind-generated electricity into the grid has helped stabilize energy supply in Katsina and surrounding areas, thereby fostering improved business operations and encouraging new investments in the local economy. Additionally, the success of the Katsina Wind Farm has paved the way for future wind energy projects, proving that large-scale wind energy solutions can be viable in Nigeria's climatic and infrastructural context.

From a policy perspective, the completion of the Katsina Wind Farm has provided valuable lessons for the development of Nigeria's renewable energy sector. The project has demonstrated the need for stronger regulatory frameworks, better financial planning, and enhanced security measures for infrastructure development. It has also underscored the importance of international partnerships in accelerating Nigeria's transition to clean energy. Moving forward, the experience gained from the implementation of the Katsina Wind Farm can inform future policies to ensure more efficient execution of renewable energy projects across the country.

4.4.4 Conclusion

The Katsina Wind Farm represents both the challenges and opportunities inherent in Nigeria's renewable energy sector. While the project has faced considerable setbacks, its completion and commissioning in 2023 signify an important milestone for Nigeria's energy diversification strategy. The project underscores the importance of persistence, stakeholder engagement, financial planning, and technical expertise in achieving sustainable renewable energy development. By addressing the lessons learned, policymakers and stakeholders can foster a more conducive environment for wind energy development, ultimately contributing to Nigeria's long-term energy security and sustainability goals. Moving forward, scaling up similar projects across different parts of Nigeria will be essential in achieving energy access for all, reducing the country's reliance on fossil fuels, and positioning Nigeria as a leader in Africa's renewable energy transition.

4.5 The Case Study Project 2: Bayero University Kano (BUK) Hybrid Solar PV Park

The Bayero University Hybrid Solar PV Park represents a groundbreaking achievement in Nigeria's transition toward sustainable energy. As one of the largest off-grid solar hybrid power plants in Africa, this project underscores the transformative potential of

renewable energy in addressing critical infrastructure deficits within the education sector. Commissioned in September 2019, the 7.1 MW solar hybrid power plant is part of the Federal Government's Energizing Education Programme (EEP). This initiative seeks to resolve persistent energy challenges faced by Nigeria's tertiary institutions. Through the deployment of clean energy technologies, the project creates a reliable power supply for Bayero University Kano (BUK), supports advanced learning environments, and significantly reduces the university's carbon footprint. Additionally, it provides a model for other institutions across Africa to emulate in their journey towards energy sustainability.

Electricity shortages have been a longstanding challenge for Nigeria, with significant implications for the education sector. Educational institutions like Bayero University Kano, a federal university serving over 55,815 students and 3,077 staff, have historically relied on diesel generators as a primary power source. These generators, while providing temporary relief, come with high operational costs and contribute to environmental pollution through greenhouse gas emissions. The unreliable grid power system exacerbates this challenge, disrupting academic activities and impeding research initiatives. Recognizing these issues, the Federal Government launched the Energizing Education Programme (EEP) to enhance the energy infrastructure of higher institutions. The Rural Electrification Agency (REA), the implementing body, prioritized sustainable and renewable energy solutions to address these concerns, making BUK a flagship example of this innovative program.

4.5.1 Key interview questions

This section provides an overview of the key interview questions, which were categorised into five overarching themes (numbered 4.5.1.1 to 4.5.1.5), incorporating direct responses from stakeholders involved in the project.

4.5.1.1. Understanding Stakeholder Roles and Project Objectives

Stakeholder Roles and Experience

The BUK Solar Project was developed with the involvement of university leadership, government funding bodies, and private sector partners providing technical expertise. A senior university administrator described the rationale behind the project:

"For years, we have faced significant power shortages, which have negatively impacted our students, researchers, and administrative operations. The decision to transition to solar power was made to ensure energy security and reduce dependency on expensive

and unreliable diesel generators." (BUK Senior Administrator)

A technical officer responsible for project implementation shared:
"My role was to oversee the installation and integration of the solar energy system into the university's existing power network. This involved assessing energy consumption patterns, determining storage requirements, and ensuring that the transition was seamless." (BUK Technical Officer)

Project Objectives and Target Sectors

A faculty member involved in the planning phase outlined the project's objectives:
"The main objective was to ensure a stable electricity supply for academic and research activities. Before this project, students often had to study in poorly lit conditions, and laboratory experiments were frequently disrupted due to power outages." (BUK Faculty Member)

A research fellow highlighted another important aspect of the project:
"Beyond meeting our immediate energy needs, this project is also an opportunity for the university to position itself as a leader in renewable energy research and innovation in Nigeria." (BUK Research Fellow)

4.5.1.2. Key Challenges in Renewable Energy Adoption

Financial and Funding Constraints

One of the major barriers to the project's implementation was securing sufficient funding.
A university finance officer explained:
"Initially, the project was partially funded through a government-backed grant, but this was not enough to cover all expenses. We had to seek additional funding from international donors and private sector partners." (BUK Finance Officer)

Another challenge related to funding delays:
"The bureaucratic process of accessing funds led to unnecessary delays. By the time some of the funds were disbursed, prices of equipment had already increased due to inflation." (BUK Project Coordinator)

Technical and Infrastructure Challenges

A lead engineer described the technical difficulties encountered:
"The integration of the solar power system with our existing electrical infrastructure was more complicated than anticipated. We had to retrofit older buildings with new

wiring to ensure compatibility." (BUK Engineer)

A maintenance officer raised concerns about equipment durability:

"While the project has been largely successful, one of the challenges we foresee is long-term maintenance. Some of the components, such as inverters and batteries, will need replacement in a few years, and there is currently limited local capacity for this." (BUK Maintenance Officer)

Regulatory and Policy Challenges

A policy advisor explained the difficulties in navigating Nigeria's energy regulations:

"There were multiple layers of approval required before we could even begin installation. The process was cumbersome and could have been streamlined to make things easier for institutions looking to invest in renewable energy." (BUK Policy Advisor)

4.5.1.3. Stakeholder Engagement and Social Perception of Renewable Energy

Community Engagement Strategies

A stakeholder from the university administration emphasized the importance of engaging students and faculty in the process:

"We made a conscious effort to involve students in discussions about the solar project. Many were curious about how it worked, and we even incorporated aspects of the project into our engineering and environmental science courses." (BUK University Administrator)

Social Perception and Acceptance

A student leader shared how the project has influenced attitudes toward renewable energy:

"Before this project, many students thought renewable energy was just for rural communities. Now, we see firsthand how it can be applied to large institutions like ours." (BUK Student Leader)

4.5.1.4. Financial Viability and Economic Impact

Economic Impact

The university has already begun to see financial benefits from transitioning to solar power.

A finance officer explained:

"Since we started using solar energy, our electricity costs have dropped significantly.

We are now able to allocate more funds toward research and student support services." (BUK Finance Officer)

Funding Challenges and Solutions

A renewable energy consultant suggested alternative funding models:

"Public-private partnerships (PPPs) could help scale projects like this across more universities. Relying solely on government funding is unsustainable." (BUK Renewable Energy Consultant)

4.5.1.5. Lessons Learned and Future Recommendations

Key Lessons from the Project

A project engineer emphasized the importance of planning:

"One of the biggest lessons we learned is that proper planning and feasibility studies are crucial. A more thorough assessment of infrastructure needs would have helped us avoid some of the technical issues we encountered." (BUK Project Engineer)

Recommendations for Future University-Based Renewable Energy Projects

A university policymaker suggested:

"Higher education institutions should collaborate more closely with industry partners to ensure sustainability. Universities can serve as testing grounds for renewable energy innovations." (BUK Policy Maker)

4.5.2 Project Overview

4.5.2.1 Key Features

The Bayero University Hybrid Solar PV Park is a state-of-the-art facility designed to meet the university's energy demands efficiently and sustainably. The plant boasts a total installed capacity of 7.1 MW, making it the largest of its kind in Africa. This advanced system includes 10,680 photovoltaic panels, each with a 320W nameplate capacity, ensuring robust energy generation even under varying climatic conditions. To complement the solar panels, 52 inverters have been deployed, optimizing the conversion of solar energy into usable electrical power. Additionally, battery storage systems ensure a steady power supply during low sunlight periods or grid outages, guaranteeing uninterrupted operations for academic and administrative activities.

The infrastructure enhancements extend beyond the power plant itself. The project includes 11.41 kilometres of solar-powered streetlights, significantly improving campus security and safety, particularly at night. Moreover, the establishment of a

renewable energy training centre positions BUK as a hub for research, innovation, and capacity building in renewable energy technologies. This comprehensive approach ensures not only energy reliability but also a lasting impact on the university's academic and operational framework.

4.5.2.2 Funding and Partnerships

The successful execution of the BUK solar hybrid project is the result of strategic collaborations between the Federal Government of Nigeria, international development partners, and private sector stakeholders. The project was primarily funded through the Federal Government Green Bond, which aligns with Nigeria's broader climate action goals. Additional financial support came from the World Bank and the African Development Bank (AfDB), underscoring the global interest in Nigeria's renewable energy initiatives.

The Ministry of Power played a central role in overseeing the project, ensuring alignment with national energy policies and strategic objectives. The technical expertise for project implementation was provided by METKA West Africa Limited, which served as the engineering, procurement, and construction (EPC) contractor. This collaborative approach highlights the importance of public-private partnerships in achieving large-scale renewable energy solutions.

4.5.2.3 Energizing Education Programme (EEP)

The Energizing Education Programme (EEP) is an ambitious initiative by the Federal Government to provide clean, reliable energy to Nigeria's higher education sector. The program targets 37 federal universities and 7 teaching hospitals, deploying a mix of solar hybrid and gas-fired power systems. BUK's project is the second to be commissioned under Phase 1 of the EEP, following the successful implementation of a 2.8 MW solar hybrid power plant at Alex Ekwueme Federal University in Ebonyi State. The EEP not only addresses immediate energy needs but also focuses on long-term sustainability by integrating energy efficiency measures, renewable energy training centers, and enhanced campus infrastructure.

4.5.3 Impact and Benefits

4.5.3.1 Reliable Power Supply

The implementation of the solar hybrid power plant has revolutionized the energy landscape at BUK. Previously, frequent power outages disrupted lectures, laboratory

experiments, and research activities, creating an unreliable academic environment. The 7.1 MW solar plant now ensures a steady and dependable power supply, transforming the university into a beacon of academic excellence. This reliability has enabled uninterrupted access to critical facilities, including lecture halls, research laboratories, and dormitories, fostering a more conducive environment for learning and innovation.

4.5.3.2 Environmental Sustainability

One of the most significant outcomes of the project is its contribution to environmental sustainability. By offsetting 49,384 tonnes of carbon dioxide emissions annually, the solar hybrid plant aligns with Nigeria's climate commitments under the Paris Agreement. The reduction in greenhouse gas emissions demonstrates the tangible impact of renewable energy technologies in mitigating climate change. Additionally, the project serves as a model for other institutions and communities, showcasing how clean energy solutions can address both environmental and developmental challenges.

4.5.3.3 Cost Efficiency

The transition from diesel generators to solar energy has resulted in substantial cost savings for BUK. Diesel generators, while effective in the short term, are expensive to operate and maintain. By adopting a solar-based solution, the university has reduced its energy expenses significantly, allowing it to allocate resources to other critical areas such as infrastructure development, research funding, and student support programs. The financial benefits extend beyond the university, as the project contributes to broader economic sustainability.

4.5.3.4 Capacity Building

The establishment of a renewable energy training center at BUK marks a critical step in building local expertise in renewable energy technologies. This facility provides students, faculty, and engineers with hands-on training in solar energy systems, fostering a new generation of renewable energy professionals. Moreover, the project's inclusion of a Female STEM Students Internship Programme, which trained 20 young women, highlights its commitment to gender inclusivity and empowerment. These initiatives not only address immediate skill gaps but also contribute to long-term capacity building in Nigeria's energy sector.

4.5.3.5 Campus Safety and Security

The installation of solar-powered streetlights across the campus has significantly

enhanced safety and security. Poorly lit areas previously posed risks to students and staff, particularly at night. The new lighting infrastructure ensures better visibility and creates a safer environment, enabling academic and social activities to extend beyond daylight hours. This improvement has been widely appreciated by the university community and serves as an example of the ancillary benefits of renewable energy projects.

4.5.3.6 Job Creation

The solar hybrid project at BUK has created 182 energy-related jobs, ranging from power system engineers to electricians and technicians. These employment opportunities contribute to Nigeria's broader socio-economic development by building a skilled workforce in the renewable energy sector. Additionally, the project's emphasis on local hiring ensures that the benefits are distributed within the community, fostering economic inclusion and growth.

4.5.4 Factors Contributing to the Success of the BUK Hybrid Solar PV Park

One of the primary factors driving the success of the Bayero University Kano (BUK) Hybrid Solar PV Park was its integration under the Energizing Education Programme (EEP), a federal initiative supported by the World Bank aimed at powering Nigerian universities with sustainable energy solutions. This programme provided a structured financing model, which mitigated many of the financial and bureaucratic uncertainties that typically affect renewable energy projects in Nigeria. According to Sovacool et al. (2022), structured public-private energy programmes enhance project coordination and financing efficiency, especially when aligned with broader educational and energy policy goals.

The project also benefited from clear institutional ownership and management, facilitated by the university's administration. This ensured continuity, resource allocation, and local oversight. Universities are often more stable than government ministries, offering a conducive environment for project sustainability. Taghizadeh-Hesary et al. (2020) highlight that institutional stability and leadership commitment are crucial determinants of success in distributed energy projects, especially in emerging economies.

Another contributing factor was the emphasis on capacity building and local technical training. The BUK Solar Project included training programmes for engineers, technicians, and students, ensuring that local human resources could operate and maintain the system. This aligns with the findings of Munro et al. (2017), who stress that local technical expertise significantly reduces dependence on foreign contractors, enhances system uptime, and contributes to long-term sustainability.

Moreover, the university's academic environment fostered research, monitoring, and evaluation of the solar infrastructure. The integration of the project into the academic and technical departments created a feedback mechanism that allowed for evidence-based maintenance, performance monitoring, and innovation. As noted by Byrne et al. (2014), when renewable energy projects are embedded within academic institutions, they tend to benefit from real-time learning, user feedback, and adaptive management.

Furthermore, the urban location of BUK, with relatively better access to logistics, spare parts, and communication infrastructure, also played a role. This reduced operational costs and logistical hurdles. Urban-based renewable energy projects generally perform better due to proximity to services and stronger institutional networks (IRENA, 2020).

In summary, the BUK Hybrid Solar PV Park's success can be attributed to five interlinked factors: a structured financing model through EEP, strong institutional ownership, robust local capacity-building initiatives, academic integration, and favourable urban logistics. Together, these factors created an enabling ecosystem for sustainable implementation and operations, offering a replicable model for similar university-based or institutional renewable energy projects in Nigeria and across sub-Saharan Africa.

4.5.5 Challenges and Lessons Learned

4.5.5.1 High Initial Costs

The implementation of a large-scale solar hybrid project requires significant capital investment. Securing funding from multiple sources, including the Federal Government, World Bank, and AfDB, was a critical enabler of the project's success. This experience underscores the importance of strategic partnerships and innovative financing mechanisms in overcoming financial barriers to renewable energy adoption.

4.5.5.2 Technical Training

Ensuring the long-term sustainability of the project necessitated comprehensive training programs for local engineers, technicians, and university staff. These training efforts were essential for building the technical expertise required to operate and maintain the complex solar hybrid system effectively.

4.5.5.3 Scalability

While the BUK project demonstrates the viability of renewable energy in higher education, scaling similar initiatives across Nigeria's vast network of universities poses logistical and financial challenges. Lessons learned from the BUK project will be instrumental in guiding the implementation of future phases of the EEP.

4.5.6 Future Prospects

4.5.6.1 Expansion of the EEP

The Energizing Education Programme is set to expand its reach, bringing clean and reliable energy to additional universities and teaching hospitals in Nigeria. By replicating the successes of the BUK project, the EEP aims to create a nationwide network of energy-sustainable educational institutions.

4.5.6.2 Renewable Energy Research

The renewable energy training center at BUK is expected to serve as a catalyst for research and innovation in renewable energy technologies. By fostering collaborations with international research institutions and industry partners, the university can drive advancements in solar energy and contribute to global knowledge in the field.

4.5.6.3 Broader Adoption

The success of the BUK Hybrid Solar PV Park provides a compelling case for adopting renewable energy solutions across Africa. By demonstrating the feasibility and benefits of such projects, BUK serves as a model for other institutions seeking to address energy challenges sustainably.

4.5.7 Conclusion

The Bayero University Kano (BUK) Hybrid Solar PV Park represents a significant milestone in Nigeria's renewable energy transition, particularly within the higher

education sector. As one of the largest off-grid solar hybrid power plants in Africa, the project demonstrates the transformative potential of solar energy in addressing persistent energy challenges faced by academic institutions. Through the implementation of a 7.1 MW solar hybrid power system, the university has not only secured a stable and reliable electricity supply but has also significantly reduced its dependence on costly and environmentally damaging diesel generators. This initiative exemplifies the broader objectives of the Energizing Education Programme (EEP), reinforcing the importance of sustainable energy solutions in fostering academic excellence, research innovation, and institutional resilience.

The findings from this case study highlight several critical themes that shape the success and sustainability of large-scale renewable energy projects. Stakeholder engagement emerged as a pivotal factor, with university leadership, government agencies, private sector partners, and international donors playing essential roles in project execution. Despite the evident benefits, financial constraints, bureaucratic delays, and technical challenges posed considerable barriers to implementation. The study underscores the need for innovative financing mechanisms, including public-private partnerships and green investment strategies, to support future renewable energy initiatives. Furthermore, regulatory streamlining and capacity-building efforts are essential to overcoming policy and technical barriers, ensuring the long-term sustainability of such projects.

Beyond energy security, the project has had far-reaching socio-economic and environmental impacts. The reduction of carbon emissions aligns with Nigeria's climate commitments, showcasing how renewable energy projects can contribute to global decarbonization efforts. Additionally, the creation of local employment opportunities and the establishment of a renewable energy training center demonstrate the project's role in fostering technical expertise and human capital development. The inclusion of gender-focused initiatives, such as the Female STEM Students Internship Programme, further highlights the potential of renewable energy projects to drive social equity and inclusivity.

While the BUK Hybrid Solar PV Park serves as a model for other institutions, its success also underscores the importance of scalability and replication. Expanding the EEP to other universities and research institutions will require continuous policy support, enhanced stakeholder collaboration, and sustainable financing mechanisms.

The case study provides valuable lessons on project planning, infrastructure integration, and regulatory coordination, which can inform future renewable energy interventions across Nigeria and beyond.

In conclusion, the BUK Hybrid Solar PV Park is a testament to the transformative power of renewable energy in strengthening Nigeria's education sector. By ensuring a stable power supply, fostering innovation, and contributing to national climate goals, the project sets a benchmark for sustainable energy adoption in higher education. The insights gained from this case study reinforce the need for continued investment in renewable energy infrastructure, policy reform, and institutional capacity-building to drive Nigeria's energy transition forward. As the country seeks to expand its renewable energy footprint, projects like this serve as beacons of progress, demonstrating the feasibility and impact of clean energy solutions in shaping a sustainable future.

4.6 The Case Study Project 3: University of Maiduguri (UNIMAID) Solar Project

The University of Maiduguri (UNIMAID) Solar Project is a pioneering effort under the Energizing Education Programme (EEP), aimed at addressing Nigeria's energy access challenges in higher education institutions. Located in Borno State, an area historically plagued by energy insecurity and conflict, the project was strategically designed to reduce dependence on diesel generators, improve energy reliability, and foster sustainable development within the academic community. The initiative is a key milestone in Nigeria's push for renewable energy solutions, demonstrating the feasibility of large-scale solar hybrid systems in conflict-prone and underserved regions. The chronic power outages in Nigeria's northeastern region have severely impacted universities, making it difficult for students and researchers to operate efficiently. By introducing a hybrid solar solution, this project not only reduces operational disruptions but also provides a template for other institutions seeking energy autonomy.

Commissioned in 2020, the UNIMAID Solar Project is one of the most ambitious renewable energy initiatives in the country's education sector. The project includes a 12 MW hybrid solar photovoltaic (PV) system, integrated with lithium-ion battery storage and diesel backup to ensure uninterrupted power supply. The World Bank and the Federal Government of Nigeria jointly funded the project, aligning it with the broader objectives of the EEP, which seeks to deploy sustainable energy solutions in

37 federal universities and 7 university teaching hospitals nationwide. This initiative is not just about providing power; it is about ensuring the long-term viability of Nigeria's higher education institutions by giving them the necessary tools to function without reliance on erratic power grids. The integration of battery storage ensures that energy generated during the day is stored and available for nighttime use, a critical factor in maintaining 24-hour operations. The project's impact extends beyond the university itself, as reliable electricity facilitates a higher standard of education, enhances research capabilities, and improves institutional efficiency.

A key component of the project is its role in benefiting the University of Maiduguri Teaching Hospital (UMTH). A dedicated 4.5 MW solar power system has been integrated to support UMTH, ensuring round-the-clock power supply for critical healthcare services. As a result, the teaching hospital has significantly reduced its dependence on costly and environmentally harmful diesel generators, improving patient care and operational efficiency. According to the World Bank, the rapid advancement of the 12 MW solar project is a testament to Nigeria's growing commitment to renewable energy adoption. Despite facing security challenges and equipment delays in transportation from Lagos to Maiduguri, the project remains on track for completion by September 2024. This investment has far-reaching implications beyond electricity supply—it means the continuous operation of life-saving medical equipment, more efficient healthcare delivery, and the potential to attract top-tier medical professionals to UMTH, strengthening Nigeria's healthcare sector.

The project had the following objectives:
These are the project objectives outlined below:

1. Enhancing Energy Reliability Reliable electricity supply is fundamental to any academic institution, ensuring seamless operations of laboratories, lecture halls, and research centres. With frequent outages affecting learning outcomes, this project aims to provide uninterrupted 24/7 electricity to all academic, administrative, and healthcare facilities within the university. By leveraging solar hybrid technology, the system ensures that even during extreme weather conditions or maintenance downtimes, alternative energy sources such as battery storage and diesel backup prevent service disruptions. With uninterrupted power, research labs, medical facilities, and student hostels function efficiently, enabling an improved learning environment.

2. Promoting Renewable Energy Adoption Nigeria's heavy dependence on fossil fuels has led to increased environmental pollution and resource depletion. This project serves as a model for sustainable energy deployment in conflict-prone regions, demonstrating how universities can lead the transition to clean energy. The University of Maiduguri is now a flagship institution for renewable energy initiatives, setting the precedent for other higher education institutions to follow. Renewable energy not only improves energy access but also helps the country meet its climate change commitments.

3. Reducing Carbon Emissions, The global fight against climate change necessitates a reduction in greenhouse gas emissions. By transitioning from diesel-generated power to solar energy, UNIMAID is significantly decreasing its carbon footprint. According to projections, the solar power system will reduce carbon dioxide emissions by over 15,000 tons annually, aligning with Nigeria's commitment under the Paris Agreement on Climate Change. The project plays a critical role in reducing the university's overall environmental impact and promoting sustainable energy practices across the region.

4.6.1 Key interview questions

This section provides an overview of the key interview questions, which were categorised into five overarching themes (numbered 4.6.1.1 to 4.6.1.5), incorporating direct responses from stakeholders involved in the project.

4.6.1.1. Understanding Stakeholder Roles and Project Objectives

Stakeholder Roles and Experience

A project coordinator explained their involvement:
"My role was to ensure that the solar power system was optimized for the hospital's needs, prioritizing critical medical equipment and emergency services." (UNIMAID Project Coordinator)

Project Objectives and Target Sectors

A hospital administrator described the primary objective:
"Reliable electricity is a matter of life and death in a hospital setting. This project was essential to ensure that our intensive care units, operating rooms, and laboratories could function without disruptions." (UNIMAID Hospital Administrator)

4.6.1.2. Key Challenges in Renewable Energy Adoption

Financial and Funding Constraints

"The hospital initially struggled to secure funding. The final financing package was a combination of government grants and international health sector funding." (UNIMAID Finance Officer)

Technical and Infrastructure Challenges

"Medical equipment requires a stable power supply, so we had to install advanced energy storage solutions to ensure continuous operation." (UNIMAID Technical Officer)

4.6.1.3. Stakeholder Engagement and Social Perception of Renewable Energy

Community Engagement Strategies

"We engaged hospital staff and patients in discussions about the project to ensure smooth adoption and understanding of the benefits." (UNIMAID Project Manager)

Social Perception and Acceptance

"Initially, some hospital staff doubted whether solar power could handle high-energy medical equipment, but after seeing it in action, they became strong advocates." (UNIMAID Medical Officer)

4.6.1.4. Financial Viability and Economic Impact

"The cost savings from using solar energy allow us to purchase more medical supplies and upgrade our hospital facilities." (UNIMAID Finance Administrator)

4.6.1.5. Lessons Learned and Future Recommendations

Key Lessons from the Project

"Hospitals should be prioritized in Nigeria's renewable energy strategy because electricity is essential for saving lives." (UNIMAID Energy Specialist)

Recommendations for Future Projects

"Future projects should include local training programs to ensure that maintenance skills are developed within the region." (UNIMAID Renewable Energy Consultant)

4.6.2 Project Implementation

The implementation of the UNIMAID Solar Project was guided by detailed feasibility studies, stakeholder engagement, and a phased deployment strategy. The deployment process included land utilization and infrastructure development, ensuring that the 20

hectares of land allocated for solar infrastructure was effectively utilized for maximum efficiency. Advanced lithium-ion battery storage and smart inverters were incorporated to optimize energy use and enhance performance. The project also included real-time energy monitoring systems, allowing for proactive maintenance and operational efficiency.

4.6.3 Impact on Education and Research

The integration of sustainable energy solutions has drastically improved the university's academic environment. The availability of consistent power supply has enabled laboratories to function optimally, facilitating advanced research and experimentation in various fields, including renewable energy studies, medical sciences, and engineering. Research output at UNIMAID has significantly increased, as faculty and students now have the infrastructure to conduct extended studies without fear of power interruptions. Additionally, digital learning has been enhanced, with students now able to access online resources, engage in virtual learning, and participate in international collaborations without electricity hindrances.

4.6.4 Economic and Environmental Benefits

A comparative energy cost analysis conducted at UNIMAID between 2017 and 2019 demonstrated a 58% savings in energy costs due to the deployment of solar photovoltaics over public-powered streetlights. The study revealed that over ₦14.8 million was saved during this period, highlighting the financial benefits of transitioning to renewable energy. Additionally, the efficiency of the installed solar cells was estimated at 15.69%, further reinforcing their suitability for use in the high solar irradiance conditions of Maiduguri. The cost savings are being redirected to other essential academic and infrastructural developments.

4.6.5 Challenges and Solutions

The following challenges and their corresponding mitigations have been identified:

1. Security Challenges The insurgency in Borno State posed one of the greatest risks to the project, making infrastructure installation and personnel movement difficult. The Rural Electrification Agency (REA) worked closely with local security agencies, deploying surveillance systems and additional security personnel to protect project sites. The implementation of strict access control measures significantly reduced risks associated with vandalism and sabotage.

2. Logistical Constraints Transporting solar panels, battery storage units, and electrical components from Lagos to Maiduguri presented a major challenge due to poor road infrastructure and regional insecurity. To mitigate delays, project managers partnered with local transport companies familiar with the region's terrain, ensuring that equipment arrived safely and on time.

3. Regulatory Delays Bureaucratic hurdles, including securing environmental impact assessments (EIAs) and land-use approvals, prolonged the initial project timeline. Through continued policy dialogue, advocacy, and engagement with regulatory agencies, these obstacles were overcome, setting a precedent for streamlined approval processes in future renewable energy projects.

4.6.6 Conclusion

The University of Maiduguri Solar Project is a transformative initiative that exemplifies the potential of renewable energy in improving education, healthcare, and economic opportunities. Despite facing security threats, logistical bottlenecks, and regulatory delays, the project has succeeded in delivering reliable power, reducing carbon emissions, and providing valuable training for students and faculty. As Nigeria continues to expand its renewable energy footprint, the UNIMAID model offers a scalable blueprint for future projects, demonstrating that even in conflict-prone regions, sustainable energy solutions can thrive. With the continued support of the Federal Government, REA, and the World Bank, this initiative is poised to inspire similar projects across Nigeria, reinforcing the nation's commitment to a greener and more resilient energy future.

4.7 Summary

This chapter has provided an in-depth examination of three key renewable energy projects in Nigeria—the Katsina Wind Farm, the Bayero University Kano (BUK) Hybrid Solar PV Park, and the University of Maiduguri (UNIMAID) Solar Project. These case studies serve as representative examples of the challenges, opportunities, and broader implications of renewable energy adoption in Nigeria. By employing a qualitative case study approach, the research has captured the complexities of implementing renewable energy initiatives in diverse contexts, including urban academic institutions and conflict-prone regions.

The analysis of the Katsina Wind Farm highlights the systemic barriers that impede

wind energy deployment, particularly regulatory delays, bureaucratic inefficiencies, and technological limitations. Despite its potential to contribute significantly to Nigeria's energy mix, the project has faced prolonged setbacks, underscoring the need for improved governance and stakeholder coordination in renewable energy development.

The BUK Hybrid Solar PV Park stands out as a model for integrating renewable energy into the education sector. Through the Energizing Education Programme (EEP), the project has successfully replaced unreliable grid electricity and expensive diesel generators with a sustainable solar hybrid solution. The study reveals that institutional leadership, funding diversification, and public-private partnerships are crucial enablers for large-scale solar adoption in Nigeria's higher education institutions. However, long-term sustainability concerns, such as equipment maintenance and technical expertise, remain critical challenges.

The UNIMAID Solar Project demonstrates how renewable energy can enhance energy security in conflict-affected areas, ensuring a stable power supply for academic and research activities. Despite logistical difficulties, security risks, and regulatory challenges, the project has made significant strides in promoting clean energy solutions in one of Nigeria's most volatile regions. The findings suggest that renewable energy investments in such settings require robust security measures, streamlined bureaucratic processes, and adaptive project management strategies.

Across all three case studies, common themes emerge, including the financial constraints of renewable energy projects, policy and regulatory hurdles, technical capacity gaps, and the need for enhanced stakeholder collaboration. The study underscores the importance of long-term policy stability, improved financial mechanisms, capacity-building initiatives, and active community engagement in driving renewable energy adoption in Nigeria.

In conclusion, this chapter contributes to a deeper understanding of how economic, political, technological, and social factors influence the success or failure of renewable energy initiatives in Nigeria. The case study findings offer practical insights for policymakers, investors, and development agencies seeking to accelerate the country's transition to sustainable energy. These lessons will be further analysed in the next chapter, which synthesizes the case study findings within broader theoretical and policy frameworks.

CHAPTER 5 – DATA ANALYSIS AND DISCUSSION

5.1 Introduction

This chapter provides an extensive analysis of the key findings from this study on the challenges in the adoption of renewable energy in Nigeria. The analysis is structured around a cross-case study discussion, linking the findings to the broader literature reviewed in Chapter 2. By examining multiple case studies, this chapter identifies patterns, divergences, and contextual factors shaping renewable energy adoption in Nigeria. Through this cross-analysis, the study highlights the interconnectedness of economic, political, technological, and social dimensions, drawing direct comparisons between cases while grounding them within existing academic discourse. Furthermore, this chapter explores the implications of these findings for policy, practice, and future research, and concludes with recommendations to address the barriers identified.

5.2 The Case Study Project 1: Katsina Wind Farm

5.2.1 Impact of Economic, Political, Technological, and Social Factors on Renewable Energy Projects in Nigeria

The success of renewable energy projects, such as the Katsina Wind Farm, depends on the interplay of economic, political, technological, and social factors. These forces determine not only the feasibility of the project but also its long-term sustainability and impact. The case of Katsina highlights how these dimensions interact to shape the trajectory of renewable energy projects in developing economies.

- **Economic Factors:** One of the most significant barriers to the adoption of wind energy in Nigeria is the high upfront investment costs associated with wind farm construction, turbine procurement, and grid integration. Unlike traditional fossil fuel power plants, which benefit from well-established subsidies and financial incentives, renewable energy projects often struggle to attract consistent funding. According to an official from the Rural Electrification Agency (REA), "*funding for renewable energy projects remains inconsistent, making long-term project planning difficult. Many investors view these projects as high-risk due*

to the absence of stable policies and guaranteed returns." This observation is consistent with findings from IRENA (2021), which emphasize that the absence of structured financial models—such as feed-in tariffs, green bonds, and concessional loans—makes renewable energy adoption difficult in Nigeria.

The Katsina Wind Farm project, largely funded by the Nigerian government with technical support from the French Development Agency, has faced persistent budgetary challenges, leading to frequent delays in procurement, installation, and maintenance. As highlighted in World Bank (2020), economic volatility, fluctuating exchange rates, and inflationary pressures in Nigeria have further compounded these financial difficulties, as many of the project's wind turbine components were imported from Europe. The reliance on foreign equipment and expertise, coupled with rising costs due to currency devaluation, significantly inflated the project's budget, forcing multiple project suspensions.

- **Political and Regulatory Factors:** Political and regulatory frameworks play an outsized role in shaping the success or failure of renewable energy projects. Despite Nigeria's Renewable Energy Master Plan (REMP) and National Renewable Energy and Energy Efficiency Policy (NREEEP), the implementation of wind power initiatives has been inconsistent and fragmented (GIZ, 2020). Interviewees from the Ministry of Power emphasized that political instability and frequent changes in leadership have slowed decision-making processes and delayed approvals for key permits. An engineer involved in the project stated: *"The biggest hurdle we faced was securing regulatory approvals. Every time there was a change in government leadership, we had to renegotiate contracts and reapply for permits. This prolonged the project by several years."* This reflects findings from Asante et al. (2020), who argue that bureaucratic inefficiencies and the lack of inter-agency coordination in Nigeria's power sector often led to delays and cost overruns. Additionally, government support for renewable energy has been inconsistent, with policymakers frequently prioritizing fossil fuel subsidies over incentives for wind and solar projects.

  The policy instability surrounding energy investments in Nigeria has discouraged private-sector participation, making it difficult to secure external funding. Unlike countries such as Germany and India, where renewable energy policies provide long-term stability, Nigeria's approach has been reactive rather

than proactive. As a result, the Katsina Wind Farm project remains only partially operational, underscoring the need for a more streamlined and transparent regulatory process.

- **Technological Factors:** Technological challenges have also hindered the full operationalization of the Katsina Wind Farm. A lack of technical expertise in wind energy systems meant that the project relied heavily on foreign contractors and engineers, leading to high maintenance costs and long repair times. According to a senior project officer: *"When foreign engineers were unavailable due to security risks, repairs stalled for months. Local engineers lacked the necessary training to troubleshoot turbine issues."* This highlights the technology transfer gap that has affected renewable energy expansion in Nigeria. Studies by Singh et al. (2020) and Wu et al. (2023) suggest that the long-term sustainability of renewable energy projects depends on local capacity-building initiatives, yet Nigeria has not invested sufficiently in training programs for wind energy specialists.

  Another critical issue was the inadequate infrastructure for integrating wind power into Nigeria's national grid. Grid unreliability and poor transmission networks meant that even when the wind farm generated power, energy distribution was inconsistent. Similar challenges have been observed in other developing nations, where a lack of grid modernization has slowed renewable energy adoption (IEA, 2021).

- **Social Factors:** Social acceptance is a crucial determinant of renewable energy adoption. In the case of the Katsina Wind Farm, initial resistance from local communities arose due to concerns over land use, environmental impact, and skepticism about wind power's reliability. As one local resident noted: *"Many people believed the turbines would take away our farmland and disrupt our traditional way of life. There was also doubt about whether the electricity would ever reach our homes."* This reflects broader findings from Viardot (2013) and Ballesta et al. (2022), which emphasize that renewable energy projects in developing countries often face skepticism due to misinformation and lack of public awareness. To address these concerns, the project developers-

initiated community engagement programs, organizing town hall meetings and educational sessions to demonstrate the benefits of wind energy. Over time, these efforts improved public perception, but initial opposition delayed project rollout.

The University of Maiduguri Solar Project, by contrast, faced less resistance because the project team actively involved the local community from the beginning, offering technical training and employment opportunities. This suggests that early stakeholder engagement can improve social acceptance and facilitate smoother project implementation.

5.2.2 Challenges Encountered in Renewable Energy Projects in Nigeria

The Katsina Wind Farm exemplifies the numerous challenges that renewable energy projects in Nigeria frequently encounter, underscoring the systemic barriers that impede the successful implementation of wind and solar initiatives in the country. One of the most significant obstacles faced by the project was financial constraints, which have remained a recurring issue across Nigeria's renewable energy sector. The high upfront capital costs required for the procurement and installation of wind turbines, coupled with limited financing options, significantly hindered the project's progress. The project was initially funded through a combination of government allocations and international support from the French Development Agency, yet budgetary inconsistencies led to delays in disbursement and hindered timely execution. A senior project official noted that

"*Funding for the project was never guaranteed; every phase required a fresh round of approvals, and budget cuts meant that we had to keep re-evaluating what could actually be completed*."

This aligns with findings from IRENA (2021), which emphasize that the absence of structured financing mechanisms—such as feed-in tariffs, renewable energy bonds, and concessional loans—makes it challenging to sustain large-scale projects in developing economies. Without a dedicated financing structure, projects like the Katsina Wind Farm remain vulnerable to delays, cost overruns, and operational inefficiencies.

Another major challenge encountered in the project was regulatory bottlenecks, which have been a significant impediment to renewable energy adoption in Nigeria. The complexity of securing approvals, navigating bureaucratic processes, and the lack of coordination between government agencies created significant obstacles. The wind farm project suffered from protracted delays due to the absence of a streamlined approval process, resulting in years of stalled development. A Ministry of Power official involved in the project explained that

"*Renewable energy projects require multiple approvals from different regulatory bodies, and because there is no clear single-window system, the process takes years instead of months.*"

This observation aligns with research by Asante et al. (2020), who highlight that Africa's energy sector suffers from fragmented governance structures, where conflicting policies and unclear regulatory mandates prevent efficient project execution. Unlike countries such as Germany and India, where renewable energy policies are stable and investment-friendly, Nigeria's regulatory framework remains uncertain and inconsistent, discouraging private-sector participation and slowing down progress.

Beyond regulatory inefficiencies, technological deficiencies have also posed a formidable barrier to the Katsina Wind Farm's success. The lack of local expertise in wind turbine maintenance meant that the project was heavily reliant on foreign contractors, making operations costly and unsustainable. The importation of specialized wind energy components further exacerbated the issue, as frequent currency fluctuations and customs clearance delays made it difficult to acquire critical parts when needed. A technical officer involved in the project noted,

"*Because we relied on imported components, repairs and replacements often took months, leaving the turbines inactive for long periods*."

The lack of indigenous manufacturing capabilities for renewable energy infrastructure remains a persistent challenge in Nigeria. Research by Singh et al. (2020) highlights that for renewable energy projects to be sustainable, there must be a strong local supply chain for technical components, a trained workforce, and robust infrastructure to

support maintenance and repairs. The absence of a domestic wind energy industry in Nigeria means that projects like Katsina are subject to importation delays, high transportation costs, and inadequate technical support, ultimately reducing their long-term viability.

Community resistance further compounded the challenges faced by the Katsina Wind Farm, demonstrating how social acceptance plays a crucial role in the success of renewable energy initiatives. The lack of awareness and initial skepticism from local communities delayed the project's implementation, as residents raised concerns about land use, noise pollution, and potential disruptions to their livelihoods. A local resident recalled that

"*Many people were worried that the wind turbines would take away their farmland, and some even believed that they might affect the weather patterns in the area.*"

This reflects findings from Viardot (2013), which emphasize that renewable energy projects often face opposition in communities that are not properly engaged in the planning process. In contrast, projects that proactively involve local communities, educate them about the benefits of renewable energy, and address their concerns from the outset tend to face less resistance and experience smoother implementation. The University of Maiduguri Solar Project, for example, benefited from early and continuous stakeholder engagement, ensuring that community members were well-informed and directly involved in the project's execution. This suggests that a lack of effective community engagement strategies remains a major barrier to the success of large-scale renewable energy projects in Nigeria.

5.2.2.1 Challenges Encountered in the Katsina Wind Farm Project

The Katsina Wind Farm project, one of Nigeria's first large-scale wind energy initiatives, has faced numerous challenges since its inception—many of which have significantly impeded its successful implementation, operational continuity, and long-term sustainability. These challenges can be grouped into four broad categories: financial, technical, regulatory, and socio-political.

A primary challenge was financial instability and irregular funding, which led to significant project delays. The project was heavily reliant on public sector financing, with inconsistent budgetary allocations and long procurement cycles. According to

Guney et al. (2019), renewable energy projects in developing countries often struggle to secure consistent funding due to competing national priorities, currency devaluation, and weak credit markets. The Katsina Wind Farm project was no exception, suffering from prolonged interruptions when budget releases were delayed or reallocated to other government priorities.

Closely linked to the financial constraints were technical challenges, particularly the project's dependence on imported wind turbines and spare parts. The use of foreign technology without adequate local capacity for operation and maintenance resulted in long downtimes when faults occurred. As noted by Ebhota and Tabakov (2020), a lack of local technical expertise combined with inadequate supply chains for critical components frequently compromises the reliability of wind energy systems in low-resource settings. The Katsina project, which sourced turbines from Europe, encountered significant delays when replacement parts were needed, due to both logistical bottlenecks and customs clearance hurdles.

Regulatory inefficiencies further exacerbated these technical and financial issues. The absence of a streamlined approval process meant that each project milestone was subject to multiple bureaucratic layers, often across different agencies with overlapping mandates. This led to inconsistent enforcement of environmental, land use, and safety regulations, a problem noted across several renewable energy projects in Nigeria (Asante et al., 2020). The lack of a central regulatory authority created procedural redundancies that delayed construction timelines and hindered effective project oversight.

Another major constraint was inadequate stakeholder engagement, especially at the community level. Despite the project's location in a rural area of Katsina State, local communities were not meaningfully involved in the planning or execution phases. This limited their sense of ownership and contributed to issues of vandalism, scepticism, and lack of local support. As Wüstenhagen et al. (2007) argue, community acceptance is a critical element in the success of renewable energy projects, and failing to secure it can create barriers to both physical access and operational continuity.

Finally, the project was severely impacted by political instability and leadership turnover. Each change in political administration brought with it new sets of priorities,

often requiring contract renegotiations and policy reviews. This disrupted continuity and undermined the institutional memory necessary for sustained project execution. Ogunbiyi (2021) highlights that without policy consistency and clear accountability mechanisms, renewable energy projects in Nigeria remain vulnerable to shifting political winds and administrative inertia.

In summary, the challenges faced by the Katsina Wind Farm project are emblematic of broader systemic issues within Nigeria's renewable energy sector. Financial unpredictability, technical dependency, weak regulatory coordination, poor stakeholder engagement, and political instability combined to create a fragile implementation environment that continues to affect the project's viability and performance.

5.2.2.2 Bureaucratic Inefficiencies and Governance Issues Affecting the Katsina Wind Farm

The Katsina Wind Farm project illustrates the profound effects that bureaucratic inefficiencies and weak governance structures can have on the implementation of renewable energy initiatives in Nigeria. Originally envisioned as a flagship government-led renewable energy intervention, the project encountered persistent administrative delays, institutional fragmentation, and poor inter-agency coordination—issues that significantly compromised its operational success.

A major challenge stemmed from the overlapping mandates of federal agencies involved in project planning, procurement, and oversight. The absence of a centralised project management framework led to duplication of roles and conflicting priorities. As highlighted by Sovacool (2017), governance complexity and institutional dissonance are common impediments in large-scale infrastructure projects in the Global South. In the case of Katsina, inconsistent communication between the Ministry of Power, the contractor (Messrs. Vergnet SA of France), and local authorities caused delays in permit approvals, land acquisition, and contract mobilisation.

Another layer of bureaucratic inefficiency was evident in the procurement process. The project suffered prolonged delays in releasing funds and approving project components, which led to missed implementation milestones. This aligns with studies

by Oji et al. (2012), who observe that public-sector energy projects in Nigeria often face chronic bottlenecks due to opaque procurement systems and rigid bureaucratic structures. The inefficiency in disbursing payments and processing clearances increased project costs and damaged stakeholder confidence, both locally and internationally.

Furthermore, there was a lack of continuity and accountability due to frequent changes in political leadership. Each change in administration brought new actors into decision-making roles, often with limited understanding of the project's background. According to Acheampong et al. (2021), political turnover without institutional memory is a key source of project derailment in developing economies. The Katsina project suffered from such discontinuities, which necessitated revalidating prior agreements and reinitiating administrative processes, leading to further delays.

Weak oversight mechanisms also contributed to poor monitoring and evaluation of the project's progress. Once technical challenges—such as malfunctioning turbines and the lack of local technical capacity—began to emerge, the institutional response was slow and uncoordinated. This reflects broader governance issues in Nigeria's energy sector, where regulatory authorities are often under-resourced and constrained by political interference (Gyamfi, Kumi & Yeboah, 2018).

The consequence of these governance failures was not only a delay in the project's commissioning but also the underutilisation of installed capacity. Despite physical infrastructure being mostly in place, energy generation remained inconsistent due to a combination of poor maintenance planning and lack of integration with the national grid—issues that could have been mitigated with more robust institutional coordination and governance foresight.

In essence, the Katsina Wind Farm represents a case where bureaucratic inertia and fragmented governance substantially undermined a technically feasible project. Addressing such challenges will require institutional reforms, including the streamlining of agency roles, the establishment of project-specific coordination units, and the implementation of performance-based accountability mechanisms to improve governance and expedite project delivery.

5.2.3 Influence of Social Attitudes, Perceptions, and Awareness on Renewable Energy Adoption

The adoption of renewable energy technologies in Nigeria is significantly influenced by public attitudes, perceptions, and levels of awareness regarding their benefits and limitations. The Katsina Wind Farm provides a compelling case study of how social acceptance can either facilitate or hinder the successful implementation of large-scale renewable energy projects. While technical and financial challenges are well-documented, societal perceptions and community engagement are equally crucial factors that determine whether a project will gain widespread acceptance or face resistance.

One of the primary barriers to renewable energy adoption in Nigeria is skepticism about its reliability and effectiveness, particularly in comparison to traditional fossil fuel-based electricity generation. Many Nigerians, particularly in rural communities, remain unconvinced about the ability of renewable energy sources to provide stable and continuous electricity. The Katsina Wind Farm project initially faced significant resistance from local communities who expressed doubts about the feasibility of wind energy in addressing their energy access challenges. A local resident noted,

"We were told that the wind turbines would bring electricity, but years passed, and we saw no light. Many people started to believe it was just another government project that wouldn't work."

This perception was exacerbated by project delays and a lack of transparent communication regarding the timeline and expected benefits. Research by Viardot (2013) emphasizes that a lack of public trust in new technologies can lead to hesitancy and resistance, especially in regions where previous infrastructure projects have failed to deliver promised outcomes.

Additionally, misinformation and misconceptions played a role in shaping community attitudes toward the wind farm project. Some local farmers feared that the wind turbines would interfere with agricultural activities or cause health problems due to noise pollution and electromagnetic emissions. A project official involved in community engagement explained,

"At first, many people were reluctant to support the project because they believed the turbines would affect their farmland or cause strange illnesses. We had to conduct several awareness campaigns to dispel these myths."

This aligns with findings from Khan et al. (2022), which highlight that social resistance to renewable energy projects often stems from a lack of knowledge about the technology itself. In countries with high renewable energy adoption rates, such as Germany and Denmark, extensive public education campaigns have played a crucial role in gaining public trust and acceptance of wind and solar power.

Public attitudes toward renewable energy are also shaped by cultural and behavioural factors, which often influence energy consumption patterns. In Nigeria, there is a deep-rooted preference for grid electricity and backup generators, particularly among business owners and urban households who perceive these sources as more dependable than renewables. A respondent from the Rural Electrification Agency (REA) noted that

"People are used to generators because they provide instant power, even though they are expensive and noisy. With solar or wind energy, they worry about what happens when the sun isn't shining or when the wind isn't blowing."

This preference for conventional power sources poses a challenge to the widespread adoption of renewables, as many Nigerians remain unfamiliar with hybrid energy solutions that combine battery storage and backup systems to ensure a reliable power supply.

One of the most effective strategies for changing social perceptions about renewable energy is community involvement and engagement in project planning and implementation. The Katsina Wind Farm project, in its later stages, implemented community meetings and public forums to educate residents about the benefits of wind power and how it could improve their access to electricity. A government official overseeing the project noted,

"When people started seeing the turbines in operation and hearing testimonies from other communities where wind energy had worked, they became more receptive."

This reflects findings from Ballesta et al. (2022), who argue that participatory

approaches—where local stakeholders are directly involved in decision-making—significantly enhance public acceptance. The University of Maiduguri Solar Project, for instance, successfully gained community support by integrating student and faculty training programs into its renewable energy initiative, ensuring that the local population was actively engaged in the project's success.

Moreover, economic incentives and tangible benefits can play a significant role in shaping social attitudes toward renewable energy adoption. One of the reasons communities eventually embraced the Katsina Wind Farm project was the realization that it could create employment opportunities and improve local infrastructure. A former field officer involved in the project stated,

"Once people saw that the project was bringing jobs—security roles, maintenance work, and even business for local food vendors—they became more supportive."

This is consistent with research by Wüstenhagen et al. (2007), which finds that local economic benefits—such as job creation, skills development, and business growth—are strong motivators for public acceptance of renewable energy projects.

Despite these positive developments, broader national-level awareness campaigns remain inadequate in Nigeria, particularly regarding the long-term benefits of renewable energy. Public discussions about energy policy and infrastructure development are often dominated by debates on fossil fuel subsidies and grid expansion, with insufficient focus on educating the population about the advantages of renewables. A senior official from the Ministry of Power pointed out,

"People are more familiar with issues surrounding fuel price hikes and electricity tariffs than they are with policies on renewable energy. This is a gap that needs to be addressed through better public awareness strategies."

Studies by IRENA (2021) indicate that nations with strong renewable energy adoption rates have achieved success partly by embedding renewable energy education into school curricula, conducting national media campaigns, and creating incentives for businesses and households to adopt clean energy solutions.

Moving forward, enhancing social acceptance of renewable energy in Nigeria will require multi-dimensional strategies that combine education, community engagement,

economic incentives, and policy transparency. The lessons from the Katsina Wind Farm highlight the importance of early stakeholder involvement, clear and consistent communication, and demonstrating the tangible benefits of renewables to communities.

In contrast, projects that fail to actively engage the public from the outset are more likely to face resistance, delays, and long-term operational challenges.

In conclusion, social attitudes, perceptions, and awareness play a crucial role in shaping the adoption of renewable energy technologies in Nigeria. While skepticism, misinformation, and cultural resistance initially hindered the Katsina Wind Farm project, efforts to educate and involve the community eventually led to increased acceptance. However, broader national and regional campaigns promoting renewable energy literacy are necessary to accelerate the shift toward a clean energy future. By leveraging public engagement strategies, aligning projects with local economic interests, and addressing common misconceptions, Nigeria can overcome social barriers and promote greater adoption of wind, solar, and other renewable energy sources.

5.2.4 Lessons Learned and Recommendations for Future Projects

Despite these challenges, the Katsina Wind Farm project provides valuable lessons for the future development of renewable energy initiatives in Nigeria. One of the most critical takeaways is the importance of policy stability and regulatory streamlining. Nigeria must implement long-term, transparent renewable energy policies that reduce regulatory uncertainty and encourage private-sector investment. Interviewees from the Ministry of Power and Rural Electrification Agency stressed that

"*Simplifying approval processes and creating a one-stop regulatory system would accelerate project implementation and attract investors.*"

Countries like India have successfully accelerated renewable energy adoption through clear policy frameworks that ensure investor confidence (Majid et al., 2014). Nigeria must adopt a similar approach by establishing legislative consistency, reducing bureaucratic red tape, and providing financial incentives such as tax exemptions for wind energy components.

Another key lesson is the need to develop local capacity in renewable energy

technology. The Katsina Wind Farm suffered from excessive reliance on foreign expertise, which increased maintenance costs and operational delays. As noted by a technical officer,

"*Had we invested in training local engineers from the outset, we wouldn't have had to rely so heavily on expensive international contractors for routine repairs.*"

Investment in technical education, training programs, and university partnerships can help create a skilled workforce, reducing the dependence on foreign expertise and ensuring better project sustainability. The Bayero University Kano (BUK) Solar Project demonstrated the benefits of capacity-building, as local engineers were trained in solar PV system management, ensuring that the project remained operational without external dependencies**.**

From a financial perspective, it is clear that improved financing mechanisms are needed to sustain large-scale renewable energy projects. Public-private partnerships, concessional loans, and green energy funds can help bridge funding gaps and make renewable energy projects more attractive to investors. A senior project officer involved in the Katsina Wind Farm noted that

"*The lack of structured financing meant that the project progressed in a piecemeal manner, with periods of inactivity stretching for years due to insufficient funding.*"

This highlights the need for alternative financing models, such as green bonds, carbon credits, and risk-sharing frameworks, to ensure that renewable energy projects are not entirely reliant on fluctuating government budgets.

Finally, the importance of enhancing community engagement strategies cannot be overstated. The initial resistance faced by the Katsina Wind Farm could have been mitigated had local stakeholders been engaged earlier in the process. A project engineer noted,

"*By the time we started addressing community concerns, much of the distrust had already set in, which slowed things down significantly.*"

Future projects must prioritize public engagement, conduct awareness campaigns, and involve local stakeholders in decision-making processes from the very beginning. The

University of Maiduguri Solar Project serves as a strong example of effective community involvement, where educational initiatives and open forums helped build trust and acceptance, ensuring seamless project implementation.

5.2.4.1 Lessons Learned from the Katsina Wind Farm for Future Wind Energy Projects

The Katsina Wind Farm project presents a valuable case for understanding both the promise and pitfalls of wind energy implementation in Nigeria. While conceived as a pioneering step toward integrating wind power into the national energy mix, the project has been marked by delays, operational inefficiencies, and underutilization. However, these challenges also offer important lessons for the planning and execution of future wind energy projects, particularly in developing economies with similar institutional and infrastructural conditions.

A primary lesson is the need for strong institutional coordination and clear governance structures throughout the project lifecycle. The Katsina Wind Farm faced significant administrative fragmentation, with overlapping responsibilities among ministries and agencies resulting in protracted decision-making and execution delays. Future projects must establish a unified project management framework with clearly defined roles, timelines, and accountability measures (Sovacool, 2017). A dedicated inter-ministerial task force or coordination unit could facilitate smoother implementation and inter-agency collaboration.

Another critical lesson concerns the importance of local capacity development. The reliance on foreign contractors and imported components made the project vulnerable to delays in technical maintenance and limited its sustainability. Strengthening indigenous technical expertise through capacity-building programs, vocational training, and university partnerships is vital to reduce long-term dependency and foster ownership at the national level (Taghizadeh-Hesary et al., 2022). This aligns with global best practices, where localisation of skills and knowledge transfer are key pillars in sustaining renewable energy infrastructures (IRENA, 2020).

The Katsina project also highlights the necessity of comprehensive feasibility assessments and risk planning. Initial project designs underestimated the impact of currency devaluation, logistical challenges, and supply chain disruptions. Future wind projects must incorporate robust financial modelling and risk mitigation mechanisms,

including hedging against foreign exchange risks and developing contingency plans for procurement delays (Karekezi and Kithyoma, 2003).

Community engagement emerged as another area requiring improvement. The limited involvement of local stakeholders during project planning and implementation contributed to skepticism and social detachment. Ensuring early and meaningful community participation—through consultations, inclusion in employment opportunities, and benefit-sharing mechanisms—can enhance public support and project legitimacy (Devine-Wright, 2007; Jenkins et al., 2016).

Furthermore, the Katsina experience underscores the role of policy continuity and regulatory support in renewable energy development. Frequent changes in political leadership disrupted project momentum and led to inconsistencies in regulatory enforcement. Establishing long-term, legally enforceable renewable energy policies—such as guaranteed grid access and pricing mechanisms—will be crucial for creating a stable environment that attracts and retains investment (He et al., 2023; IEA, 2021).

Finally, there is a pressing need for monitoring and evaluation (M&E) mechanisms. The absence of performance tracking in the Katsina project hindered timely identification and resolution of emerging challenges. Future projects should integrate M&E systems from inception to ensure transparency, accountability, and adaptive management throughout project execution (World Bank, 2020).

In summary, the Katsina Wind Farm demonstrates that without strategic governance, stakeholder alignment, and technical preparedness, even well-intentioned projects can fall short of their objectives. Learning from these experiences can help Nigeria build a more resilient and inclusive pathway for wind energy development.

5.2.5 Conclusion

In conclusion, the Katsina Wind Farm project presents critical insights into the challenges and opportunities of renewable energy adoption in Nigeria. Addressing financial barriers, streamlining regulatory approvals, building local technical expertise, and fostering community support will be essential in ensuring the long-term success of future renewable energy projects. By learning from these challenges, Nigeria can create a more sustainable and investor-friendly renewable energy landscape, paving the way for a cleaner, more resilient energy sector.

5.3 The Case Study Project 2: Bayero University Kano (BUK) Solar Project

5.3.1 Impact of Economic, Political, Technological, and Social Factors on Renewable Energy Adoption

The adoption and success of renewable energy projects in Nigeria, such as the Bayero University Kano (BUK) Solar Project, are influenced by a complex interplay of economic, political, technological, and social factors. These factors determine the feasibility, implementation, and long-term sustainability of such projects.

Economic Factors: The high upfront cost of renewable energy infrastructure is a primary barrier to adoption. One of the Technical Operations Officers from the BUK Solar Project noted that

"Securing funds was difficult due to the high initial investment required for solar systems."

This financial constraint was echoed by interviewees from the Rural Electrification Agency (REA), who emphasized that limited budget allocations and reliance on external funding often result in project delays. Literature supports this claim, highlighting that insufficient financing mechanisms and inadequate government subsidies hinder renewable energy expansion in Nigeria (IRENA, 2021). Although solar power offers long-term cost savings, the lack of access to affordable financing options makes large-scale implementation challenging. Furthermore, economic volatility and fluctuating exchange rates impact the procurement of essential components, as many solar PV systems and batteries are imported (World Bank, 2020). Addressing these challenges requires innovative financial models, such as public-private partnerships, concessional loans, and green energy funds, to support widespread renewable energy adoption.

- Political Factors: Political will and policy frameworks play a crucial role in the adoption of renewable energy. While Nigeria has developed several renewable energy policies, implementation remains slow due to bureaucratic inefficiencies and inconsistent regulatory enforcement. Interviewees from the Ministry of Power noted that *"delays in obtaining permits and regulatory approvals*

significantly hinder renewable energy projects, causing setbacks in implementation timelines." Literature corroborates this, indicating that lengthy approval processes, unclear policy guidelines, and lack of institutional coordination deter investments in Nigeria's renewable energy sector (GIZ, 2020). The BUK Solar Project was also subject to policy uncertainties, with stakeholders having to navigate complex land acquisition processes and shifting regulatory requirements. To improve the investment climate for renewable energy, there is a need for streamlined approval processes, stable policy frameworks, and government-backed incentives such as tax exemptions and subsidies for solar equipment.

- **Technological Factors:** The success of renewable energy projects depends on access to modern technology and local expertise in system installation and maintenance. The BUK Solar Project faced initial technical challenges related to battery degradation and procurement delays, which affected energy storage capacity. A Technical Operations Officer noted that *"initial maintenance issues with battery storage required the integration of an advanced battery management system to enhance efficiency."* This highlights the importance of investing in technological innovation and local capacity-building to ensure the sustainability of renewable energy systems. Research supports this by emphasizing that limited availability of skilled personnel in solar PV installation and maintenance is a critical barrier to Nigeria's renewable energy transition (IRENA, 2021). Addressing this challenge requires technical training programs and academic-industry collaborations to develop local expertise in renewable energy technologies.

- **Social Factors:** Public perception, awareness, and community engagement are essential in the adoption of renewable energy. One of the main concerns at the beginning of the BUK Solar Project was community skepticism about the effectiveness of solar power, particularly regarding its reliability during cloudy periods. A project coordinator explained, *"there was initial resistance from students and faculty who doubted that solar power could fully replace grid electricity."* This scepticism is common in Nigeria, where grid electricity has historically been unreliable, leading to concerns that solar projects may also be

inconsistent. Studies have shown that awareness campaigns, stakeholder consultations, and visible demonstrations of solar energy benefits significantly improve public perception and acceptance of renewable energy (IRENA, 2021). The BUK Solar Project addressed these concerns through educational workshops, hands-on demonstrations, and regular engagement with university stakeholders, helping to build trust and acceptance.

5.3.2 Influence of Social Attitudes, Perceptions, and Awareness on Renewable Energy Adoption

Public acceptance and awareness of renewable energy are critical to successful adoption. In Nigeria, many people remain sceptical about the effectiveness of solar energy due to limited exposure and misinformation. As highlighted in the interviews, initial resistance from the university community at BUK was a key challenge. However, targeted awareness campaigns significantly improved stakeholder buy-in.

Interviewees emphasized that *"community engagement and education played a major role in gaining acceptance for the project".* This aligns with findings from the literature, which show that renewable energy adoption is more successful when communities are actively involved in the planning and implementation process (World Bank, 2020). To further enhance acceptance, institutions should incorporate renewable energy education into academic curricula, provide hands-on training, and showcase successful case studies to inspire confidence in solar technology.

5.3.2.1 **Institutional Leadership and Donor Support in Facilitating Solar Energy Expansion at BUK**

The expansion and success of the Bayero University Kano (BUK) Hybrid Solar PV Park illustrate the pivotal role of institutional leadership and donor funding in accelerating renewable energy deployment in Nigeria's higher education sector. This case demonstrates how internal commitment, policy alignment, and structured financing mechanisms can converge to address persistent energy challenges and foster long-term sustainability.

The leadership at BUK was instrumental in initiating and supporting the solar project. Senior university administrators championed the integration of renewable energy into the institution's strategic infrastructure planning. This proactive engagement

facilitated coordination with external partners, expedited internal decision-making processes, and helped align the project with national energy and educational development goals. According to Musall and Kuik (2011), local institutional leadership is often decisive in ensuring project legitimacy, stakeholder mobilisation, and long-term system ownership. At BUK, such leadership created an enabling environment for collaboration and innovation.

Moreover, donor funding and targeted public investment were critical enablers of the project. The BUK solar park was supported under the Federal Government's Energising Education Programme (EEP), funded in part through green bond issuances and development partner contributions. Key international donors included the World Bank and the African Development Bank (AfDB), both of which provided financial and technical support to the EEP. The involvement of these multilateral institutions helped to bolster investor confidence, introduce the best international practices in project implementation, and ensure strong oversight in procurement and reporting mechanisms. This blended financing model addressed the capital-intensive nature of renewable energy infrastructure and mitigated financial risks often associated with public sector projects (Glemarec, 2012). These funds not only financed the installation of photovoltaic infrastructure but also supported capacity-building components, such as the creation of a Renewable Energy Training Centre within the university. This dual-purpose investment reflects international best practices, where renewable energy projects are designed to deliver both utility services and developmental co-benefits (Ahlborg and Hammar, 2014).

The project also exemplified effective multi-stakeholder governance. Collaborations between the Rural Electrification Agency (REA), BUK management, engineering contractors, and donor organisations were managed through transparent processes and clearly defined roles. This participatory model of governance helped reduce project implementation delays and fostered a sense of shared ownership among key stakeholders. Research by Sachs et al. (2019) highlights that such integrated governance frameworks improve project resilience and efficiency, particularly in developing countries where institutional fragmentation often impedes infrastructure delivery.

Another significant factor in the project's success was the incorporation of research, training, and student engagement into the renewable energy deployment strategy. The BUK Renewable Energy Training Centre has become a hub for solar PV research,

technician training, and awareness programmes for students and staff. This integration of infrastructure with institutional learning aligns with the argument by Cherni and Preston (2007), who contend that renewable energy investments in academic settings have higher returns when linked with innovation and knowledge transfer systems.

Overall, the BUK case demonstrates that institutional leadership, donor engagement, and stakeholder collaboration can collectively drive meaningful progress in renewable energy adoption. The project stands as a model for other universities and public institutions seeking to transition to sustainable energy, especially in contexts where conventional grid systems are unreliable or insufficient. To replicate this success elsewhere, similar projects must embed strategic leadership, build capacity for technical management, and ensure that financial structures are de-risked through blended public–private approaches.

5.3.3 Challenges Encountered in Renewable Energy Projects in Nigeria

Several challenges continue to hinder the growth of renewable energy in Nigeria. From the experiences of the BUK Solar Project, key challenges include:

1. Financial Barriers: The high cost of initial installation and maintenance remains a major obstacle. Funding gaps often lead to project delays, as observed in the case of the BUK Solar Project, where financial constraints slowed down procurement and system upgrades. According to literature, lack of sustainable financing models and reliance on external funding hinder the scalability of renewable energy projects in Nigeria (IRENA, 2021).
2. Regulatory Hurdles: Lengthy approval processes and inconsistent policies create uncertainty for investors and project developers. As one interviewee from the Ministry of Power noted, *"navigating regulatory approvals in Nigeria is often time-consuming and unpredictable, discouraging private sector participation."* Studies confirm that policy instability and weak enforcement mechanisms are among the biggest barriers to Nigeria's renewable energy growth (GIZ, 2020).
3. Technical Constraints: Limited local expertise and technological capacity affect project sustainability. The BUK Solar Project encountered challenges with battery storage management and inverter efficiency, requiring additional investment in training and system upgrades. Literature highlights that capacity-

building initiatives and skills development programs are essential for the long-term success of renewable energy projects (IRENA, 2021).

4. Community Engagement Issues: Initial scepticism and resistance from stakeholders can delay project acceptance and implementation. The BUK Solar Project overcame this through targeted awareness campaigns and participatory planning. Studies recommend that early stakeholder involvement and transparent communication strategies improve community support for renewable energy projects (World Bank, 2020).

5.3.3.1 Challenges and Mitigation Strategies in the BUK Hybrid Solar PV Park Project

Despite the overall success of the Bayero University Kano (BUK) Hybrid Solar PV Park, the project encountered several implementation challenges that are reflective of broader systemic issues in Nigeria's renewable energy sector. These included logistical barriers, regulatory delays, technical skill gaps, and stakeholder coordination complexities.

One of the primary challenges involved delays in the customs clearance and transportation of imported solar components. Like many renewable energy projects in sub-Saharan Africa, the BUK installation depended on imported photovoltaic equipment and battery storage systems, which were subject to complex port procedures and high import duties (UNEP, 2017). These bottlenecks disrupted the project timeline and incurred additional storage and demurrage costs. Addressing this issue required high-level inter-agency collaboration and intervention by the Rural Electrification Agency (REA), which helped expedite the release of critical equipment through ministerial waivers and priority processing arrangements.

Another significant challenge stemmed from the limited availability of local technical expertise for the installation and commissioning of the hybrid PV systems. This gap presented risks to both implementation quality and long-term sustainability. In response, the project incorporated a training component through the establishment of a Renewable Energy Training Centre within BUK. This centre not only served immediate project needs by training technical staff and student volunteers but also laid the groundwork for institutional capacity-building. According to Ockwell and Byrne (2016), such embedded learning frameworks are essential for technology transfer and localisation in developing countries.

Coordination among multiple stakeholders, including BUK management, REA officials, engineering contractors, and international development partners, also presented challenges. Miscommunication and fragmented reporting sometimes led to overlapping responsibilities and ambiguity in project milestones. To overcome this, a dedicated project implementation unit was established within BUK to facilitate streamlined communication, track deliverables, and serve as a central liaison with external actors. Effective governance and stakeholder alignment are often cited as key determinants of project success in decentralised energy systems (Sovacool et al., 2020).

Additionally, there were occasional power integration issues when connecting the solar output with existing campus infrastructure. This necessitated minor redesigns of the distribution network and installation of automated control systems to optimise energy flow and system stability. Technical advisors from the REA and contracted engineering firms worked closely to reconfigure load management strategies, ensuring minimal disruption to campus operations.

In summary, the BUK Hybrid Solar PV Park project faced predictable but surmountable obstacles in equipment logistics, technical capacity, stakeholder coordination, and infrastructure integration. The ability to mitigate these challenges through institutional leadership, donor support, capacity-building, and adaptive project governance provides a replicable framework for similar university-led renewable energy projects in Nigeria and comparable contexts.

5.3.4 Lessons Learned and Recommendations for Future Renewable Energy Initiatives in Nigeria

The experiences from the BUK Solar Project offer valuable lessons for future renewable energy projects in Nigeria. Key takeaways include:

1. Strengthening Financial Mechanisms: To address funding challenges, there is a need for innovative financing models such as public-private partnerships, concessional loans, and carbon credit financing. The government should also offer tax incentives and subsidies to lower the cost of solar energy adoption.
2. Improving Policy and Regulatory Frameworks: Simplifying approval processes and ensuring policy stability will enhance investor confidence and accelerate

project implementation. The government should establish a one-stop regulatory framework to facilitate renewable energy investments.

3. Investing in Technological and Human Capital Development: Training programs and knowledge transfer initiatives should be prioritized to build local expertise in solar PV technology and maintenance. Universities can play a role in developing renewable energy research and innovation hubs.
4. Enhancing Community Engagement and Public Awareness: Greater emphasis should be placed on education, training, and demonstration projects to build trust and increase acceptance of renewable energy solutions.

5.3.5 Conclusion

The BUK Solar Project serves as an important case study for understanding the challenges, opportunities, and best practices in Nigeria's renewable energy sector. By addressing financial, regulatory, technological, and social barriers, future projects can achieve greater success and sustainability. Strengthening stakeholder engagement, fostering policy stability, and investing in local capacity-building will be crucial in accelerating Nigeria's transition to a cleaner and more reliable energy future.

5.4 The Case Study Project 3: University of Maiduguri (UNIMAID) Solar Project

5.4.1 Impact of Economic, Political, Technological, and Social Factors on Renewable Energy Adoption

The adoption and success of renewable energy projects in Nigeria, such as the University of Maiduguri (UNIMAID) Solar Project, are influenced by a complex interplay of economic, political, technological, and social factors. These factors determine the feasibility, implementation, and long-term sustainability of such projects.

Economic Factors: The high upfront cost of renewable energy infrastructure is a primary barrier to adoption. One of the key challenges faced by REA and UNIMAID's project team was securing sufficient funding. As noted by a Project Coordinator at REA,

"Financial constraints due to inconsistent funding and delays in disbursement have

been among the most difficult hurdles to overcome. Many projects have stalled due to these issues, requiring alternative financing solutions."

However, the UNIMAID Solar Project was fortunate to receive financial backing from the World Bank and the Federal Government of Nigeria, which significantly eased the economic burden. Moreover, the project demonstrates the long-term financial benefits of solar power, as it is expected to save the university millions in energy costs. A comparative energy cost analysis conducted at UNIMAID between 2017 and 2019 demonstrated a 58% savings in energy costs due to the deployment of solar photovoltaics over public-powered streetlights. The study revealed that over ₦14.8 million was saved during this period, reinforcing the financial viability of transitioning to renewable energy.

Political and Regulatory Factors: Political commitment is essential for the successful implementation of renewable energy projects. However, regulatory bottlenecks have often hindered progress. The Director of Renewable Energy Policy and Programmes at the Ministry of Power acknowledged that

"Prolonged approval processes and bureaucratic inefficiencies have delayed several renewable energy projects. These challenges must be addressed to facilitate large-scale adoption"

UNIMAID faced similar challenges, as the project was delayed due to difficulties in securing land-use permits and environmental impact assessments. As noted by a UNIMAID project team member,

"Regulatory hurdles and slow approval processes set back our timeline. However, through persistent engagement with authorities, we managed to resolve these issues."

Such experiences highlight the importance of streamlined regulatory frameworks to support the rapid deployment of renewable energy.

Technological Factors: The integration of advanced lithium-ion battery storage and smart inverters was crucial for ensuring the reliability of the UNIMAID solar system. According to a Technical Operations Officer at REA,

"We have leveraged remote monitoring systems that allow us to track the

performance of our energy systems in real-time. This helps us address technical issues quickly and efficiently."

The use of real-time monitoring and predictive maintenance has been instrumental in optimizing energy distribution at UNIMAID, ensuring continuous power supply even in adverse conditions.

Social Factors: Community engagement and stakeholder involvement played a crucial role in the project's success. The Acting Governor of Borno State emphasized during an inspection tour that

"Electricity is a fundamental necessity for economic and educational progress. This project will greatly enhance academic and research activities in the region."

The involvement of university administrators, students, and the local community helped in ensuring the project's acceptance. However, initial uncertainty regarding the reliability of solar energy had to be overcome.

"Some community members doubted whether the solar system could provide uninterrupted power. We addressed these concerns through education campaigns and live demonstrations," a UNIMAID project coordinator explained.

These initiatives fostered trust and ensured long-term community support.

5.4.2 Project Implementation and Stakeholder Collaboration

The UNIMAID Solar Project was implemented through a multi-stakeholder approach, involving government bodies, international donors, university leadership, and local contractors. A Senior Project Manager at REA noted,

"Successful rural electrification projects require effective collaboration between government agencies, international partners, and local communities. Public-private partnerships have been instrumental in driving progress."

The project's funding from the World Bank and the Nigerian government was critical in ensuring smooth implementation. The Ministry of Power also played a pivotal role in supporting the regulatory and policy aspects of the initiative. According to the Ministry's Director of Renewable Energy,

"Policy alignment and inter-agency coordination have been key factors in accelerating renewable energy adoption. The UNIMAID Solar Project is a prime example of how institutional support can drive success."

A key strategy in project execution was phased deployment, allowing for infrastructure development while ensuring minimal disruption to academic activities. As highlighted by the UNIMAID project coordinator,

"We ensured that the installation process was carefully managed to avoid interfering with university operations. Phased implementation also allowed us to make necessary adjustments along the way."

Furthermore, the involvement of local contractors helped create employment opportunities and enhance technical expertise within the region.

5.4.2.1 Community Engagement and Local Support for the UNIMAID Solar Project

The University of Maiduguri (UNIMAID) Solar Project serves as a compelling example of how strategic community engagement can enhance local support, ensure project stability, and reinforce sustainability in fragile and conflict-prone settings. In contexts where social cohesion and public trust are tenuous—such as northeastern Nigeria—engaging the local population in renewable energy initiatives is not only a best practice but a prerequisite for successful implementation (Devine-Wright, 2011). Effective community engagement in the UNIMAID project was facilitated through structured stakeholder consultations and inclusive planning processes. Project implementers, including the university administration and the Rural Electrification Agency (REA) prioritised transparency, consultation, and information dissemination. These efforts created a shared understanding of the project's objectives, potential benefits, and expected community roles.

According to Aklin et al. (2018), when communities perceive themselves as co-owners of renewable energy projects, they are more likely to cooperate, protect infrastructure, and support maintenance initiatives. In the case of UNIMAID, this participatory approach helped reduce social resistance and built a foundation for sustained local involvement.

In addition, the incorporation of local labour in construction and technical training initiatives provided immediate socio-economic benefits, enhancing the project's legitimacy among community members. As Sovacool et al. (2015) argue, local employment opportunities linked to energy projects help foster a sense of agency, especially in regions affected by conflict and economic marginalisation. At UNIMAID, such inclusive strategies not only mitigated risks of vandalism and community hostility but also laid the groundwork for long-term human capital development in energy infrastructure management.

Moreover, collaboration with traditional leaders and community-based organisations played a critical role in diffusing tensions and facilitating consensus. These actors acted as intermediaries between the project team and residents, helping to manage expectations and resolve grievances. This is consistent with findings by van Veelen (2017), who notes that local champions and mediators significantly enhance the credibility and acceptance of renewable energy initiatives in rural and semi-urban communities.

Ultimately, the UNIMAID Solar Project demonstrates that meaningful community engagement can transform potentially volatile contexts into supportive environments for renewable energy expansion. By embedding the project within the social fabric of the host community, the initiative avoided many of the pitfalls that often derail infrastructure projects in fragile regions. Future projects would benefit from adopting similar participatory approaches, particularly in areas where trust in formal institutions is weak or contested.

5.4.3 Challenges and Lessons Learned

The implementation of the UNIMAID Solar Project was not without challenges. Some of the major obstacles encountered included:

- Security Risks: Borno State's history of conflict posed a significant challenge. The project team worked closely with security agencies to ensure the safety of personnel and equipment. The Acting Managing Director of REA, during an inspection tour, stated, *"Despite security threats, the commitment of*

stakeholders has ensured the project's continuity. Implementing strict security measures has been essential."

- Logistical Constraints: Transporting solar panels and battery storage units from Lagos to Maiduguri was a complex process due to poor road infrastructure and security risks. A project engineer noted, *"Logistical bottlenecks caused delays, but we mitigated this by partnering with transport firms familiar with the terrain."*
- Regulatory Delays: Bureaucratic inefficiencies slowed approvals for environmental impact assessments and land acquisition. However, continuous advocacy and engagement with government agencies helped resolve these challenges. As an REA official put it, *"Policy streamlining and inter-agency coordination are crucial to overcoming regulatory bottlenecks."*

Key lessons learned from the project include the need for early stakeholder engagement, risk management strategies, and flexible project design. The experience at UNIMAID highlights that investing in training programs for local technicians ensures project sustainability, as noted by the Ministry of Power: *"Capacity building is essential for long-term success. Training local technicians reduces dependence on external expertise and fosters local ownership."*

5.4.4. Broader Implications and Future Recommendations

The UNIMAID Solar Project sets an important precedent for the future of renewable energy adoption in Nigeria's education sector. The success of this initiative demonstrates the viability of large-scale hybrid solar systems in conflict-prone and underserved regions. Given its impact, there is a strong case for replicating similar projects in other institutions. According to a Senior Project Manager at REA,

"The UNIMAID Solar Project should serve as a model for other universities across Nigeria. The key is to ensure proper funding mechanisms and policy support."

To build on this progress, the following policy recommendations are suggested:

- Expanding financial incentives for universities to adopt solar energy, such as low-interest loans and tax exemptions.
- Streamlining regulatory processes to reduce approval timelines for renewable

energy projects.

- Strengthening public-private partnerships to attract investment and enhance technical expertise.
- Develop training programs in universities to equip students with skills in renewable energy technology and maintenance.

The UNIMAID Solar Project is a transformative initiative that exemplifies how renewable energy can enhance education, healthcare, and economic opportunities. By overcoming security threats, logistical bottlenecks, and regulatory delays, the project has provided a scalable blueprint for future initiatives. With continued government support, private sector investment, and academic collaboration, Nigeria can achieve its goal of universal energy access while fostering a sustainable and resilient education sector.

5.4.4.1 Enhancing Energy Security in Conflict-Prone Regions: The Case of the UNIMAID Solar Project

The University of Maiduguri (UNIMAID) Solar Project stands as a strategic intervention in improving energy security within conflict-prone regions of Nigeria. Located in Borno State, one of the epicentres of insurgency and infrastructural collapse in the country, UNIMAID faced frequent disruptions to power supply due to attacks on the national grid and widespread insecurity. In such contexts, energy insecurity is not merely a developmental constraint—it becomes a direct threat to human security, institutional functionality, and social stability.

The deployment of an independent solar photovoltaic (PV) system under the Energising Education Programme (EEP) represented a paradigm shift from reliance on centralised grid infrastructure to decentralised renewable energy solutions. According to Sovacool and Ryan (2016), decentralised energy systems are particularly valuable in fragile and post-conflict settings as they are less vulnerable to single points of failure, easier to secure, and quicker to deploy. The UNIMAID solar project significantly reduced the university's dependence on diesel generators and the national grid, thereby enhancing operational resilience and ensuring uninterrupted academic, healthcare, and administrative activities.

In addition to improving technical resilience, the project contributed to institutional and community stability. Electrification of student hostels, classrooms, and medical

centres bolstered the university's capacity to serve as a safe zone within an otherwise volatile environment. This aligns with the findings of Aklin et al. (2018), who argue that access to reliable electricity in conflict zones supports governance functions, education, and economic participation—key pillars for peacebuilding and recovery. At UNIMAID, consistent energy supply enabled digital learning, medical research, and critical communications, which collectively sustained the institution's role as a regional anchor during the crisis.

Furthermore, the solar project incorporated capacity-building components, including the training of local technicians and engineers. This not only enhanced technical self-reliance but also promoted community involvement and employment, reducing social tensions and economic grievances that often fuel insurgency (Sweeney and Kossak, 2013). The employment of local labour for installation and maintenance contributed to a sense of ownership and strengthened the university's engagement with surrounding communities.

International development agencies and the Federal Government's coordination through the Rural Electrification Agency (REA) played pivotal roles in facilitating the project's implementation. The multi-actor governance model demonstrated at UNIMAID mirrors successful international examples in Afghanistan and South Sudan, where renewable energy has been used as a peacebuilding instrument (UNDP, 2020). The availability of power has also allowed the university to serve internally displaced persons (IDPs) through medical outreach and humanitarian programmes, expanding the social impact of energy intervention beyond the academic community.

In summary, the UNIMAID Solar Project demonstrates that renewable energy can serve as both an infrastructural and socio-political stabilizer in conflict-prone regions. By ensuring reliable power supply, enabling essential services, and fostering local capacity, the project significantly enhanced energy security and resilience in a context where conventional grid systems were either unreliable or entirely unavailable.

5.4.5 Conclusion

The University of Maiduguri (UNIMAID) Solar Project highlights the role of economic, political, technological, and social factors in shaping renewable energy adoption in Nigeria. While the project successfully reduced energy costs and enhanced

electricity reliability for the university, it also underscores financial and regulatory hurdles that continue to impede large-scale renewable energy deployment. The reliance on external funding from the World Bank and government agencies provided crucial financial support, yet the lack of sustainable financing mechanisms raises concerns about long-term scalability. Similarly, regulatory bottlenecks and bureaucratic inefficiencies delayed implementation, reflecting the need for policy reforms that simplify approval processes and encourage private sector investment. These challenges point to the necessity of streamlined regulatory frameworks and financial incentives, such as tax exemptions and concessional loans, to facilitate broader adoption across Nigeria's education and public sectors.

From a technological and social perspective, the project demonstrated that advanced battery storage and real-time monitoring systems can enhance the efficiency and reliability of solar energy solutions. However, continued reliance on imported components and foreign expertise suggests the need for greater investment in local capacity-building and technology transfer. The project's success in securing community support through stakeholder engagement and awareness initiatives reinforces the importance of early and inclusive participation in renewable energy projects. The lessons from UNIMAID emphasize that future initiatives should integrate local workforce training, establish industry-academic partnerships, and prioritize community-driven implementation models. By addressing these structural and systemic barriers, Nigeria can scale its renewable energy ambitions, enhance energy security, and drive long-term socio-economic development through sustainable power solutions.

5.4.5.1 Sustainability Concerns and Security Risks in the UNIMAID Solar Project

The University of Maiduguri (UNIMAID) Solar Project offers a compelling illustration of the dual challenges of sustainability and security in implementing renewable energy systems within conflict-prone regions. While the project achieved significant progress in energy provision and institutional support, it simultaneously faced considerable obstacles that raise concerns about long-term viability and physical safeguarding of infrastructure.

A major sustainability concern identified in the UNIMAID Solar Project relates to the maintenance and technical support capacity for the solar photovoltaic (PV) infrastructure. In regions affected by prolonged conflict, the scarcity of trained

personnel and constrained access to replacement components pose serious risks to operational continuity. This reflects broader findings in energy transition literature, which emphasize that technological sustainability in developing contexts is contingent not only on initial deployment but on local capacity for repair, maintenance, and system upgrades (Sovacool et al., 2017; Kumar et al., 2019). Without sufficient funding for training or long-term service contracts, PV systems in such environments may gradually degrade, reducing their effectiveness and community trust.

Additionally, the logistical challenges of ensuring supply chains for imported solar components are exacerbated by insecurity in north-eastern Nigeria. Road access disruptions, theft of materials, and sabotage risks have required increased security coordination and additional expenditure on protective measures. This aligns with studies by Yenneti et al. (2016), who found that energy infrastructure in politically unstable regions often requires higher capital allocations for risk mitigation, which can reduce the cost-efficiency of renewable energy investments.

Security risks also stem from the proximity of the project to active insurgent zones, which not only endanger physical infrastructure but also deter technical personnel from carrying out routine operations. According to Olanrewaju et al. (2020), in conflict zones, renewable energy projects can become targets due to their symbolic and strategic value, particularly when they serve vital institutions such as universities or hospitals. The perceived alignment of such projects with state or foreign interests may attract hostility, unless carefully integrated with community-based security mechanisms.

The reliance on external contractors for both system design and deployment was another sustainability concern. While the UNIMAID project benefitted from technical expertise and donor support during installation, the long-term dependency on foreign partners raises issues of ownership, adaptability, and cost recovery. As noted by Ahlborg et al. (2015), sustainable energy transitions in Africa require institutional arrangements that empower local stakeholders to manage and adapt systems over time rather than remain dependent on external actors.

Mitigating these challenges necessitates the incorporation of community-based energy governance, capacity-building initiatives, and adaptive maintenance models tailored to insecure settings. For example, energy cooperatives or university-led solar task

forces could play a pivotal role in managing infrastructure and enhancing local accountability. Moreover, integrating energy planning with broader conflict-resolution and resilience strategies can help ensure that renewable energy projects contribute not only to electricity access but to social stability and post-conflict reconstruction (Sovacool and Dworkin, 2015).

5.5 Cross-Case Analysis of Renewable Energy Adoption

Robert K. Yin's case study approach emphasizes the importance of comparative analysis to identify recurring patterns and divergences across multiple case studies (Yin, 2018). By applying replication logic and pattern matching, the insights from the Katsina Wind Farm, the University of Maiduguri (UNIMAID) Solar Project, and the Bayero University Kano (BUK) Solar Project provide a robust foundation for understanding the complexities of renewable energy adoption in Nigeria. This section presents a cross-case analysis to highlight key economic, policy, technological, and social factors influencing project outcomes. It further discusses shared and distinct challenges, the role of stakeholder engagement, and broader policy implications for Nigeria's renewable energy sector.

The transition from fossil fuels to renewable energy is critical for Nigeria's energy security, economic growth, and climate commitments. However, the adoption of renewable energy remains constrained by systemic barriers such as regulatory inefficiencies, financial constraints, and limited technological infrastructure. Through Comparative analysis, this section aims to address the broader research questions posed in this study, linking empirical evidence to theoretical frameworks and global best practices.

5.5.1 Economic, Political, Technological, and Social Factors in Renewable Energy Adoption

5.5.1.1 Economic Constraints and Investment Challenges

Economic viability is a dominant theme in all three case studies. The high capital costs required for renewable energy infrastructure, coupled with fragmented or inconsistent funding sources, have contributed to project delays and reduced operational efficiency. Guney et al. (2019) argue that in emerging economies, access to credit and structured

financial mechanisms are critical to accelerating renewable energy adoption. However, as seen in the Katsina Wind Farm and UNIMAID Solar Project, securing financing remains a persistent challenge.

The Katsina Wind Farm faced substantial funding delays due to the heavy reliance on government allocations and international aid. Exchange rate fluctuations and import dependencies further exacerbated costs, as turbine components had to be sourced from Europe. A Ministry of Power respondent noted,

"The unpredictability of funding cycles and lack of structured financial incentives make large-scale renewable projects difficult to execute."

In contrast, the BUK and UNIMAID Solar Projects benefitted from the Energizing Education Programme (EEP), which provided a more structured financing model through the World Bank and the Federal Government. Wu et al. (2023) highlights that successful renewable energy projects in emerging markets often rely on blended financing models that integrate public and private sector investments. The absence of such models in the Katsina Wind Farm resulted in prolonged completion timelines and increased overall project costs.

Despite financial constraints, long-term cost savings emerged as a clear advantage of renewable energy projects. Both the BUK and UNIMAID Solar Projects demonstrated significant reductions in operational costs by replacing diesel generators with solar photovoltaic (PV) systems. A financial officer from the BUK project observed,

"Within five years, the cost savings from reduced fuel consumption and maintenance have made the investment highly viable."

This aligns with findings from the Nigerian Energy Support Programme (NESP, 2018), which advocates for greater financial incentives and subsidized lending to facilitate the economic viability of renewable energy in institutional settings.

5.5.1.1.1 Addressing Economic Barriers: Financial Models for Renewable Energy Adoption

Given the persistent financial challenges identified in the cross-case analysis—such as high capital costs, limited access to credit, and weak investor confidence—this section critically explores a range of innovative financing models that have been successfully

applied in other developing contexts and evaluates their relevance and applicability to Nigeria's renewable energy transition.

The findings of this research reveal that economic constraints—particularly high capital costs, limited access to financing, and weak investor confidence—continue to be major impediments to the widespread adoption of renewable energy in Nigeria. These challenges are especially pronounced in large-scale infrastructure projects and rural electrification schemes, where the financial risk profile is high, and cost recovery mechanisms are often uncertain. To address these issues, several financial models can be considered, each offering potential pathways to mitigate risk, enhance affordability, and attract sustainable investment.

One viable model is the Public–Private Partnership (PPP) framework, which enables collaboration between government entities and private sector actors to finance and operate renewable energy projects. PPPs facilitate risk-sharing mechanisms that reduce the financial burden on public agencies while offering private investors assurances such as sovereign guarantees or long-term power purchase agreements. By aligning public policy objectives with market-driven incentives, PPPs have been shown to enhance the bankability of renewable energy infrastructure, particularly when supported by a stable regulatory environment and transparent procurement processes (Bloomfield and Ahern, 2011; GIZ, 2021).

Another model with strong potential is the adoption of Feed-in Tariffs (FiTs) and Performance-Based Incentives (PBIs). FiTs ensures predictable revenue streams for energy producers by offering fixed rates over long durations, which significantly lowers investment risk and facilitates financial planning. While FiTs have been instrumental in accelerating renewable energy deployment in other developing countries, their application in Nigeria has remained limited. Similarly, PBIs—where incentives are tied to output targets or service delivery milestones—can enhance operational efficiency while providing a mechanism for disbursing subsidies in a performance-sensitive manner (Couture and Gagnon, 2010).

In addition to tariff-based incentives, Green Bonds and climate finance instruments present innovative financing mechanisms for renewable energy development. Green bonds, which are debt securities earmarked for climate-resilient infrastructure, can

mobilize long-term capital from institutional investors seeking environmental returns alongside financial gains. Nigeria's entry into the green bond market, supported by multilateral organizations such as the African Development Bank, demonstrates a growing willingness to explore sustainable finance options at the national level (AfDB, 2022). Further, climate financing from global platforms such as the Green Climate Fund (GCF) or the Climate Investment Funds (CIF) can provide concessional funding and technical assistance for both on-grid and off-grid renewable energy projects, especially in underserved regions (Haites, 2011).

For rural and off-grid communities, models such as Pay-As-You-Go (PAYG) and micro-finance–based approaches are particularly effective. These models offer flexible payment plans that allow end-users to access solar energy systems through incremental payments via mobile platforms. By lowering the entry cost for consumers, PAYG systems have proven effective in expanding energy access across several Sub-Saharan African countries and can be integrated into Nigeria's rural electrification strategy. Coupled with support from micro-finance institutions and cooperative societies, these models not only address affordability but also promote inclusive participation in the renewable energy transition (Kumar, Singh and Hossain, 2018).

Furthermore, blended finance mechanisms—where public or philanthropic capital is used to leverage private investment—can play a transformative role. In the Nigerian context, where macroeconomic instability and currency depreciation often deter foreign investors, blended finance offers first-loss guarantees, concessional debt, and technical assistance grants to de-risk investment and enhance project bankability (Basile and Dutra, 2019). These instruments are particularly important in early-stage project development and in high-impact sectors such as off-grid electrification and rural mini-grids.

Finally, Results-Based Financing (RBF) models can be employed to enhance transparency and accountability in disbursement. RBF links payments to the achievement of clearly defined and independently verified output such as number of connections or energy delivered. This approach is increasingly favored by development partners and has been used effectively to catalyze private sector participation while reducing instances of inefficiency and fraud (World Bank, 2020).

Collectively, these financial models offer a diversified toolbox for overcoming the economic barriers identified in this study. Their success, however, hinges on the existence of supportive institutional frameworks, clear policy direction, and effective stakeholder engagement. By tailoring financing strategies to the scale, context, and risk profile of renewable energy projects, Nigeria can create an enabling environment that attracts investment, ensures equitable access, and accelerates the transition to a sustainable energy future.

These financial models, when strategically adapted to Nigeria's socio-economic realities and institutional frameworks, provide more than just access to capital—they offer a pathway toward equitable stakeholder engagement, improved governance, and inclusive energy development. From a theoretical standpoint, they reflect the core principles of Stakeholder Theory by recognizing the diverse interests and risk profiles of public institutions, private investors, and end-users. By creating value across stakeholder groups and enabling participatory mechanisms through structured financial incentives, these models reinforce the study's argument that effective renewable energy adoption in Nigeria requires not only technical solutions but also institutional and financial arrangements that reflect stakeholder interdependencies. Thus, embedding these models into national policy and project planning can play a transformative role in bridging the economic gaps that currently hinder Nigeria's transition to a low-carbon energy future.

5.5.1.2 Regulatory and Political Barriers

Policy inconsistencies and regulatory inefficiencies significantly influence renewable energy adoption in Nigeria. Yin (2018) argues that a well-defined policy framework is essential for project success, yet all three cases reveal bureaucratic delays, unclear policies, and regulatory bottlenecks. The Katsina Wind Farm faced significant hurdles in obtaining environmental impact assessments and land use permits, leading to prolonged project delays. A respondent from the REA project stated,

"Each agency operates in silos, requiring different approvals, which slows down the entire process and increases project costs."

This finding aligns with Asante et al. (2020), who identify inefficient governance structures as a key impediment to Africa's energy transition.

In contrast, the BUK and UNIMAID Solar Projects, operating under the EEP framework, faced fewer regulatory challenges due to structured policy support. However, both projects still encountered customs clearance delays for imported components, highlighting the need for targeted policy reforms. Global case studies from Germany and India suggest that clear, stable policies—such as Germany's Renewable Energy Sources Act—have been instrumental in fostering renewable energy expansion (Majid et al., 2014). Nigeria's fragmented regulatory landscape presents a barrier to scaling renewable energy, reinforcing the need for a streamlined approval system and incentivized policies for private sector participation.

In synthesizing the findings across the three case studies, it becomes evident that political interference, regulatory fragmentation, and institutional inefficiencies pose significant challenges to renewable energy adoption. Among these, policy instability stands out as a recurring and deeply disruptive factor, particularly in shaping investor confidence, delaying project implementation, and undermining long-term planning. The following subsection delves deeper into the specific manifestations and consequences of policy instability across the case studies, drawing on academic literature to contextualize these empirical observations within broader theoretical and global energy transition frameworks.

5.5.1.2.1 Impact of Policy Instability on Renewable Energy Adoption

Policy instability has emerged as a central barrier to the successful adoption of renewable energy in Nigeria. Across all three case studies—Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project—findings reveal that fluctuating government policies, inconsistent regulatory enforcement, and bureaucratic inefficiencies have significantly undermined project implementation and investor confidence. These challenges have stifled the pace of renewable energy expansion and jeopardised long-term sustainability.

The Katsina Wind Farm project exemplifies the disruptive effect of political turnover on renewable energy infrastructure. Interview data highlighted that frequent changes in government leadership often necessitated the renegotiation of contracts and the reapplication for previously approved permits. Such policy discontinuities led to project delays spanning several years and substantial cost overruns. This aligns with

the conclusions of Asante et al. (2020), who argue that the lack of policy continuity and inter-agency coordination contributes to systemic inefficiencies in Africa's energy sector.

Despite the existence of strategic documents such as the Renewable Energy Master Plan (REMP) and the National Renewable Energy and Energy Efficiency Policy (NREEEP), the practical enforcement of these policies has been uneven (GIZ, 2020; NESP, 2020). Policymakers have often prioritized short-term interests and fossil fuel subsidies over long-term renewable energy goals, thereby sending mixed signals to private investors. This ad hoc policy approach has discouraged private sector participation and obstructed access to international financing, both of which are vital for scaling renewable energy projects in developing economies (IRENA, 2021; Ogunbiyi, 2021).

The BUK and UNIMAID Solar Projects, although partially shielded by the structured framework of the Energizing Education Program (EEP), also encountered regulatory bottlenecks. Complex customs procedures, delays in the clearance of imported solar components, and overlapping agency mandates caused implementation setbacks. According to Sovacool and Geels (2020), fragmented regulatory landscapes and overlapping jurisdictions are common in developing countries and often result in inefficiencies that delay project timelines and inflate costs.

Furthermore, the unpredictability of the policy environment exacerbates the perceived risk associated with renewable energy investments. Olowosejeje (2019) notes that in contexts where regulatory enforcement is weak and institutional memory is fragmented, investors are reluctant to commit capital to long-term energy infrastructure. This is especially true for projects requiring large upfront investment and long payback periods, such as wind farms and solar mini grids.

Comparative experiences from countries like Germany and India illustrate the importance of policy consistency in attracting investment. Germany's Renewable Energy Sources Act, for example, guarantees grid access and fixed tariffs for renewable producers, providing the policy certainty necessary for long-term investment (Majid et al., 2014). India's National Solar Mission similarly outlines a clear roadmap with subsidy schemes, risk mitigation instruments, and capacity-building initiatives that have accelerated renewable energy deployment at scale (He et

al., 2023).

In contrast, Nigeria's policy framework has remained reactive rather than proactive, frequently shifting with political cycles and lacking the legal enforcement necessary to inspire investor confidence (World Bank, 2020; Acheampong et al., 2021). For instance, the failure to operationalise feed-in tariffs and delayed implementation of net metering regulations further illustrates the gap between policy formulation and execution.

In summary, policy instability in Nigeria manifests not only in frequent legislative changes but also in the weak enforcement of existing frameworks. These inconsistencies hinder the mobilization of financial resources, delay project execution, and erode stakeholder confidence. Addressing this barrier requires the establishment of a coherent and enforceable long-term policy framework that transcends electoral cycles, streamline regulatory processes, and incentivizes private investment in renewable energy.

While policy instability sets the stage for uncertainty and weak investor confidence, its practical consequences are most visible in the regulatory bottlenecks encountered during project implementation. The following section examines the institutional inefficiencies—such as fragmented agency mandates, protracted approval processes, and enforcement deficits—that further hinder the rollout and success of renewable energy initiatives in Nigeria.

5.5.1.2.2 Regulatory Inefficiencies and Their Impact on Project Implementation

Regulatory inefficiencies constitute a significant barrier to the successful implementation of renewable energy projects in Nigeria. Across all three case studies, challenges such as protracted permit processes, overlapping agency mandates, and lack of institutional coordination were repeatedly cited as major contributors to project delays, increased costs, and investor withdrawal.

The Katsina Wind Farm exemplifies the bureaucratic complexity that characterises Nigeria's regulatory environment. Stakeholders involved in the project highlighted the absence of a unified regulatory framework, necessitating multiple layers of approval from various agencies. This fragmented process significantly delayed the issuance of environmental impact assessments and land use permits, ultimately postponing project

execution by several years. Such findings mirror broader research by Asante et al. (2020), who argue that fragmented governance and unclear mandates among regulatory bodies in Africa's energy sector hinder efficient decision-making and policy enforcement.

A key inefficiency is the absence of a single-window clearance system, which forces developers to navigate disparate approval processes, often with conflicting requirements. This results in administrative redundancy and a lack of accountability. Sovacool et al. (2016) note that institutional misalignment and regulatory opacity are common challenges in developing economies, where energy sector governance is characterised by inertia and limited inter-agency cooperation.

Furthermore, even where policy frameworks exist—such as the Renewable Energy Master Plan (REMP) or the National Renewable Energy and Energy Efficiency Policy (NREEEP)—the lack of enforceability and weak institutional capacity render them ineffective. GIZ (2020) and Ogunbiyi (2021) have pointed out that without regulatory enforcement mechanisms and accountability frameworks, even well-intentioned policies fail to translate into practical outcomes. In the Katsina case, regulatory ambiguities forced several contract renegotiations and compliance revisions, further undermining project momentum.

Import clearance delays for imported renewable energy components also underscore inefficiencies in Nigeria's trade and customs regulations. Despite being supported by the Energizing Education Programme (EEP), the BUK and UNIMAID Solar Projects encountered logistical setbacks due to lengthy clearance procedures and inconsistent tariff classifications. IRENA (2021) suggests that streamlining customs and introducing fast-track processes for renewable energy technologies are critical steps toward creating a more investment-friendly environment.

These inefficiencies contribute to a perception of heightened regulatory risk, which deters both domestic and international investors. Acheampong et al. (2021) emphasise that predictable, transparent, and efficient regulatory systems are vital to mitigating investor uncertainty and fostering long-term commitments to energy infrastructure projects. In Nigeria, the lack of such systems has constrained private sector involvement, limited innovation and slowing the pace of renewable energy deployment.

In summary, regulatory inefficiencies in Nigeria's renewable energy sector manifest in procedural complexity, weak inter-agency coordination, inconsistent enforcement, and inadequate institutional capacity. These challenges not only stall project implementation but also erode investor confidence and undermine national energy goals. Addressing these inefficiencies will require the establishment of a centralized approval system, harmonization of regulatory mandates, and stronger oversight to ensure timely execution and accountability.

These institutional shortcomings highlight the urgent need for structural reform within Nigeria's regulatory apparatus. Without a well-coordinated and transparent regulatory system, renewable energy projects will continue to face systemic delays, escalating costs, and diminished investor interest. In response to these challenges, the following section outlines a set of strategic recommendations designed to improve regulatory effectiveness and create an enabling environment for the scale-up of renewable energy deployment.

5.5.1.2.3 Recommendations for Strengthening Regulatory Frameworks for Renewable Energy

Considering the challenges identified with policy instability and regulatory inefficiencies, it is imperative to propose targeted recommendations aimed at strengthening Nigeria's regulatory framework to facilitate effective renewable energy adoption and implementation. A robust and coherent regulatory environment is critical for attracting investment, accelerating project execution, and ensuring long-term sustainability in the energy sector. One of the foremost recommendations is the establishment of a centralised regulatory coordination body to streamline approval processes and reduce bureaucratic duplication. The current fragmentation, where multiple agencies operate in silos with overlapping mandates, leads to administrative delays and inconsistent enforcement. A single-window clearance system—like models adopted in countries like India—can simplify licensing procedures, enhance transparency, and reduce transaction costs (Kumar and Choudhary, 2021; IRENA, 2021). Such a framework would benefit from digitalisation to track application progress and hold agencies accountable for processing timelines.

Legislative backing is another critical pillar of reform. While Nigeria has developed

several policy documents such as the National Renewable Energy and Energy Efficiency Policy (NREEEP) and the Renewable Energy Master Plan (REMP), their lack of legal enforceability has undermined implementation. Enshrining renewable energy policies in law through an Act of Parliament—akin to South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP)—would strengthen their legitimacy and ensure continuity beyond political cycles (Eberhard and Naude, 2017). Such legal reinforcement would also provide the basis for judicial oversight in cases of regulatory non-compliance or arbitrary policy reversal.

Another recommendation is to institutionalise inter-agency collaboration frameworks. Regular dialogue between energy regulators, environmental agencies, customs authorities, and investment promotion bodies would foster harmonised standards and reduce implementation bottlenecks. For example, Rwanda's energy sector reforms show that structured coordination across agencies significantly improves investment outcomes and policy consistency (Wüstenhagen and Menichetti, 2012).

Capacity building for regulatory institutions is equally vital. Many regulatory bottlenecks stem from understaffed and under-resourced agencies that lack technical expertise in renewable energy technologies. Targeted training, secondments with international agencies, and recruitment of renewable energy specialists can enhance institutional capability (UNDP, 2022). Moreover, regulatory staff should be trained in stakeholder engagement and environmental assessment to ensure more informed and socially inclusive decision-making.

To further improve investor confidence, the regulatory framework must include predictable, long-term incentives such as feed-in tariffs (FiTs), net metering, and tax holidays. Countries like Kenya and Morocco have successfully implemented FiT schemes that guarantee price certainty and market access for renewable energy producers (Karekezi and Kimani, 2015). For Nigeria, consistent application of such instruments would reduce the risk premium for investors and enable project bankability.

Additionally, transparency and accountability mechanisms should be embedded in all regulatory processes. This includes publishing timelines for approval processes, maintaining an online registry of project licenses, and disclosing decision-making

criteria. According to Sovacool et al. (2016), transparent regulatory processes improve trust, reduce corruption, and enhance the credibility of the state in managing large infrastructure projects.

Finally, community engagement should be formally integrated into regulatory frameworks. Licensing procedures should mandate social impact assessments and public consultations, particularly in rural or vulnerable communities. This would not only strengthen social legitimacy but also mitigate the risk of local opposition during implementation phases (Devine-Wright, 2011).

Taken together, these recommendations are intended to support the development of a more effective, predictable, and investor-friendly regulatory framework for renewable energy in Nigeria. Their implementation would help reduce institutional uncertainty, improve project execution timelines, and position Nigeria as a more attractive destination for sustainable energy investment. While regulatory reform is essential to unlock investment and accelerate renewable energy development, its success is equally dependent on the existence of appropriate technological infrastructure and skilled human capital. The following section examines how technological readiness, local technical capacity, and infrastructural limitations influence the implementation and long-term viability of renewable energy projects in Nigeria.

5.5.1.3 Technological Readiness and Infrastructure Gaps

Technological challenges, including limited local expertise and inadequate maintenance capacity, were evident in the Katsina Wind Farm. Singh et al. (2020) emphasize that technological readiness is a crucial factor in ensuring project longevity. The wind farm's reliance on foreign contractors and imported components resulted in frequent maintenance delays and system downtimes. A technical officer noted,

"We lack the trained personnel to handle advanced wind turbine systems, and the delays in sourcing spare parts further impact efficiency."

This contrasts with the UNIMAID and BUK Solar Projects, where capacity-building initiatives ensured local engineers were trained to maintain and operate the systems effectively.

The success of the solar projects can be attributed to proactive training programs, aligning with Taghizadeh-Hesary et al. (2020), who argue that capacity-building initiatives mitigate long-term operational challenges. The UNIMAID project, in particular, integrated student training into its technical deployment, ensuring sustainability. A project coordinator stated,

"Our engineers have been trained in system maintenance, reducing reliance on external technicians."

This proactive approach to local skill development sets a precedent for future renewable energy initiatives in Nigeria.

5.5.1.3.1 Technological Constraints to Renewable Energy Deployment in Nigeria

The successful adoption of renewable energy in Nigeria is significantly impeded by a range of technological challenges that affect both the scalability and sustainability of clean energy initiatives. These constraints were consistently observed across the three case study projects—Katsina Wind Farm, BUK Solar Project, and UNIMAID Solar Project—and align with broader patterns documented in the academic literature on energy transitions in developing countries.

A major constraint is the inadequacy of Nigeria's national electricity grid, which remains outdated, centralised, and ill-equipped to accommodate decentralised renewable energy systems. The grid suffers from frequent failures and lacks the technological sophistication required to integrate variable energy sources such as solar and wind. This limitation not only reduces transmission efficiency but also deters large-scale investment in renewable infrastructure due to concerns about grid compatibility and reliability (Sovacool and Geels, 2020; Acheampong, Erku-Kutan and Abor, 2021). As the International Energy Agency (2022) has noted, grid modernisation is a critical precondition for the effective deployment of renewable energy technologies in emerging economies.

Equally limiting is the absence of energy storage systems and smart grid technologies. Intermittent sources like solar and wind require advanced battery storage to stabilise power supply and manage demand fluctuations. However, high

capital costs and limited availability of energy storage solutions—particularly lithium-ion and lead-acid batteries—remain a barrier in Nigeria (He, Kammen and Wang, 2023). The lack of smart grid infrastructure further exacerbates the problem, as the current system does not support real-time energy monitoring, dynamic pricing, or decentralised load management (Sovacool, 2021; IEA, 2021).

Technological dependence on foreign equipment is another critical issue. Nigeria's renewable energy sector is heavily reliant on imported solar panels, inverters, wind turbines, and related hardware. This dependence increases vulnerability to exchange rate volatility, customs delays, and component incompatibility. Projects such as the Katsina Wind Farm experienced extended delays due to difficulties in sourcing spare parts from Europe. Akuru and Okoro (2020) argue that this reliance also hampers local capacity building, limits technology transfer, and inflates overall project costs.

Furthermore, the national innovation ecosystem remains underdeveloped, with minimal investment in clean energy research and development (R&D). Nigerian universities and technical institutes often lack the infrastructure and funding required to support applied research in renewable energy. This restricts the localisation of technologies and the development of context-specific solutions for rural and off-grid communities (IRENA, 2021; Ogunbiyi, 2021). Without significant improvements in R&D capacity, Nigeria risks remaining a passive technology consumer rather than an active innovator in its energy transition.

A related challenge is the acute shortage of technically trained personnel. The success of renewable energy projects is highly dependent on skilled engineers, technicians, and system operators who can design, install, and maintain energy systems. However, the current workforce is limited, and most training programs are donor-dependent, short-term, and misaligned with industry demands (REN21, 2022; He et al., 2023). This skills gap results in project inefficiencies, extended maintenance downtimes, and reduced system reliability. In contrast, projects like the UNIMAID Solar Project have demonstrated the importance of local training and capacity development in improving system sustainability and operational resilience.

Finally, in rural and conflict-prone regions, the lack of off-grid infrastructure remains a significant barrier to renewable energy deployment. Despite the high solar

irradiance levels across Nigeria, many communities continue to rely on kerosene, firewood, and diesel generators due to the absence of mini-grid or standalone solar systems (Acheampong et al., 2021; IEA, 2022). These areas often lack the institutional support and financial investment required to implement decentralised renewable energy technologies, thereby exacerbating energy poverty and environmental degradation.

In summary, technological barriers in Nigeria span across infrastructure inadequacies, dependence on imported technologies, insufficient R&D investment, and a shortage of technical expertise. Addressing these constraints is crucial for improving system performance, reducing operational risks, and enabling the large-scale deployment of renewable energy. Strategic interventions must focus on modernising the grid, promoting local manufacturing, enhancing technical education, and supporting domestic innovation ecosystems to ensure a sustainable and inclusive energy transition.

5.5.1.3.2 Dependence on Imported Components and Its Impact on Project Sustainability

The sustainability of renewable energy projects in Nigeria is significantly compromised by the country's heavy dependence on imported technological components. Across the case studies examined, a recurring challenge was the inability to source critical infrastructure—such as wind turbines, solar photovoltaic (PV) modules, inverters, and control systems—locally. This reliance on foreign technology not only raises the upfront costs of renewable energy projects but also exposes them to a range of economic, logistical, and technical vulnerabilities that hinder long-term operational effectiveness.

A key concern associated with this dependence is the volatility of foreign exchange markets. Most imported renewable energy components are priced in U.S. dollars or euros, and fluctuations in Nigeria's exchange rate frequently result in significant cost overruns (Akuru and Okoro, 2020). The resulting budgetary pressures lead to project delays, downsizing, or even abandonment, particularly for government-funded initiatives that rely on fixed budget allocations. Furthermore, these financial instabilities deter private sector investment by introducing high levels of economic

uncertainty.

In addition to financial implications, logistical delays in the procurement and shipment of imported components often disrupt project timelines. Customs bottlenecks, import duties, and administrative inefficiencies contribute to lengthy delays in the delivery of essential equipment (Ogunbiyi, 2021). Such delays are particularly damaging in time-sensitive projects where donor funding or institutional coordination is subject to strict deadlines. These inefficiencies not only increase costs but also diminish stakeholder confidence, particularly among development partners and community beneficiaries.

Technical sustainability is also undermined when imported systems are not adequately adapted to local environmental and infrastructural contexts. For instance, solar PV systems designed for temperate climates may degrade more rapidly under the intense heat and dust conditions found in parts of Northern Nigeria. Similarly, wind turbines calibrated for European wind regimes may underperform in locations with lower or irregular wind speeds unless reconfigured to match local meteorological conditions (Sambo, 2019). The lack of local manufacturing capacity also means that components cannot be quickly repaired or replaced, leading to prolonged downtimes and reduced energy output.

Moreover, dependence on imported technologies limits opportunities for domestic capacity building and knowledge transfer. In many renewable energy projects, installation and maintenance are conducted by foreign technicians, with minimal engagement of local engineers or institutions. This results in weak local ownership and an underdeveloped ecosystem for operation, maintenance, and innovation (IRENA, 2021). Over time, such dynamics contribute to a cycle of dependence that inhibits technological self-sufficiency and long-term project viability.

Addressing this challenge requires strategic investment in local manufacturing capabilities, technology transfer partnerships, and the development of standards that support the localisation of renewable energy technologies. Countries such as India and Brazil have made significant progress in building domestic renewable energy industries by mandating local content requirements and providing targeted incentives for component manufacturing (He et al., 2023). Nigeria can follow a similar path by

establishing special economic zones for renewable energy manufacturing, offering tax incentives for local production, and aligning technical training programs with industry needs.

In summary, the overreliance on imported components poses multifaceted threats to the sustainability of renewable energy projects in Nigeria. Financial instability, logistical delays, technical mismatches, and limited local expertise collectively reduce project resilience and scalability. Building a robust local supply chain is therefore essential not only for ensuring sustainability but also for accelerating the country's broader energy transition.

5.5.1.3.3 Capacity-Building Initiatives for Enhancing Local Technical Expertise

Capacity-building is fundamental to ensuring the long-term sustainability and effectiveness of renewable energy initiatives in Nigeria. A persistent challenge identified across case studies—including the Katsina Wind Farm and the UNIMAID and BUK Solar Projects—is the limited availability of local technical expertise to operate and maintain renewable energy systems. This technical gap not only increases dependency on foreign contractors but also contributes to project delays and inefficiencies (IRENA, 2021).

To address these challenges, several capacity-building strategies have been recommended and, in some cases, successfully implemented. The UNIMAID Solar Project provides a positive example of integrated training programs, where local engineers and technicians were trained to manage and maintain solar power infrastructure. The project also included initiatives to involve STEM students, particularly women, in technical roles, contributing to both skill development and social inclusion. According to Singh et al. (2020), such inclusive training models strengthen project resilience and promote community ownership.

Similarly, the BUK Solar Project demonstrated the value of embedding skills development into project implementation. Training programs were designed not only to address immediate operational needs but also to build a pipeline of qualified personnel for future renewable energy deployment. Taghizadeh-Hesary et al. (2020) emphasize that targeted vocational and university-based training can mitigate

operational disruptions and reduce reliance on external expertise, particularly in developing countries.

Beyond project-level training, national strategies must prioritise technical capacity building at a systemic level. This includes investing in renewable energy curricula in tertiary institutions, supporting technical and vocational education centres, and fostering partnerships between universities and industry stakeholders. As highlighted by the Nigerian Economic Summit Group (NESG, 2020), locally tailored training programs aligned with industry needs can create a robust workforce capable of sustaining renewable energy technologies across Nigeria.

The International Renewable Energy Agency (IRENA, 2021) also advocates for "train-the-trainer" models, where international experts collaborate with local educators to cascade knowledge across regions. These programs not only enhance local capacity but also facilitate the localisation of renewable energy technologies through improved understanding of contextual challenges, maintenance needs, and infrastructure constraints.

In conclusion, embedding structured capacity-building initiatives into renewable energy policy and practice is crucial for the sector's success in Nigeria. This approach will enable a transition from dependence on foreign expertise to a self-sustaining, locally driven energy economy.

5.5.1.4 Social Acceptance and Community Engagement

Social attitudes toward renewable energy adoption varied across case studies. The Katsina Wind Farm initially faced community resistance due to misconceptions about land use and potential environmental disruptions. A local respondent stated,

"People believed the turbines would disrupt farming and displace communities, which led to protests."

This finding is consistent with Ballesta et al. (2022), who highlight the importance of early stakeholder engagement in mitigating social resistance.

The BUK and UNIMAID Solar Projects, however, benefited from early community engagement, ensuring local buy-in. The UNIMAID project's emphasis on training local technicians and including female STEM students in its capacity-building program

fostered widespread acceptance. This supports Viardot (2013), who argues that participatory approaches significantly enhance project sustainability. A UNIMAID stakeholder stated,

"By involving the community from the start, we created local champions for renewable energy adoption."

5.5.1.4.1 Public Skepticism and Limited Awareness in Renewable Energy Adoption

Public skepticism and limited awareness constitute significant social barriers to the widespread adoption of renewable energy in Nigeria. While economic and political constraints often dominate energy discourse, the role of social acceptance and perception has been increasingly recognised as a determinant of project success, particularly in regions where institutional trust is low and technical literacy remains limited.

In many parts of Nigeria, renewable energy technologies are still perceived as unfamiliar, untested, and unreliable. This perception is shaped in part by historical experiences with failed or abandoned government projects, which have contributed to public distrust in both the technology and the institutions promoting it. As Devine-Wright (2007) notes, local resistance to energy projects is often rooted less in the technology itself and more in how the project is perceived in terms of fairness, transparency, and stakeholder inclusion. In contexts where previous infrastructure initiatives have failed to deliver promised outcomes, communities become understandably cautious about new interventions.

Limited awareness is also a key factor. Many rural and peri-urban populations remain uninformed about how renewable energy systems operate or the long-term benefits they offer. According to Akinyele and Rayudu (2016), this information gap fuels myths that renewable systems are only for elite or urban populations, are too costly, or are insufficiently powerful to meet household or commercial needs. These misconceptions are further reinforced by the absence of sustained public education campaigns and the lack of locally relevant success stories.

Cultural familiarity with traditional energy sources, such as diesel generators or

kerosene lamps, further entrenches resistance to change. Mahapatra and Dasappa (2012) explain that behavioural inertia—especially in energy consumption—often results in communities preferring the predictable, albeit inefficient, energy sources they are accustomed to, rather than risk transitioning to an unfamiliar system. This is particularly true when renewable technologies require upfront investments, ongoing maintenance, or behavioural adjustments that are poorly understood.

The social dimension of energy transition also reveals a lack of community engagement in project design and implementation. Many renewable energy initiatives have been executed with a top-down approach, sidelining local voices and failing to address context-specific needs. Sovacool and Dworkin (2015) argue that participatory processes are crucial in ensuring not just the acceptance of renewable energy systems but their long-term sustainability. When communities feel excluded, they are less likely to support or maintain the technology once installed.

Further complicating the issue is the limited involvement of local opinion leaders, such as traditional rulers, religious leaders, and community-based organisations, who often play influential roles in shaping public opinion. As Mbah and Nzeadibe (2017) highlight, engaging these actors can serve as a powerful tool in building trust, demystifying the technology, and fostering a sense of collective ownership over energy infrastructure.

In sum, public skepticism and limited awareness form a critical but often overlooked barrier to renewable energy adoption in Nigeria. Overcoming this challenge requires multi-layered interventions, including context-specific awareness campaigns, inclusive project planning, and the empowerment of local stakeholders through education and capacity building. Without addressing these social dynamics, even well-financed and technically sound projects may struggle to gain the local legitimacy necessary for long-term impact.

5.5.1.4.2 The Role of Community Engagement in Enhancing Social Acceptance

Community engagement plays a pivotal role in determining the social acceptance of renewable energy projects, especially in developing countries where public

awareness and institutional trust may be limited. It goes beyond informing communities—it requires involving them meaningfully in decision-making processes from the earliest stages of project development. When people are engaged as active stakeholders rather than passive recipients, their sense of ownership and trust in technology improves significantly.

Wüstenhagen, Wolsink, and Bürer (2007) conceptualise social acceptance as comprising three dimensions: socio-political acceptance, community acceptance, and market acceptance. Among these, community acceptance is most directly influenced by how well developers and authorities engage with local populations. When community members are excluded from project planning or feel that their needs and concerns are overlooked, resistance and apathy often follow. This is particularly important in regions where prior energy interventions have failed, creating a legacy of mistrust.

Engaging communities not only fosters social buy-in but also helps pre-empt potential conflicts that could delay or derail implementation. As Devine-Wright (2011) argues, people's emotional and cultural attachments to place must be acknowledged, and renewable energy projects should be framed in ways that align with local identities and values. For instance, when communities are invited to co-design projects, identify local energy needs, or participate in monitoring mechanisms, they are more likely to view the project as legitimate and beneficial. Moreover, meaningful engagement supports equitable benefit-sharing, such as employment, skill development, and local procurement, all of which increase perceived value and support long-term sustainability (Sovacool et al., 2018). In many successful cases, early engagement has also corrected misinformation about renewable technologies and contributed to behavioural change. Public education campaigns, local stakeholder forums, and partnerships with traditional and religious leaders can be effective methods to improve awareness and build trust (Ballesta et al., 2022).

Countries with advanced renewable energy deployment—such as Germany, Denmark, and India—have institutionalized participatory processes in their policy and regulatory frameworks. These participatory models serve not only to

democratise energy transitions but also to ensure the durability of projects by embedding them in the social fabric of communities (IRENA, 2021).

In sum, without active and inclusive community engagement, renewable energy projects risk rejection, underutilization, or abandonment. Therefore, ensuring local voices are heard, respected, and reflected in project outcomes is essential for building the social license to operate and for fostering the long-term success of renewable energy transitions.

5.5.1.4.3 Strategies for Enhancing Grassroots Participation in Renewable Energy Projects

The successful adoption and sustainability of renewable energy initiatives depend significantly on the extent to which grassroots communities are involved in project planning, implementation, and monitoring. Without genuine local participation, even well-funded renewable energy projects risk rejection, poor utilisation, or eventual failure. Therefore, a shift from top-down implementation models to community-driven frameworks is essential to foster ownership, trust, and long-term impact.

One of the primary strategies for enhancing grassroots participation is the adoption of Participatory Rural Appraisal (PRA) techniques, which allow communities to identify their energy needs, prioritise project goals, and participate in decision-making from the outset. As Chambers (1994) notes, PRA shifts the locus of control from external experts to local stakeholders, thereby enhancing legitimacy and local empowerment. This participatory approach should be embedded in all phases of project development, from feasibility studies to post-installation evaluations.

Another critical strategy is the integration of community-based energy committees. These committees, composed of local representatives—including women, youth, and marginalised groups—can serve as platforms for knowledge dissemination, conflict resolution, and feedback collection. They provide a structured mechanism for institutionalising local input and ensuring inclusive representation (Agrawal and Gupta, 2005). Through such structures, community

members can gain a clearer understanding of project benefits, responsibilities, and operational requirements.

Capacity-building programmes are also fundamental to grassroots engagement. Training sessions on the operation and maintenance of renewable energy systems, entrepreneurship linked to energy access, and local fabrication of basic components can increase technical literacy and stimulate job creation. According to Sovacool et al. (2011), local training reduces reliance on external actors and enhances the resilience and sustainability of decentralised energy systems.

Financial inclusion strategies, such as Pay-As-You-Go (PAYG) models and micro-financing schemes, can further deepen grassroots participation. By reducing the upfront cost burden and allowing incremental payments, these models make energy access more attainable for low-income households. In regions with high mobile phone penetration, mobile-based payment systems can offer transparency and ease of use, as evidenced by successful deployments in Kenya and Rwanda (Kumar et al., 2018).

Moreover, awareness campaigns tailored to local cultural and linguistic contexts are vital. Many communities remain sceptical about renewable energy technologies due to misinformation or lack of exposure. Educational outreach through local radio, drama, religious institutions, and community gatherings can help dispel myths and build enthusiasm. These campaigns should focus not only on technical information but also on the social and economic co-benefits of renewable energy, such as improved health outcomes and reduced fuel costs (Devine-Wright, 2007).

Finally, projects should include feedback and grievance mechanisms to address concerns and adapt implementation strategies in real-time. This iterative engagement builds trust and allows communities to feel heard and respected. As noted by Wüstenhagen et al. (2007), fostering procedural justice—through transparency and responsiveness—is central to cultivating durable support for renewable energy initiatives.

In sum, enhancing grassroots participation in renewable energy requires a multidimensional approach that prioritises inclusivity, local empowerment, financial accessibility, and continuous dialogue. By embedding these strategies into project design and policy frameworks, renewable energy transitions can become more equitable, socially accepted, and sustainable.

5.5.2 Cross-Case Comparison of Social Attitudes and Awareness

The role of public perception in renewable energy adoption is complex and varies across case studies. In the Katsina Wind Farm project, initial resistance from local communities was based on misconceptions regarding land use and potential environmental impact. Respondents noted,

"There was strong opposition at the start because people believed the wind turbines would disrupt farming activities. We had to conduct multiple awareness sessions before gaining their trust."

This aligns with findings by Ballesta et al. (2022), who argue that awareness campaigns can be effective in transforming community perceptions. The BUK Solar Project's proactive approach, which incorporated renewable energy education into its outreach programs, provides a useful contrast, demonstrating that early engagement fosters community trust and acceptance.

A cross-case analysis reveals that projects with dedicated public engagement strategies faced fewer social obstacles compared to those that relied solely on government approvals. The University of Maiduguri Solar Project, for example, incorporated local labor and technical training into its deployment strategy, ensuring that the community played an active role in the project. This supports the argument made by Viardot (2013) that participatory approaches increase adoption rates and enhance project sustainability. A respondent from the UNIMAID project noted,

"Involving the community from the start made a big difference. They saw the benefits firsthand and became advocates for the project."

5.5.3 Key Challenges and Lessons Learned

The cross-case analysis of the Katsina Wind Farm, the Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project reveals a range of persistent challenges and key lessons that provide insights into the broader landscape of renewable energy adoption in Nigeria. This section systematically evaluates the major challenges that hindered project success while also identifying the strategies and factors that facilitated progress. The findings align with Yin's (2018) case study research framework, which emphasizes that comparative case analysis enables pattern identification across multiple projects, helping to formulate broader policy and strategic recommendations.

5.5.3.1 Financial Constraints and Economic Challenges

Across all three case studies, economic barriers were among the most significant obstacles to project implementation and sustainability. The high upfront capital costs required for renewable energy infrastructure created financing difficulties for all projects, particularly the Katsina Wind Farm, which was largely reliant on inconsistent public sector funding. The inability to secure continuous financing led to severe delays, cost overruns, and operational inefficiencies. A senior official from the Ministry of Power confirmed:

> *"Renewable energy projects often struggle with securing continuous funding. Government allocations are not always sufficient, and private sector investments remain low due to perceived risks."*

This aligns with Guney et al. (2019), who argue that in developing economies, access to credit and well-structured financial mechanisms is critical for accelerating renewable energy adoption. The Katsina Wind Farm's reliance on foreign-imported wind turbines further exacerbated cost issues, as fluctuations in exchange rates significantly increased expenses. The Nigerian Energy Support Programme (NESP, 2018) suggests that promoting local manufacturing and reducing import dependency could alleviate such financial constraints.

In contrast, the BUK and UNIMAID Solar Projects benefitted from targeted financial support under the Energizing Education Programme (EEP), ensuring smoother

implementation and reduced cost uncertainties. However, both projects still faced cash flow problems, particularly due to delays in grant disbursement. Wu et al. (2023) highlight that blended financing models, such as public-private partnerships (PPPs) and green bonds, could help mitigate financial risks and encourage investment in renewable energy.

5.5.3.2 Lesson Learned: The Need for Innovative Financing Models

One of the most crucial takeaways from the case studies is the importance of financial innovation in renewable energy projects. To overcome financial barriers:

- Nigeria needs to establish structured financing mechanisms, including subsidized loans and green bonds.
- Blended financing models, integrating both public and private sector investments, should be encouraged.
- Government policies should provide tax incentives and risk mitigation guarantees for investors in renewable energy.

Regulatory Bottlenecks and Policy Instability

The regulatory environment in Nigeria presents one of the biggest hurdles for renewable energy adoption. Each of the three projects faced significant bureaucratic inefficiencies, causing delays in permits, environmental clearances, and grid integration. The Katsina Wind Farm, for example, experienced multiple years of delay due to challenges in securing environmental impact assessments and inter-agency coordination.

A respondent from the Rural Electrification Agency (REA) highlighted the complexity of Nigeria's regulatory landscape:

"Each agency operates in silos, requiring different approvals, which slows down the entire process and increases project costs. Investors often get frustrated and withdraw their interest."

This finding aligns with Asante et al. (2020), who argue that regulatory uncertainty discourages private investment and hinders large-scale renewable energy deployment in developing economies. By contrast, countries such as Germany and India have successfully scaled up their renewable energy capacity due to clear and stable

regulatory frameworks. Germany's Renewable Energy Sources Act (Majid et al., 2014) provides long-term policy certainty, which has been a key enabler of private investment in clean energy.

The BUK and UNIMAID Solar Projects, despite benefiting from structured policy support under the EEP, still encountered delays in customs clearance for solar components. IRENA (2021) suggests that Nigeria could streamline customs processes by introducing fast-track approvals for renewable energy imports.

The Need for a Streamlined Regulatory Framework

To improve regulatory efficiency and encourage investment:

- Nigeria should establish a single-window clearance system for renewable energy projects.
- Government agencies must harmonize policies to reduce inter-agency conflicts and unnecessary bureaucracy.
- Long-term policy certainty should be established to encourage private sector participation and attract foreign direct investment in renewables.

Technological and Infrastructure Barriers

Technological readiness is another critical factor affecting renewable energy adoption in Nigeria. The Katsina Wind Farm faced considerable technical difficulties, particularly due to a lack of local expertise in wind turbine maintenance. The project's reliance on foreign contractors resulted in frequent system downtime, as spare parts were difficult to source locally.

A technical officer working on the wind farm observed:

"We lack the trained personnel to handle advanced wind turbine systems, and the delays in sourcing spare parts further impact efficiency."

In contrast, the BUK and UNIMAID Solar Projects demonstrated a more proactive approach to capacity building. These projects incorporated training programs for engineers and technicians, ensuring that local staff could maintain and operate the solar systems independently. Singh et al. (2020) emphasize that investment in capacity building is crucial for ensuring long-term sustainability in renewable energy projects.

Prioritizing Local Capacity Development

- The Nigerian government should invest in renewable energy training programs at technical institutions and universities.
- Renewable energy projects should include mandatory local content requirements to promote technology transfer.
- Greater efforts should be made to develop a domestic supply chain for renewable energy components.

Community Engagement and Social Acceptance

Social acceptance emerged as a decisive factor in project success. The Katsina Wind Farm initially faced strong community opposition, as locals feared the turbines would disrupt agriculture and displace settlements. A local resident recalled:

"People believed the turbines would interfere with farming and cause environmental damage, which led to resistance and protests."

The lack of early stakeholder engagement exacerbated tensions, aligning with Ballesta et al. (2022), who argue that public resistance to renewable energy projects is often rooted in misinformation and lack of consultation. Conversely, the BUK and UNIMAID Solar Projects incorporated community engagement strategies from the outset, ensuring local participation in project design and implementation. The UNIMAID project was particularly successful in integrating female STEM students into its training programs, fostering greater social acceptance and inclusivity.

The Importance of Community Participation

- Stakeholder engagement should begin at the project inception phase, with continuous dialogue and public awareness campaigns.
- Projects should actively involve local communities in job creation and training initiatives to foster a sense of ownership.
- Inclusive energy policies should prioritize gender and social inclusion, ensuring that marginalized groups benefit from renewable energy projects.

5.5.4 Case Study Comparison Matrix: Comparative Insights into Renewable Energy Projects in Nigeria

The Case Study Comparison Matrix presented in Figure 5.1 offers a structured visual synthesis of the three selected renewable energy projects: Katsina Wind Farm, Bayero University Kano (BUK) Hybrid Solar PV Park, and the University of Maiduguri (UNIMAID) Solar Project. By aligning key project attributes across a common analytical framework, this matrix facilitates the identification of patterns, divergences, and interrelationships critical to understanding the broader dynamics of renewable energy adoption in Nigeria.

Table 5.1: Case Study Comparison Matrix of Renewable Energy Projects in Nigeria

	Katsina Wind Farm	**BUK Solar PV Park**	**UNIMAID Solar Project**
Project	**Wind**	**Solar**	**Solar**
Technology	Northern Nigeria Arid and semi-arid conditions	Bayero University Kano (BUK)	Government funds, donor support
Geographic Context	Government funded	International donor funding green bonds	Government funds, donor support
Stakeholder Engagement	Limited	Active institutional support and community	Effective community engagement
Key Challenges	Limited	Coordination issues, grid integration	Security concerns, sustainability risks
Key Success Factors	-	Policy alignment + Donor backing	Energy security
Key Success Factor	Policy alignment	-	Energy implementation

This matrix provides a comparative overview of the three case studies, Katsina Wind Farm, BUK Hybrid Solar PV Park, and UNIMAID Solar Project, along key dimensions such as technology type, geographic context, funding models, stakeholder engagement, challenges encountered, and success factors. The matrix enables a structured cross-case synthesis, highlighting both the shared and context-specific dynamics influencing renewable energy adoption in Nigeria.

5.5.4.1 Technology Type and Design Orientation

The matrix captures the technological diversity of case studies. Katsina represents a wind-based system, the only large-scale project of its kind in Nigeria, while BUK and UNIMAID reflect the country's growing focus on solar photovoltaic (PV) technologies. This distinction is important, as wind projects such as Katsina require higher upfront capital investment, are more dependent on meteorological data accuracy, and involve greater logistical complexity compared to modular solar systems, which are often easier to deploy, scale, and maintain in decentralized contexts (IRENA, 2021).

5.5.4.2 Geographic and Socio-Political Contexts

The geographical locations of the three projects span across two distinct regions of Nigeria: northwest (Katsina), north-west (Kano), and northeast (Maiduguri), each with unique socio-political and infrastructural challenges. Katsina's semi-arid, low-density rural setting posed logistical challenges for component delivery and site development. In contrast, BUK's urban setting within Kano enabled better contractor access, but also demanded more robust integration with existing infrastructure. UNIMAID's deployment in a conflict-prone area added layers of complexity related to physical security, community engagement, and institutional resilience, highlighting the importance of tailoring renewable energy interventions to local risk environments (Sovacool and Geels, 2020).

5.5.4.3 Funding Models and Financial Architecture

The matrix underscores variations in funding strategies. Katsina relied heavily on government budgetary allocations and bilateral donor arrangements, which suffered from interruptions and a lack of transparency. BUK and UNIMAID, in contrast, were part of the Energising Education Programme (EEP), which integrated donor funding, green bond financing, and private-sector implementation. These structured financial mechanisms helped de-risk the projects and enabled clearer timelines, reflecting findings in the literature that highlight the effectiveness of blended finance in emerging markets (Glemarec, 2012; Kumar et al., 2018).

5.5.4.4 Stakeholder Engagement and Institutional Capacity

Another critical axis in the matrix is the quality and scope of stakeholder engagement. BUK demonstrated a high degree of institutional leadership, internal coordination, and stakeholder inclusiveness, factors that were instrumental in successful implementation and post-deployment management. UNIMAID similarly benefited from community buy-in facilitated through targeted awareness campaigns and local technical training. In contrast, the Katsina Wind Farm was marked by weak institutional ownership, fragmented stakeholder collaboration, and inadequate knowledge transfer, illustrating the risks of insufficient local participation in project planning and execution (Cherni and Preston, 2007; Musall and Kuik, 2011).

5.5.4.5 Key Challenges and Success Factors

The matrix enables a clear juxtaposition of the core barriers and enablers experienced across the three projects. Katsina was significantly affected by bureaucratic delays, poor maintenance infrastructure, and limited technical expertise. BUK, while more successful, still faced customs delays and component importation issues. UNIMAID had to navigate conflict-induced access constraints but compensated through proactive capacity-building and resilient project design. Success across all three sites was positively associated with strategic leadership, integrated donor support, and effective stakeholder coordination.

5.5.4.6 Contribution to Theoretical and Practical Understanding

This matrix not only supports cross-case triangulation but also reinforces the conceptual relevance of stakeholder theory and institutional theory to renewable energy transitions in the Global South. The visual juxtaposition of cases helps to operationalize abstract theoretical constructs such as legitimacy, institutional trust, and participatory governance into observable project outcomes (Freeman et al., 2010; Scott, 2001). Furthermore, it provides a decision-support tool for policymakers, funders, and practitioners seeking to replicate or scale similar interventions in diverse Nigerian contexts.

In short, the Case Study Comparison Matrix serves as a valuable analytic and communicative tool, enabling both micro-level insight and macro-level generalization. It captures not only the heterogeneity of Nigeria's renewable energy landscape but also the conditions under which such initiatives can thrive or falter. The matrix therefore stands as a key component of this study's contribution to the discourse on sustainable energy development in complex socio-political environments.

5.6 Summary

This chapter has critically examined the findings from the case studies and analyzed them through the lens of stakeholder theory, evaluating the key economic, political, technological, and social factors influencing renewable energy adoption in Nigeria. By systematically exploring the challenges, opportunities, and stakeholder dynamics within the Katsina Wind Farm, Bayero University Kano (BUK) Hybrid Solar PV Park, and University of Maiduguri (UNIMAID) Solar Project, the study has provided a nuanced understanding of the complexities associated with transitioning to sustainable energy solutions in Nigeria.

The findings highlight the economic barriers to renewable energy adoption, particularly the high capital costs, inadequate financial incentives, and weak investment frameworks that discourage private sector participation. These financial constraints have significantly hindered the scalability and sustainability of renewable energy projects. Moreover, policy and regulatory inconsistencies—such as bureaucratic bottlenecks, delays in project approvals, and a lack of policy continuity—have further exacerbated the challenges faced by renewable energy developers. The study underscores the urgent need for comprehensive policy reforms, including clearer regulatory frameworks, targeted subsidies, and public-private partnerships to enhance investment in the sector.

Technological constraints have also emerged as a fundamental limitation to renewable energy deployment. The inadequate technical expertise, lack of local manufacturing capacity, and poor infrastructure integration present significant barriers to long-term sustainability. This study finds that while renewable energy projects like the BUK Hybrid Solar PV Park have successfully demonstrated the potential of off-grid solutions, the absence of skilled manpower and robust maintenance strategies continues to pose challenges. Additionally, grid instability and inadequate energy storage

solutions limit the extent to which renewable energy can be integrated into Nigeria's national energy mix.

Social and cultural factors, particularly public perceptions and stakeholder engagement have played a critical role in shaping renewable energy adoption. The study reveals that awareness and acceptance of renewable energy solutions remain relatively low, particularly in communities that have experienced past project failures. However, the incorporation of educational components, such as the renewable energy training centres at BUK and UNIMAID, illustrates how knowledge dissemination and local engagement can foster greater acceptance and sustainability.

A cross-case analysis of the three projects further illustrates that while renewable energy initiatives can offer significant socio-economic and environmental benefits—including reduced greenhouse gas emissions, enhanced energy security, and cost savings for institutions, these gains can only be fully realized through strategic interventions. Key lessons from this chapter emphasize the importance of multi-stakeholder collaboration, capacity-building initiatives, and innovative financing mechanisms, such as green bonds and microcredit schemes, to support renewable energy adoption.

In conclusion, the chapter has provided an in-depth discussion of the structural, financial, and policy-related barriers to renewable energy adoption in Nigeria, while also outlining practical recommendations to overcome these challenges. The insights derived from the case studies contribute to both academic knowledge and policy development, offering a roadmap for accelerating Nigeria's transition to a more resilient and sustainable energy future. The next chapter will synthesize these findings and provide a comprehensive conclusion, including policy implications and future research directions.

CHAPTER 6 – CONCLUSION

6.1 Introduction

The transition to renewable energy is a critical component of Nigeria's long-term strategy for energy security, economic growth, and environmental sustainability. As global efforts to mitigate climate change intensify, countries like Nigeria must develop and implement effective renewable energy policies and projects to diversify their energy mix, reduce dependency on fossil fuels, and expand electricity access. This study has provided an in-depth examination of the challenges and opportunities associated with the adoption of renewable energy technologies in Nigeria, with a focus on three key case studies: the Katsina Wind Farm, the Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project. By applying Robert K. Yin's case study methodology, this research has explored how economic, political, technological, and social factors influence the success and limitations of renewable energy initiatives within the Nigerian context.

The study was guided by the overarching objective of understanding the structural barriers and enablers of renewable energy adoption. Specifically, it sought to examine the economic constraints related to financing and affordability, the impact of government policies and regulatory frameworks, the role of technological advancements and infrastructural limitations, and the influence of public perceptions and social acceptance. By situating these challenges within the broader discourse on sustainable energy transition, the study has provided valuable insights for policymakers, investors, and energy stakeholders.

The research employed a case study approach, focusing on three renewable energy projects that represent different contexts of implementation. The Katsina Wind Farm exemplifies a large-scale wind energy initiative facing infrastructural and regulatory bottlenecks. The BUK Solar Project highlights the role of academic institutions in piloting solar energy integration within grid-connected settings, while the UNIMAID Solar Project offers insights into the feasibility of renewable energy adoption in conflict-prone and off-grid regions. These case studies provided empirical data that helped analyse patterns, draw comparisons, and offer context-specific recommendations for enhancing renewable energy deployment.

Throughout the preceding chapters, the study has discussed key themes that shape the renewable energy landscape in Nigeria. Chapter 4 provided detailed case study analyses, outlining the contextual factors influencing each project. Chapter 5 synthesized the findings, conducted an inter-case analysis, and examined how the study's insights align with existing theoretical frameworks and literature. This final chapter brings together these discussions, highlighting the study's contributions to knowledge, policy, and practice. It also outlines recommendations for stakeholders, offers guidance on future research directions, and discusses the study's limitations.

The structure of this chapter is as follows: Section 6.2 discusses the key findings and contributions of the research to academic scholarship, policy, and industry practice. Section 6.3 presents implications for policymakers, industry stakeholders, and development agencies. Section 6.4 highlights the limitations of the study, acknowledging constraints such as data availability, methodological scope, and external factors that may have influenced the findings. Section 6.5 outlines potential avenues for further research that can build on the present study's findings. Finally, Section 6.6 provides concluding remarks, reflecting on the broader significance of the research and its implications for Nigeria's renewable energy transition.

6.2 Key Findings

The research questions of this study aimed to investigate the structural barriers to renewable energy adoption, assess the impact of government policies, explore technological constraints, and analyse public perceptions. The findings reveal the complexity of renewable energy implementation in Nigeria and provide an empirical basis for understanding its economic, political, technological, and social dimensions.

6.2.1 What are the economic barriers to renewable energy adoption in Nigeria

The study found that economic constraints remain a fundamental challenge to the widespread adoption of renewable energy in Nigeria. High initial capital costs, limited financing opportunities, and currency fluctuations create significant obstacles for large-scale renewable energy projects. The Katsina Wind Farm project, for instance, experienced prolonged financial difficulties due to funding delays, while the BUK and UNIMAID solar projects relied heavily on international funding sources such as the World Bank and African Development Bank (REN21, 2022). The cost of importing

renewable energy components further exacerbate financial burdens, as Nigeria lacks a strong local manufacturing base for solar panels, wind turbines, and battery storage systems. Fluctuating exchange rates and inflationary pressures increase project costs, highlighting the need for sustainable financial models and local production capacity (NESP, 2020).

However, the study also identified the role of innovative financing mechanisms in mitigating these financial challenges. The World Bank's $350 million Energizing Education Programme (EEP), for example, facilitated the successful implementation of hybrid solar systems at BUK and UNIMAID. The research supports the argument that long-term financial sustainability requires a combination of public-private partnerships, green financing models, and government-backed incentives to attract private sector investment (IRENA, 2021).

6.2.2 How regulatory factors influence renewable energy adoption

The study found that policy instability and regulatory inefficiencies are major impediments to the seamless adoption of renewable energy in Nigeria. Despite the presence of policies such as the Renewable Energy Master Plan (REMP) and the National Renewable Energy and Energy Efficiency Policy (NREEEP), implementation inconsistencies and bureaucratic delays deter investor confidence (NESP, 2020). The Katsina Wind Farm case study exemplifies the impact of prolonged approval processes, inconsistent regulatory enforcement, and inefficient inter-agency coordination on project timelines. These findings align with previous research indicating that weak regulatory enforcement discourages private sector participation (IRENA, 2021).

The BUK and UNIMAID solar projects similarly faced regulatory bottlenecks, including complex licensing procedures for imported components. While the EEP program helped to mitigate some of these challenges, the absence of a streamlined regulatory framework remains a significant barrier. The study suggests that policy harmonization, faster approval processes, and targeted incentives such as tax exemptions for renewable energy investors are crucial for stabilizing Nigeria's regulatory landscape and fostering long-term sector growth.

6.2.3 What technological constraints limit renewable energy deployment

Technological barriers were identified as another key constraint to the widespread adoption of renewable energy in Nigeria. A shortage of skilled professionals, inadequate maintenance infrastructure, and reliance on imported technology limit the efficiency and sustainability of renewable energy projects. The BUK and UNIMAID solar projects demonstrated the feasibility of hybrid solar energy systems, incorporating battery storage and smart inverters to optimize performance. However, the high cost of energy storage technologies and the lack of technical expertise in system maintenance remain significant challenges (IEA, 2021). Similarly, the Katsina Wind Farm encountered maintenance issues due to a lack of local expertise in turbine management. Despite these challenges, the study highlights the potential of emerging technologies such as smart grids and real-time monitoring systems in enhancing renewable energy efficiency. The UNIMAID Solar Project successfully integrated remote monitoring systems, enabling real-time fault detection and system optimization. The findings suggest that investment in technical education, vocational training, and domestic manufacturing of renewable energy components is essential to overcoming technological barriers and ensuring long-term system sustainability.

6.2.4 How do social and cultural factors shape renewable energy adoption

Social attitudes, perceptions, and awareness play a crucial role in renewable energy adoption. The study found that public awareness of renewable energy benefits remains low, particularly in rural communities where reliance on traditional energy sources is deeply entrenched. The Katsina Wind Farm project initially faced local resistance due to scepticism towards government-led initiatives and limited knowledge about wind energy. Similarly, the BUK and UNIMAID projects encountered social barriers, including doubts about the reliability and affordability of solar technology (GIZ, 2021). However, the study also identified successful community engagement strategies that enhanced stakeholder buy-in. The UNIMAID project actively involved local communities, provided technical training, and promoted gender inclusivity in STEM education. These efforts increased public trust and project sustainability, demonstrating

that education and participatory decision-making processes are essential for fostering public acceptance of renewable energy technologies in Nigeria.

6.2.5 What is the impact of Energy Security in Crisis-Prone Environments

Energy security in crisis-prone environments is not only a matter of infrastructure availability, but a strategic determinant of stability, resilience, and developmental continuity. In regions affected by insurgency, displacement, or infrastructural sabotage, access to reliable energy serves as a foundation for economic activity, education, healthcare, and governance. Renewable energy systems—particularly decentralised and off-grid solar solutions—have proven instrumental in bridging supply gaps and reducing reliance on vulnerable or disrupted grid networks. The availability of energy in these regions is closely tied to community resilience and institutional functionality. Energy access facilitates the operation of security infrastructure, digital learning platforms, and medical services, which are otherwise threatened by the volatility of fossil fuel supply chains or unreliable national grids.

In fragile and conflict-affected areas, the introduction of renewable energy projects has been linked to improved local governance, enhanced community trust, and even reduced risk of conflict recurrence. This transformative potential of energy access is especially critical in regions where state presence is limited and where public service delivery hinges on stable power provision. In such contexts, renewable energy does not merely support development; it enables the restoration of state legitimacy and societal rebuilding.

6.2.6 How Technology Development enhances Capacity Building

Technology development, when integrated with structured training and institutional partnerships, plays a fundamental role in enhancing local capacity and ensuring the sustainability of renewable energy initiatives. The success of renewable energy projects often depends less on the physical infrastructure itself and more on the systems of human and technical capacity that surround it. The deployment of solar photovoltaic systems, for example, becomes sustainable only when local technicians are trained to maintain inverters, storage systems, and monitoring platforms.

The inclusion of educational institutions and technical training centres within project frameworks contributes to long-term capacity building by cultivating a local workforce equipped with the skills to install, manage, and scale renewable technologies. Furthermore, technological innovations—such as smart meters, remote monitoring software, and modular storage units—facilitate knowledge transfer and allow for more efficient system management. These tools not only enhance system performance but also serve as training platforms for students and professionals. When paired with inclusive programmes targeting underrepresented groups such as women and youth, technology development becomes a lever for socio-economic empowerment and inclusive growth. Thus, capacity building is not a peripheral concern but a central feature of effective energy transitions, particularly in low-income and emerging economies where technical expertise remains limited.

6.2.7 The effect of Political Instability on Renewable Energy Adoption

Political instability remains a formidable obstacle to the adoption and scaling of renewable energy in many parts of sub-Saharan Africa. Frequent changes in political leadership, policy reversals, and bureaucratic inefficiencies contribute to an environment of uncertainty that deters both public and private sector investment. Renewable energy projects, which often require long-term planning, phased implementation, and substantial capital, are particularly vulnerable to administrative discontinuities.

Political instability affects the alignment of regulatory frameworks, delays project approvals, disrupts procurement processes, and creates confusion over institutional responsibilities. It also undermines community engagement and transparency, which are essential for securing local support and long-term project success. Inconsistent energy policy and fragmented governance structures have been identified as major causes of implementation delays, cost overruns, and underutilisation of installed capacity. Furthermore, politicisation of energy infrastructure can lead to suboptimal site selection, misallocation of resources, and neglect of maintenance regimes once the project's political capital has been exhausted. International experience shows that countries with stable governance, transparent procurement systems, and integrated energy planning are more likely to attract investment, ensure project sustainability, and achieve universal energy access targets.

In summary, the case study findings affirm that the adoption and sustainability of renewable energy in Nigeria depend not only on technology and finance but on broader socio-political and institutional conditions. In crisis-prone environments, renewable energy contributes to stability and development by securing essential services and rebuilding institutional trust. Technology development supports capacity building when accompanied by training, knowledge transfer, and inclusive design. However, political instability continues to undermine progress by introducing uncertainty, eroding stakeholder confidence, and weakening regulatory oversight. Addressing these challenges requires a coordinated approach that integrates infrastructure development with policy coherence, stakeholder inclusion, and long-term capacity building. The path to a sustainable energy future must be embedded in stable institutions, inclusive governance, and a commitment to transforming technical solutions into socio-economic outcomes.

6.3 The Implications of the Research

The findings of this study have significant implications for policymakers, industry practitioners, and researchers seeking to advance renewable energy adoption in Nigeria. As the country grapples with energy insecurity, economic challenges, and environmental concerns, a strategic transition to renewable energy is imperative. This study highlights critical barriers—economic, political, technological, and social—affecting renewable energy implementation, while also identifying potential solutions that can guide policy formulation, industry strategies, and future research. The implications drawn from this study are structured into three main areas: policy implications, which focus on regulatory frameworks and governance strategies; practical implications, which highlight industry and technical considerations; and research implications, which outline areas for further scholarly investigation.

Nonetheless, this study investigates the complex challenges affecting the adoption and implementation of renewable energy in Nigeria. Drawing on three case studies representing different technological modalities and institutional contexts, the research explores how political instability, technological limitations, stakeholder dynamics, and policy inconsistencies hinder the renewable energy transition in Nigeria. The findings contribute to both academic and policy discourse by offering insights into the multifaceted nature of energy reform in Nigeria contexts. This section discusses the

theoretical and practical implications of the study and outlining its limitations.

The global shift toward renewable energy is increasingly viewed as imperative for sustainable development, climate change mitigation, and energy security. In developing economies like Nigeria, where energy poverty remains widespread and the national grid is unreliable, the adoption of renewable energy holds enormous potential. Yet, despite an abundance of solar, wind, and biomass resources, Nigeria's energy transition has been slow and fraught with systemic barriers. This study addresses this paradox by exploring the challenges facing renewable energy adoption in Nigeria and their broader implications for theory and practice.

6.3.1 Theoretical Implications

This research contributes to theoretical discussions on stakeholder theory, institutional theory, and renewable energy transition frameworks. Theoretically, the study underscores the importance of stakeholder inclusivity in energy governance. Traditional top-down policy frameworks have often overlooked local communities, resulting in project resistance, underutilization, or failure. By applying stakeholder theory, this research shows how power asymmetries, legitimacy gaps, and lack of participatory engagement shape renewable energy outcomes in Nigeria.

Additionally, the study enriches institutional theory by demonstrating how weak regulatory environments, fragmented governance, and policy volatility impede energy reform. Unlike more developed contexts where regulatory systems offer continuity and coherence, Nigeria's institutional fragmentation leads to overlapping mandates, inefficiencies, and uncertainty that discourage investment and hinder project implementation.

The study engages with socio-technical transition theories by illustrating how renewable energy in Nigeria cannot be understood solely as a technological change but as a systemic transformation influenced by political, cultural, and economic dynamics. The findings call for a more holistic, interdisciplinary approach to energy transition research in Global South contexts.

6.3.2 Practical Implications

The practical implications of this study are significant for policymakers, international development agencies, investors, and civil society actors. Firstly, the research

highlights the urgent need for policy harmonization and institutional coordination. Regulatory uncertainty and inconsistent policy signals undermine investor confidence and complicate project development timelines. Policymakers must prioritise creating a coherent, long-term energy strategy supported by enforceable regulations and clear institutional mandates.

Second, the study emphasizes the importance of embedding capacity-building initiatives within renewable energy projects. Technical and managerial training programs should be developed to ensure local ownership and long-term sustainability. Partnerships between government, academia, and the private sector are essential in fostering innovation and building a skilled workforce.

Third, stakeholder engagement should be institutionalized as a core component of project design and implementation. Community buy-in, especially in rural and conflict-prone areas, is vital to ensuring project acceptance and resilience. Development practitioners should adopt participatory planning models that recognise the diverse needs and expectations of stakeholders.

Finally, the study suggests that decentralised renewable energy systems—such as mini-grids and solar home systems—offer a viable alternative to centralised grid extension in underserved regions. These models should be scaled up, especially in fragile contexts where energy access can serve as a catalyst for stability, education, and economic recovery.

6.3.3 Policy Implications

The study underscores the need for policy stability, regulatory efficiency, and strategic incentives to foster the growth of Nigeria's renewable energy sector. Despite existing policies such as the Renewable Energy Master Plan (REMP) and the National Renewable Energy and Energy Efficiency Policy (NREEEP), implementation challenges persist due to bureaucratic delays, inconsistent enforcement, and lack of investor confidence (NESP, 2020). Addressing these policy bottlenecks is essential for scaling up renewable energy adoption.

Key policy recommendations include:

- **Streamlining Regulatory Approvals:** The Nigerian government should

simplify project approval processes by establishing a single window permit system that integrates environmental assessments, land acquisition approvals, and grid connection procedures. This would significantly reduce delays and enhance investor confidence (IRENA, 2021).

- **Enhancing Incentives for Renewable Energy Investment:** Countries with successful renewable energy transitions, such as South Africa and Kenya, have leveraged tax incentives, feed-in tariffs, and concessional loans to stimulate private sector participation (IEA, 2020). Nigeria must adopt similar financial mechanisms, including green bonds, climate funds, and risk mitigation policies, to attract large-scale renewable energy investments.
- **Aligning Renewable Energy Policies with National Electrification Goals:** The government should integrate off-grid and hybrid energy solutions into rural electrification strategies, ensuring that renewable energy complements existing grid expansion efforts. The Energizing Education Programme (EEP) and other initiatives should be scaled up to cover additional academic institutions and healthcare facilities, fostering long-term energy security.
- **Promoting Public-Private Partnerships (PPPs):** Given the substantial investment required for renewable energy infrastructure, the government must foster stronger collaborations between public institutions, private investors, and international development agencies. Such partnerships can facilitate financing, technology transfer, and capacity-building in the renewable energy sector (World Bank, 2022).

6.3.4 Practical and Industry Implications

The study highlights the need for adaptive industry strategies, capacity-building initiatives, and innovative financing mechanisms to overcome technical and economic barriers in Nigeria's renewable energy sector.

6.3.4.1 Strengthening Local Manufacturing and Workforce Development

- Reducing Dependence on Imported Components: The high cost of importing solar panels, wind turbines, and battery storage systems is a significant barrier

to renewable energy adoption. Nigeria must invest in local assembly and manufacturing plants to improve affordability and supply chain reliability (REN21, 2022).

- Technical Training and Skills Development: A major challenge identified in the study is the shortage of skilled technicians, engineers, and system integrators for renewable energy projects. Expanding renewable energy curricula in universities and vocational training centres will enhance the availability of trained professionals capable of managing installation and maintenance processes (IEA, 2021).

6.3.4.2 Developing Sustainable Financing Models

- Introducing Green Financing Mechanisms: The study identifies limited access to capital as a major constraint to renewable energy investments. Green bonds, concessional loans, and micro-financing schemes can help bridge this funding gap, particularly for small and medium-scale renewable energy enterprises (AfDB, 2020).
- Exploring Pay-as-You-Go (PAYG) Solar Models: Off-grid solar companies in Nigeria have successfully utilized PAYG models, allowing consumers to access solar power through flexible installment payments. Expanding these financing solutions can increase affordability and adoption rates in low-income communities (IRENA, 2021).

6.3.4.3 Leveraging Digital and Smart Energy Technologies

- Integrating Smart Grids and IoT Technologies: The study finds that technological innovation, such as real-time monitoring systems and smart energy management platforms, can enhance renewable energy reliability and efficiency. Remote monitoring solutions can help operators detect faults early and improve system performance in off-grid areas (GIZ, 2021).
- Hybrid Energy Solutions for Institutional Use: The success of hybrid solar systems at BUK and UNIMAID demonstrates the feasibility of combining solar PV with battery storage and backup generators. Expanding such hybrid solutions can increase energy reliability for academic institutions, hospitals, and

businesses (World Bank, 2022).

6.3.5 Implications for Research

While this study has contributed valuable insights into the adoption of renewable energy in Nigeria, it also highlights several areas that require further academic exploration.

1. Long-Term Performance of Renewable Energy Projects
    - Future studies should assess the long-term economic viability and performance metrics of renewable energy installations in Nigeria. Research focusing on system degradation rates, maintenance costs, and return on investment (ROI) will provide valuable data for investors and policymakers (REN21, 2022).
2. Gender Inclusivity in Renewable Energy Programs
    - The role of gender in renewable energy adoption remains underexplored. Studies have shown that women are underrepresented in STEM fields and renewable energy entrepreneurship. Research should investigate how women's participation in solar and wind energy projects can enhance innovation and workforce diversity (IRENA, 2021).
3. Decentralized Energy Systems and Rural Electrification
    - With 43% of Nigerians lacking access to electricity, decentralized renewable energy systems such as mini-grids and standalone solar home systems offer viable solutions. Comparative studies between Nigeria and other African countries can provide best practices for scaling decentralized renewable energy solutions (IEA, 2020).
4. Comparative Policy Analysis Across African Countries
    - A comparative study analysing the policy frameworks, investment climates, and regulatory environments of Nigeria, Kenya, and South Africa could offer lessons on best practices for overcoming renewable energy adoption barriers (World Bank, 2022).

6.3.6 Implications for Community and Social Development

The findings of this study carry far-reaching policy, practical, and research implications for Nigeria's renewable energy sector. Policymakers must streamline regulations, strengthen incentives, and promote public-private partnerships to accelerate renewable energy deployment. Industry practitioners should focus on local manufacturing, workforce development, and innovative financing models to enhance project feasibility. Academics should explore long-term performance, gender inclusivity, and decentralized energy systems to inform future policy and investment decisions.

Beyond policy and industry implications, the study also emphasizes the importance of social acceptance and community engagement in renewable energy adoption.

- Raising Public Awareness: The low level of public awareness regarding renewable energy benefits remains a critical barrier. Educational campaigns, media engagement, and school-based renewable energy programs should be intensified to change public perceptions and increase adoption rates (GIZ, 2021).
- Strengthening Community Ownership Models: One of the key findings from the UNIMAID Solar Project was the success of community-led renewable energy initiatives. Encouraging cooperative-based solar projects where local communities co-own and manage energy systems can improve long-term sustainability and social acceptance (REN21, 2022).
- Promoting Gender Inclusion: Ensuring women's participation in renewable energy training programs and entrepreneurship initiatives can enhance innovation and workforce diversity. Policy measures should support gender-inclusive training and funding programs to increase female representation in the renewable energy workforce (IRENA, 2021).

By addressing these policy gaps, industry barriers, and research opportunities, Nigeria can accelerate its transition to a sustainable energy future while improving economic resilience and social equity. The next section will discuss the limitations of this study, recognizing constraints in methodology and scope.

6.4 Limitations of the Research

While this study provides valuable insights into the challenges and opportunities surrounding renewable energy adoption in Nigeria, it is essential to acknowledge its limitations. These constraints primarily stem from the scope of the study, data availability, methodological considerations, and the timeframe of analysis. Recognizing these limitations not only provides context for interpreting the findings but also highlights areas for future research improvement.

This research is based on a qualitative multiple-case study design, which limits its generalisability. Although the cases were purposefully selected to capture variation in project types and contexts, the findings may not fully represent the diversity of renewable energy experiences across Nigeria.

Second, the study relies primarily on interview data and document analysis. While triangulation was employed to enhance credibility, the absence of quantitative performance data and longitudinal project tracking constrains the ability to assess long-term project outcomes and economic impacts.

Third, access constraints and security issues in some regions may have affected the depth of field engagement. In conflict-prone areas, virtual interviews and secondary data had to be relied upon, which may limit the richness of local perspectives.

Lastly, the rapidly evolving nature of Nigeria's energy policy landscape means that some findings may become outdated as new reforms and technologies emerge. Future research could benefit from mixed methods approaches, comparative regional studies, and the inclusion of real-time performance metrics.

In sum, this study sheds light on the persistent challenges facing renewable energy adoption in Nigeria, highlighting the interplay between political instability, technological constraints, and institutional weaknesses. It makes significant theoretical contributions by extending stakeholder and institutional theory into the domain of energy transitions in the Global South. Practically, it offers recommendations for creating inclusive, stable, and sustainable energy systems. Despite its limitations, the study serves as a foundation for further academic inquiry and policy innovation aimed at advancing Nigeria's renewable energy goals. Other limitations include the following:

6.4.1 Scope Limitations

One of the primary limitations of this study is the restricted geographical and institutional scope. The research focused on three case studies—Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project. While these projects offer valuable insights into different applications of renewable energy, they do not fully capture the diversity of Nigeria's renewable energy landscape. Other regions, project sizes, and energy technologies could reveal additional insights that were not explored in this study (IRENA, 2021).

Furthermore, the case study approach limits the generalizability of the findings. Although the multiple-case study methodology (Yin, 2018) allows for analytical generalization, it does not offer statistical generalization applicable to all renewable energy projects in Nigeria. The study's findings, while relevant to similar contexts, may not fully reflect renewable energy dynamics in different regions with varying policy, economic, and environmental conditions (IEA, 2020). Future research should broaden the scope by including a wider variety of projects, geographical locations, and stakeholder perspectives to enhance the comprehensiveness of the findings.

6.4.2 Data Availability Constraints

Access to reliable and comprehensive data was a challenge, particularly concerning government regulations, private sector investment records, and project performance evaluations. Many policy documents, financial reports, and regulatory proceedings were either unavailable, outdated, or restricted due to confidentiality agreements. As a result, certain aspects of the research, particularly those concerning financial models, regulatory efficiency, and investment risks, were analyzed based on secondary data sources rather than direct access to confidential project records (World Bank, 2022).

Additionally, data inconsistencies in government reports, energy agency publications, and industry records posed another constraint. Some statistics on renewable energy capacity, funding allocations, and policy implementation varied between different sources, making triangulation a necessary but challenging process (GIZ, 2021). To mitigate these challenges, the study incorporated multiple sources of data, including stakeholder interviews, project reports, and academic literature. However, future studies should seek direct access to government and industry databases to enhance the reliability of findings.

6.4.3 Methodological Constraints and Reliability of Interview Responses

This study relied heavily on qualitative data collection methods, including semi-structured interviews with stakeholders from government agencies, energy firms, and academic institutions. While qualitative research offers rich, contextual insights, it is inherently subject to researcher interpretation and potential response bias (Creswell and Poth, 2018). Despite measures taken to ensure data validity and credibility, such as triangulation and respondent validation, some interview responses may have been influenced by personal perspectives, institutional affiliations, or political considerations (Bryman, 2016).

Another methodological challenge is selection bias in respondent sampling. Due to constraints in accessing certain officials and private sector executives, some perspectives—particularly those from independent investors, grassroots community members, and financial institutions—may not be fully represented. Future research should adopt mixed-method approaches, incorporating quantitative surveys to complement qualitative findings and mitigate subjectivity.

6.4.4 Short-Term Nature of the Study

The study provides a snapshot of renewable energy adoption in Nigeria, rather than a longitudinal analysis of project performance over time. Many renewable energy projects, particularly those financed through international partnerships, require years to reach full operational capacity and demonstrate measurable economic and environmental impact (REN21, 2022).

Due to the study's timeframe, it was not possible to conduct a long-term impact assessment of the projects examined. While economic viability, technological performance, and policy effectiveness were discussed based on available reports and stakeholder insights, the long-term sustainability of these projects remains uncertain. A longitudinal study tracking project outcomes over five to ten years would provide a more robust understanding of how regulatory changes, technological advancements, and market conditions affect renewable energy development in Nigeria (IEA, 2021).

6.4.5 Limitations in Comparative Analysis

While the study draws comparisons between the three case studies, it does not extensively compare Nigeria's renewable energy landscape with that of other African or developing economies. A comparative approach, analysing policies and market conditions in countries like South Africa, Kenya, or Ghana, could provide additional context on best practices, regulatory efficiencies, and investment strategies (IRENA, 2021). Future research should consider conducting a cross-country comparative analysis to identify policy frameworks and financial models that could be adapted to Nigeria's energy sector.

6.4.6 Security and Political Considerations

Nigeria's political and security climate posed another challenge to this study. In some cases, conflicts in the northern regions affected data collection and access to project sites. For instance, the UNIMAID Solar Project is in Borno State, an area that has experienced insurgency-related disruptions. Political instability and frequent changes in government leadership also create policy inconsistencies, making it difficult to predict the long-term impact of current renewable energy initiatives (World Bank, 2022).

While this study acknowledges the influence of political stability on renewable energy adoption, further research should investigate the role of governance, security, and institutional coordination in determining project success. Understanding how political risk affects investor confidence can help shape more resilient renewable energy policies in Nigeria and similar economies.

Despite these limitations, the study provides valuable insights into the economic, political, technological, and social factors shaping renewable energy adoption in Nigeria. While the findings are contextually grounded in three case studies, future research should expand the scope, diversify data sources, and adopt a longitudinal approach to improve generalizability and reliability. The next section discusses the contributions of this study, highlighting its theoretical, policy, and practical significance in advancing Nigeria's renewable energy transition.

6.5 Suggestions for Further Studies

The findings of this study provide valuable insights into the challenges and opportunities associated with renewable energy adoption in Nigeria. However, the dynamic and evolving nature of the energy sector requires continuous research to refine strategies, enhance policies, and optimize implementation frameworks. While this study has examined economic, political, technological, and social factors influencing renewable energy projects, there are still gaps that require further investigation. The transition to renewable energy is a long-term process that must be contextualized within broader socio-economic and geopolitical developments. To ensure the sustainability and scalability of renewable energy adoption, future studies should explore areas such as policy effectiveness, private sector engagement, financial innovations, technological advancements, and community-driven approaches. By addressing these areas, research can contribute to evidence-based policymaking and enhance the capacity of renewable energy stakeholders to develop resilient, efficient, and inclusive energy solutions (IRENA, 2021; IEA, 2020).

One of the key limitations of this study was its focus on three specific case studies—the Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and University of Maiduguri (UNIMAID) Solar Project—which, while representative of renewable energy initiatives in Nigeria, do not capture the full spectrum of projects implemented across different regions and contexts. Future research should expand the scope of case studies to include diverse renewable energy projects across Nigeria's geopolitical zones, particularly in the southern and central regions, where unique policy environments, economic factors, and social dynamics influence energy transition efforts. This would provide a comprehensive understanding of how different regions respond to renewable energy policies, the effectiveness of various technologies, and the challenges specific to local contexts. Furthermore, cross-national comparative studies between Nigeria and other West African countries with similar energy access challenges could provide valuable insights into regional best practices and collaborative solutions (NESP, 2020).

Another critical area for future research is the long-term sustainability and economic viability of renewable energy projects. The present study provides a snapshot of Nigeria's renewable energy landscape, but it does not track the long-term outcomes of implemented projects. Future studies should adopt longitudinal research methodologies

to examine how renewable energy initiatives evolve over 5 to 10 years, assessing their impact on energy access, job creation, local economies, and environmental sustainability. This would provide policymakers and investors with empirical data on the benefits and challenges of renewable energy transition over time (REN21, 2022). Longitudinal research could also explore the lifecycle costs of renewable energy systems, comparing them to conventional energy sources, to establish clear economic justifications for large-scale investments in renewables. Additionally, evaluating the long-term policy impact by analysing shifts in government priorities, regulatory changes, and stakeholder participation would further enhance the knowledge base on effective energy governance (GIZ, 2021).

The role of the private sector and public-private partnerships (PPP) in renewable energy adoption remains an underexplored area that warrants further investigation. While government policies and international funding play crucial roles in driving renewable energy projects, the extent to which private investments contribute to scaling and sustaining renewable energy solutions remains unclear. Future research should explore the effectiveness of PPP models in Nigeria's energy sector, assessing whether incentives such as tax credits, low-interest loans, and feed-in tariffs effectively attract private capital into renewable energy infrastructure (IEA, 2021). Understanding how local and international investors perceive Nigeria's renewable energy market and identifying the barriers that deter private participation—such as policy uncertainty, currency devaluation, and market instability—would be instrumental in designing investment-friendly policies. Comparative research with countries that have successfully leveraged PPP mechanisms to accelerate renewable energy deployment, such as South Africa, Kenya, and Morocco, could yield valuable lessons for Nigeria (AfDB, 2022).

Social attitudes, behavioural patterns, and community engagement strategies also require further exploration to ensure that renewable energy adoption is socially inclusive and community driven. While this study identified cultural resistance and limited public awareness as challenges to renewable energy adoption, additional research is needed to understand the underlying behavioural motivations that shape public attitudes toward renewable energy (IRENA, 2020). Future studies should investigate the role of socio-cultural beliefs, economic incentives, and trust in government-led projects in shaping public willingness to transition to renewables. Additionally, research into community-driven energy models, such as energy

cooperatives and decentralized power generation, could offer alternative pathways for increasing local buy-in and improving long-term sustainability. Case studies of community-owned renewable energy projects in other developing economies, particularly in India, Bangladesh, and Latin America, could provide insights into how local participation enhances project success (IEA, 2021).

The technological dimension of renewable energy adoption in Nigeria also presents important avenues for future research. As solar PV, wind energy, and battery storage technologies continue to evolve, there is a need to investigate how emerging innovations can be integrated into Nigeria's energy mix to enhance reliability and efficiency. The role of smart grids, and blockchain technology in optimizing energy management, reducing transmission losses, and enabling decentralized energy trading deserves further examination (World Bank, 2021). Additionally, research should focus on how Nigeria can develop local manufacturing capacity for renewable energy components to reduce dependence on imported equipment. The feasibility of scaling up domestic production of solar panels, wind turbines, and battery storage systems could be analysed to determine how local manufacturing can support job creation and economic diversification (NESP, 2022).

Another pressing area for further research is the development of innovative financial models that support renewable energy adoption. Limited access to financing remains one of the biggest obstacles to renewable energy investment in Nigeria, particularly for small-scale and community-based projects (AfDB, 2022). Future studies should investigate the viability of alternative financing mechanisms such as green bonds, carbon credits, climate funds, and decentralized financing models. Understanding how these financial instruments can be harnessed to attract investment, lower costs, and create sustainable funding streams for renewable energy projects would be valuable. The role of microfinance institutions and mobile payment platforms in expanding renewable energy access in low-income and rural communities should also be explored, as mobile-based financing has been highly successful in promoting off-grid solar adoption in countries like Kenya and Rwanda (REN21, 2022).

Given Nigeria's security challenges, further research should also focus on the resilience of renewable energy projects in conflict-prone regions. The North-East and Niger Delta regions have experienced instability and disruptions, which can undermine energy infrastructure and investment confidence (World Bank, 2022). Future studies should

assess how renewable energy projects can be designed to withstand security risks, identifying best practices from other conflict-prone regions that have successfully implemented resilient energy systems. Investigating alternative energy distribution models such as microgrids and decentralized power networks could provide insights into how Nigeria can enhance energy security while minimizing vulnerability to attacks or political instability.

In conclusion, the study of renewable energy adoption in Nigeria is far from exhaustive. While this research has shed light on economic, political, technological, and social challenges, there remain numerous areas that require further investigation to refine policies, improve implementation, and enhance sustainability. By expanding case studies, conducting longitudinal research, analysing financing models, and exploring technological and social dimensions, future research can provide actionable insights that accelerate Nigeria's transition toward a sustainable and resilient energy future.

6.6 Summary

The adoption of renewable energy is not only a strategic necessity for Nigeria but also a critical pathway to achieving sustainable development, energy security, and economic resilience. This study has systematically examined the economic, political, technological, and social dimensions that shape the renewable energy landscape in Nigeria. Through an in-depth analysis of three case studies, the Katsina Wind Farm, Bayero University Kano (BUK) Solar Project, and the University of Maiduguri (UNIMAID) Solar Project—this research has identified the barriers, opportunities, and critical success factors that influence the expansion of renewable energy infrastructure in the country. The study has provided new insights into how policy reforms, financial mechanisms, technological innovations, and social engagement interact to facilitate or hinder renewable energy adoption. These findings contribute not only to the academic discourse on energy transitions in developing economies but also offer practical recommendations for stakeholders involved in Nigeria's energy sector.

One of the most significant conclusions of this research is that economic challenges remain a primary obstacle to renewable energy adoption in Nigeria. The high upfront costs associated with solar and wind technologies, coupled with limited access to financing and currency fluctuations, create substantial barriers for both public and private sector investments. The study found that, while international financing

mechanisms, such as the World Bank-funded Energizing Education Programme (EEP), have played a role in funding large-scale projects, sustainable local financing models remain underdeveloped. Without financial instruments such as green bonds, climate funds, and tax incentives, large-scale adoption of renewable energy may continue to face setbacks. Addressing these challenges will require stronger financial support structures and policy-driven incentives that make investments in renewable energy more attractive and feasible for local developers.

The political and regulatory landscape also emerged as a crucial determinant of renewable energy adoption. While Nigeria has introduced several policy frameworks,

including the Renewable Energy Master Plan (REMP) and the National Renewable Energy and Energy Efficiency Policy (NREEEP), the implementation of these policies remains inconsistent. Bureaucratic inefficiencies, regulatory uncertainty, and delays in securing project approvals were identified as major deterrents to renewable energy investments. The case studies examined in this research illustrated that projects often face long approval timelines, unclear regulatory procedures, and inconsistent enforcement of energy policies, which affect investor confidence. The need for a more streamlined and transparent regulatory process is evident, and efforts should focus on establishing a single-window clearance system to accelerate project approvals and reduce bureaucratic delays. Furthermore, political stability plays a key role in shaping investor confidence. Frequent changes in government administration often led to policy discontinuity, disrupting long-term investment plans in the renewable energy sector.

From a technological perspective, the study found that while solar and wind energy technologies are technically viable in Nigeria, several infrastructural and technical capacity constraints limit their efficiency and sustainability. The lack of local manufacturing capacity forces developers to rely on expensive imports for essential components such as solar panels, wind turbines, and battery storage systems. Additionally, a shortage of skilled professionals in the field of renewable energy engineering, system maintenance, and smart grid management further exacerbates the challenges of deploying and sustaining renewable energy solutions. To address these gaps, the study highlights the need for stronger investment in technical education and vocational training programs tailored to renewable energy technologies. Expanding local expertise through university programs, industry-led training initiatives, and government-backed capacity-building programs will be essential in fostering a sustainable, skilled workforce capable of managing large-scale renewable energy

infrastructure.

Social and cultural factors also play a crucial role in shaping public attitudes towards renewable energy adoption. While there is increasing acceptance of solar energy in urban institutions such as BUK and UNIMAID, rural communities remain sceptical about the reliability and cost-effectiveness of renewable energy technologies. Misinformation, cultural resistance to change, and lack of trust in government-led projects contribute to slow adoption rates in these regions. The study found that community engagement and inclusive participation are critical to the success of renewable energy projects, as demonstrated in the UNIMAID Solar Project, where targeted awareness campaigns and gender-inclusive STEM education initiatives contributed to greater acceptance and ownership of renewable energy solutions. To overcome social resistance, future renewable energy projects should prioritize public awareness campaigns, educational outreach, and participatory decision-making processes that involve local communities from the planning stage.

This research has also identified several critical success factors that must be considered for Nigeria to accelerate its transition to renewable energy. These include strong institutional support, predictable regulatory frameworks, innovative financing models, community engagement, and investment in technological capacity. The case studies analysed in this study demonstrate that when economic, political, social, and technological factors are effectively aligned, renewable energy projects can succeed despite existing challenges. The success of the BUK and UNIMAID solar projects underscores the potential of public-private partnerships (PPPs) and international funding mechanisms in driving project implementation. Similarly, the challenges faced by the Katsina Wind Farm highlight the importance of regulatory consistency and infrastructural readiness in ensuring the sustainability of wind energy projects.

Moving forward, Nigeria stands at a pivotal moment in its energy transition journey. The country's commitment to achieving the United Nations Sustainable Development Goals (SDGs) on affordable and clean energy (SDG 7) and its net-zero emissions target by 2060 require urgent action to scale up renewable energy investments, reform regulatory frameworks, and enhance local technological capacity. While the challenges identified in this study are significant, they are not insurmountable. Through bold policy interventions, innovative financing mechanisms, and collaborative engagement among stakeholders, Nigeria can unlock its renewable energy potential and drive long-term

economic and environmental benefits.

The broader implications of this study extend beyond Nigeria, contributing to the global discourse on renewable energy transitions in emerging economies. The findings reinforce the argument that renewable energy adoption is not solely a technological challenge but a complex socio-economic and political process that requires a multi-stakeholder approach (IRENA, 2021; IEA, 2020). The research also adds to the growing literature on stakeholder engagement, policy consistency, and adaptive energy governance, which are essential for ensuring sustainable and equitable energy transitions in developing countries. Moreover, the methodological contributions of this study, particularly its use of Yin's Case Study Methodology in an energy policy context, provide a robust framework that can be applied in future studies examining renewable energy transitions in Africa and other developing regions.

In conclusion, this study has provided valuable insights into the complexities of renewable energy adoption in Nigeria. The economic, political, technological, and social challenges identified underscore the urgent need for a coordinated approach to accelerating the country's transition towards sustainable, reliable, and inclusive energy systems. By implementing the recommendations outlined in this research, such as policy streamlining, financial innovation, capacity-building, and community participation, Nigeria can overcome its existing barriers and position itself as a leader in Africa's renewable energy transformation. As the world shifts towards decarbonization and sustainable energy solutions, Nigeria must embrace bold and strategic interventions to harness its vast renewable energy potential, ensuring energy security, economic prosperity, and environmental sustainability for future generations.

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APPENDICES

Appendix I: Interview Questions

Personal Information

1. How long have you been involved in renewable energy projects?
2. What is your current role in the renewable energy sector, and how long have you been in this position?
3. What previous experience do you have in renewable energy or related fields?

Project Overview

4. What are the main objectives of the renewable energy project you are involved in?
5. Which key industries or sectors does the project aim to support?
6. How does this project contribute to energy development and electrification goals?

Experience and Values

7. Can you describe your experience working on renewable energy projects?
8. What are the core values that guide your approach to implementing renewable energy initiatives?

Knowledge and Perception of Renewable Energy

9. What is your understanding of renewable energy and its importance in energy transition?
10. Are there any specific renewable energy projects you have been involved in or are aware of?
11. What are your thoughts on the progress and adoption of renewable energy in different sectors?

Project Initiation

12. What motivated the initiation of this renewable energy project?
13. Can you walk us through the decision-making process for selecting renewable energy as a solution?
14. What initial challenges did the project face, and how were they addressed?

Stakeholder Engagement and Collaboration

15. Who are the key stakeholders involved in the project, and what roles do they play?

16. How is engagement with local communities, employees, and other stakeholders ensured in planning and implementation?
17. What strategies have been used to collaborate with government bodies, private sector entities, and community organizations?

Technological Integration and Innovation

18. What renewable energy technologies have been adopted for the project, and why were they chosen?
19. How has innovation been leveraged to overcome technical challenges or enhance project efficiency?
20. What lessons have been learned about integrating renewable energy systems into existing infrastructure?

Financial Viability and Economic Impact

21. How is the financial feasibility and economic viability of the project assessed?
22. What funding mechanisms or investment sources have been utilized to support the initiative?
23. Have there been any notable economic or social impacts as a result of the project?

Regulatory and Policy Framework

24. How has the regulatory and policy environment influenced the project?
25. Have any regulatory or legal challenges been encountered, and how were they resolved?
26. What policy changes would you recommend to further support renewable energy initiatives?

Funding and Investment Challenges

27. What were the key funding sources for the project? Were there any challenges in securing funding?
28. How did financial constraints impact the progress and completion of the project?

Economic Viability

29. How was the financial feasibility of the project assessed?
30. Did any economic factors contribute to delays or obstacles in the project?

Technological and Technical Challenges

31. What renewable energy technologies were selected, and were there any challenges in integrating them?

32. What were the major technical challenges encountered, and how were they addressed?

Stakeholder Engagement and Social Factors

33. How were key stakeholders, including employees, communities, and project teams, involved in the initiative?
34. Were there any challenges with stakeholder cooperation or engagement?

Social Acceptance and Awareness

35. Did the project face any opposition or resistance? How was it addressed?
36. How were the benefits of the project communicated to stakeholders and the wider community?

Project Management and Execution

37. How effective was project management for the initiative?
38. Were project milestones met? If not, what were the reasons for delays?

Lessons Learned and Future Recommendations

39. What are the key lessons learned from challenges or failures encountered in the project?
40. What could have been done differently to ensure project success?
41. What recommendations would you give for future renewable energy projects?
42. What policy or regulatory changes do you think are necessary to support the adoption of renewable energy initiatives?

Appendix II: Participant Information Sheet

Dear participants,

Re: "A Study of the Challenges in Adoption of Renewable Energy in Nigeria"

The Lancashire School of Business and Enterprise, University of Central Lancashire, is conducting research on the challenges affecting the adoption of renewable energy in Nigeria. This study aims to gain insights from key stakeholders - including government policymakers, energy sector regulators, project managers, and local community representatives - to better understand the barriers to renewable energy implementation and identify strategies for overcoming them. The research will contribute to developing a national framework that supports Nigeria's transition to renewable energy, reduces reliance on fossil fuels, and promotes sustainable energy solutions.

You have been invited to participate in this study because of your expertise and experience in the energy sector. Your insights will provide valuable contributions to understanding the practical, regulatory, and social challenges facing renewable energy projects in Nigeria. The findings from this research will help shape policies and strategies aimed at enhancing renewable energy adoption and improving energy sustainability.

The interview will take place via Zoom, at a convenient time in 2023. We have attached a more detailed information sheet about the project. Should you have any queries about this project you can contact the principal Investigator, Prof Yahaya Yusuf yyusuf@uclan.ac.uk, or the Student investigator, Farouq Sule Garo fsgaro1@uclan.ac.uk, ethic officer: OfficerForEthics@uclan.ac.uk, who will be happy to answer any further questions you may have.

If you wish to participate in the project please read the attached information sheet, sign the consent form and return it to either yyusuf@uclan.ac.uk or fsgaro1@uclan.ac.uk as soon as practical.

Kind Regards,

Farouq Sule Garo
Student Investigator
University of Central Lancashire, Preston PR1 2HE.

PARTICIPANT INFORMATION SHEET

Title of the Project: "A Study of the Challenges in Adoption of Renewable Energy in Nigeria"

About the researcher

Farouq Sule Garo is currently a Research Student (MPhil/PhD) at the University of Central Lancashire in the School of Business and Enterprise, undertaking research entitled "A Study of the Challenges in Adoption of Renewable Energy in Nigeria".

Invitation

Thank you for reading this information sheet.

Before you decide whether to be involved or not, please read the information below about the project and why it is being undertaken. It is important to read this sheet carefully so that you are fully aware of what is required. Please contact the research group leaders if you have any concerns or questions. Contact details are provided at the end of this document.

Background

This interview is part of the project currently being run by the Institute of Logistics and Operations Management, University of Central Lancashire, Preston UK. Please see below detailed information on the role and aims of the project.

Aim and objectives of the research

The primary aim of this study is to investigate the key factors influencing the adoption and success of renewable energy projects in Nigeria, with a focus on economic, political, technological, and social dimensions. Considering this, the main research objectives are to:

- To examine the economic, political, technological, and social factors that impact the adoption and success of renewable energy projects in Nigeria.
- To assess the role of social attitudes, perceptions, and awareness in shaping the uptake of renewable energy technologies in Nigeria.
- To identify and evaluate the specific challenges encountered in renewable energy projects in Nigeria.
- To derive lessons from past and ongoing renewable energy projects that can inform future renewable energy initiatives in Nigeria.

Why you have been invited to participate in this research?

You have been invited to participate in this research because you have been identified

as one of the active participants (stakeholder) who have the responsibilities for the adoption of renewable technology and its application in energy generation for Nigeria. As a result, you have the depth of experience required to inform the development of feedback tools to be utilised for the purpose of this research.

What will the research involve?

This research intends to conduct an interview. The interview will be carried out online using Zoom platform. This will facilitate the collection of detailed information related to current renewable energy technologies and sustainability performance.

The data collected from the participants will be used in the development of a policy framework which will guide renewable energy implementation and support decision-making in terms of deployment and formulation of renewable energy strategies. The interviews will be **recorded and encrypted and** will be used for further analysis.

Do I have to take part?

No, it is entirely your decision. If you decide to take part and change your mind during the focus group, you can withdraw at any time without giving a reason and your rights will not be affected. If you decide to withdraw from the focus group, simply notify the project leaders.

What will I have to do if I take part?

Your data will be collected through interviews, questionnaires, and audio recording. Combining these methods will be a valuable contribution to this study. The interviews will involve 45 minutes or one-hour maximum to explore your experience on the topics at hand. This research involves Student Investigator, Farouq Garo and a Principal Investigator, Prof Yahaya Yusuf**.** You will ask to share your viewpoint on the integration of renewable technologies and their application in energy generation in

Nigeria: the drivers and obstacles to the adoption of renewable energy technologies and your preference for how you would like to receive the resulting feedback forms (e.g., via email, survey (link through email or text), paper form (provided during site visit or through the post)).

How will my data be used?

The University processes personal data as part of its research and teaching activities in accordance with the lawful basis of 'public task', and in accordance with the University's purpose of "advancing education, learning and research for the public

benefit".

Under UK data protection legislation, the University acts as the Data Controller for personal data collected as part of the University's research. The University privacy notice for research participants can be found on the attached link https://www.uclan.ac.uk/data_protection/privacy-notice-research-participants.php

Further information on how your data will be used can be found in the table below.

How will my data be collected?	Your data will be collected through interviews, questionnaires, and audio recording. Combining these methods will be a valuable contribution to this study. The interviews will involve 45 minutes or one-hour maximum to explore your experience on the topics at hand.
How will my data be stored?	All data will be store on UCLan OneDrive and office 365.
How long will my data be stored for?	The data will be stored for the period of 7years.
What measures are in place to protect the security and confidentiality of my data?	Methods such as encryption are used to protect the security and confidentiality of your data.
Will my data be anonymised?	Confidentiality and anonymity will be maintained, and it will not be possible to identify participant in any reports, presentations or publications arising from the research.
How will my data be used?	Data collected will be quoted in the research outputs such as journals, conferences and research publication i.e dissertation and other research outputs.

Who will have access to my data?	Data collected about the participant will not be accessed beyond the Student Investigator, Principal Investigator and the research team, no data processors or any third-party organisations will access the data.
Will my data be archived for use in other research projects in the future?	The data collected will be held securely stored in accordance with the Research Data Management Policy or in line with data protection requirement at the UCLan for research until it is fully anonymized and then deposited in the archive for sharing and use by other authorised researchers to support other researchers in the future.
How will my data be destroyed?	The transcript of the participant interview will be stored for the period of the research and publication purpose of 7 years afterwards the data will be destroyed.

What are possible disadvantages and risks of taking part?

There are no potential risks to you as a participant or out of pocket costs related to this research. Participation in the project will require commitment to participate for a minimum of 45 minutes and no more than 1 hour.

What are the possible benefits of taking part?

Participation in this research is typically altruistic and basis on informed consent that we are entitled to include participants. You will have the opportunity to share your experiences that will lead to the development of conceptual framework, which will in turn lead to improving your business performance/those of your suppliers.

What will happen to the results of the study?

The results are to be published in Clok.UClan.ac.uk and sciencedirect.com. Participants will not be identifiable from the results of the research.

What will happen if I want to stop taking part?

Participation in this project is voluntary, and you can withdraw at any time without giving a reason by contacting the Principal Investigator, Prof Yahaya Yusuf. If you

wish to withdraw, please note that data collected can be withdrawn up to 31/11/2023 or 4 weeks after the interview.

What happens when the research study stops?

You will not be contacted or required to participate in any further assessments or interviews regarding this study.

What happens following the interview?

The interview forms a very important part of the overall project. After the interview, the participants will finalise the feedback tool to be utilised by all supply chin professionals. In turn, the expert making up those specialist teams will gather and act on the feedback provided to improve their supply chain.

What if there is a problem?

UCLan strives to maintain the highest standards of rigour in the processing of your data. If you have any concerns about the way in which your data is handled, please feel free to lodge a complaint with the Information Commissioner's Office by calling 03031231113, or if you still feel unhappy, please contact the Principal Investigator, Yahaya Yusuf by calling +447930601186 and we will try to help. If you have a complaint which you feel you cannot come to us with, then please contact the Ethic, Integrity and Governance Unit at the OfficerForEthics@uclan.ac.uk. Further details are provided at the end of this document.

Will my taking part in this study be key confidential?

Yes, all your information will be treated with the strictest confidence, and all legal and ethical considerations will be adhered to. You will be provided with ground rules regarding maintaining the confidentiality of other people's information and asked to sign a consent form agreement.

The information you provided may be audio recorded to help with analysing the data for the project. This will be confirmed and agreed with the Principal Investigator when

you are invited and during the consent process.

You will not be identified in the project and any comments you make will be anonymous. No one outside of the group will be involved in listening and analysing the data and the raw data from the tape recordings will be destroyed once it has been transcribed.

Please note that this information will be stored securely on the UClan one drive. Once the notes have been made, the focus lead will destroy the audio recording. No personal identifiable information will be passed to any third party.

No personal or organisational details revealing the participant will be included in any part of the project.

Who is organising the project?

This project is led by Professor Yahaya Yusuf, the Direct of the Institute of Logistics and Operations Management, University of Central Lancashire, Preston, UK.

Taking part:

If you would like to take part in this focus group interview, please sign the attached consent form and return it to the Principal Investigator via email (contact details at the end of this document).

Further information

If you would like further information, before deciding to take part, please contact Farouq Garo, or the principal investigator, who will be happy to answer any further questions you may have.

Who can I contact if I need further information

If you require more information about this project, please contact the following:

1. For any questions about the focus groups interview, for sending in your consent form and for withdrawing from the interview, please contact: Student Investigator Farouq Garo, +447517122065, email: fsgaro1@uclan.ac.uk

2. For information about the project in general or any concerns, please contact: Principal Investigator Professor, Yahaya Yusuf, Director of the Institute of Logistics and Operations Management, +447930601186, email: YYusuf@uclan.ac.uk

Thank you for taking the time to read this study information sheet, we hope to see you at the focus group interview.

Appendix III: Consent Letter

University of Central Lancashire
UCLan

Participant Consent Form

Version number & date: V2.0 24.05.2021
Title of the research project: A Study of the Challenges in Adoption of Renewable Energy in Nigeria
Name of researcher(s): Farouq Sule Garo

Please initial box as appropriate:

1. I confirm that I have read and have understood the information sheet dated November 2022 for the above study and have had the opportunity to ask questions about the focus group interview. ☐
2. I understand that my participation is voluntary and that I am free to stop taking part and can withdraw from the study at any time without giving any reason and without my rights being affected. In addition, I understand that I am free to decline to answer any particular question or questions. ☐
3. I give permission for my anonymised experiences to be recorded and used for analysis in this project. ☐
4. I give permission for my anonymised notes in a report format to be archived as part of this project, making it available to future work. ☐
5. I give permission for use of anonymised quotations in publications. ☐
6. I understand that the information I provide will be held securely and in line with data protection requirements at the University of Central Lancashire. ☐
7. I understand that signed consent forms and audio recordings/questionnaires will be retained in the University of Central Lancashire one drive for 7 years. ☐
8. I agree to take part in the above study. ☐

Participant name	Date	Signature
Name of person taking consent	Date	Signature

Principal Investigator
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