Nottingham Trent University

Investigating the Feasibility of Utilising Renewable Energy Sources in West African Households – A Case Study of Nigeria

Daminabo Pokubo

This thesis is submitted in partial fulfilment of the requirements of Nottingham Trent University for the the degree of Doctor of Philosophy

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Signature: ………………………………………………………… (Candidate)   Date 22/03/2022

Dedication

This work is dedicated to my elder sister, (late) Sotonye Pokubo, whose absence is deeply felt. I wish you were here to witness life with us. Till we meet again.

Acknowledgement

First, I would like to thank God and my Lord and Saviour, Jesus Christ, for His grace and mercy. He has given me the strength, opportunity, and ability to embark on this journey and successfully complete it.

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Abstract

Nigeria boasts a wealth of diverse energy resources capable of fostering sustainable development across its various sectors. Abundant energy resources such as crude oil, natural gas, coal, and renewable energy resources like solar, wind, and hydropower position Nigeria as a nation with immense potential in the rapidly expanding global energy sector. Despite this abundance, a substantial portion of Nigerian households, constituting 60% of the population, grapple with unreliable access to electricity and clean cooking fuels due to various challenges, including poorly managed grid infrastructure, vandalism, and disruptions in gas supply that contribute to these energy challenges. With a population exceeding 200 million, 60% of Nigerian households (160 million people) primarily depend on conventional energy resources to meet their energy needs, exacerbating climate change concerns. As global energy demand rises and environmental awareness intensifies, the imperative for West African countries like Nigeria to adoption toward renewable energy becomes increasingly evident, considering their vulnerability to the impacts of climate change.

In response to these challenges, the Nigerian government is actively pursuing its Renewable Energy Master Plan to reduce household dependence on conventional energy resources and diversify the country's energy mix. However, the adoption to renewable energy in Nigeria has encountered setbacks and is progressing at a slow pace. Therefore, this research investigates the feasibility of integrating renewable energy sources into the household energy mix in West Africa, focusing specifically on Nigerian households. Employing a concurrent mixed methods approach, the study assesses socio-economic, technological, and environmental factors influencing the adoption of renewable energy solutions in Nigeria. Surveys distributed across diverse households and interviews conducted with key policymakers collected both quantitative and qualitative data. The primary objectives of using both quantitative and qualitative methods are to identify the prevalent energy consumption patterns, assess the awareness and attitudes of households towards renewable energy technologies, and evaluate the economic viability of such adoption. The study also examines existing renewable energy policy frameworks, regulatory incentives, and potential barriers hindering widespread adoption in Nigerian households.

Findings reveal adoption barriers categorised under economic, policy, legal, technical, market, and household demographic factors. Despite a growing awareness of renewable energy benefits driven by concerns over energy security, rising utility costs, and environmental consciousness, challenges such as initial capital costs, limited financing access, and insufficient infrastructure hinder widespread adoption within households. The study highlights the role of government policies in shaping the renewable energy landscape and proposes recommendations to enhance frameworks for sustainable energy adoption.

This research significantly contributes to the discourse on renewable energy adoption in developing countries, providing a nuanced understanding of challenges and opportunities within the context of Nigerian households. The outcomes aim to inform policymakers, energy practitioners, and local communities on strategies for a more sustainable and resilient energy future in the region.

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Chapter 1. Introduction and Research Background

1.0. Introduction

The significance of energy to the global economy cannot be overemphasised, as energy is considered a fundamental asset required for sustainable development in many national economies. Globally, energy resources contribute to economic growth and play a significant role in any modern society, as it is an essential prerequisite for the development and survival of the world's citizens (Aliyu et al., 2015; Le and Nguyen, 2019). The crucial role of energy in the world is of high importance as energy has been likened to a major driver of economic growth (Barreto, 2019). This indicates that the measure by which a country's energy is being generated, supplied, and consumed and the type of energy infrastructures and energy policies employed, either improve or devalue the economic growth in any country (IEA, 2020; Mehlum, 2017). Therefore, there is a positive relationship between energy generation, consumption, and economic growth (Rahman, 2021; Hu et al, 2021).

Like in most regions, energy in sub-Saharan Africa is considered a fundamental asset required for sustainable development. Key economic sectors such as household, industrial, transportation, commercial and agricultural sectors are hinged on the quantity and type of energy resources, energy infrastructures and energy services available in the region. Therefore, it shows a link between energy resources and sectoral growth (Rahman, 2021). However, identifying the direct linkage between energy consumption and economic growth has been a widely debated topic amongst various researchers for decades, as there have been varying notions regarding the precise relationship between energy consumption and economic growth (Kraft and Kraft, 1978; Apergis and Payne, 2009; Belke, Dobnik and Dreger, 2011 and Wang et al., 2016). Nevertheless, the underlying rationale behind this debate is mainly focused on increased global access to clean, modern, and affordable energy for the world's population (UN, 2017). As it has been recognised globally that increasing access to clean, modern, and affordable energy is crucial towards achieving sustainable development in any country and the achievement of the United Nations' Sustainable Development Goals

(SDGs) 7, which focuses on providing access to affordable, reliable, sustainable, and modern energy for all global citizens (UN, 2018). However, recent studies reveal that about 15% of the global population does not have access to modern electricity, while approximately 31% lacks access to clean cooking fuels (Bonjour et al., 2013; IEA, 2017). The International Energy Agency highlighted that about 1.1 billion people globally lack access to modern energy (electricity), combined with an estimated 2.3 billion people living without access to clean cooking fuel and efficient cooking stoves (IEA, 2017). This resulted in an increased dependence on conventional energy sources (fossil fuel – crude oil, coal, and natural gas) for energy consumption and traditional solid biomass fuels (firewood, charcoal, and wood chips) as cooking fuels. However, the utilisation of these energy sources has not been without drawbacks. The combustion of fossil fuels and utilisation of traditional solid biomass fuels have been associated with increasing global warming and the occurrence of acute respiratory infections (ARI) (Mohammed et al., 2017; Lin and Ankrah, 2019).

Reports show that about 3 to 4.3 million people die annually from exposure to particulate matter from the combustion of these fuels (Dickson, 2015). Similarly, the impact of the lack of access to clean, modern, and affordable energy is particularly worse for developing countries due to high energy demand from rising population, economic growth, and high levels of poverty (Kemausuor et al., 2011; Bazilian et al., 2011 and WHO, 2016). It is estimated that about 620 million people living in sub-Saharan Africa are without access to electricity, combined with approximately 800 million people in the region relying on solid biomass fuels (particularly firewood and charcoal) for cooking and heating purposes (IEA, 2018 and Ouedraogo, 2017). This high reliance on conventional energy sources results in 600,000 deaths in sub-Saharan Africa, where almost 70% of the population is poor and resides in remote villages that are off the grid (WHO, 2016; IEA, 2014). This impact of inaccessibility to clean, modern, and affordable energy for sub-Saharan African countries has resulted in efforts to tackle the energy challenges in the region.

Hence, this gives rise to the need for a adoption to sustainable alternatives that would have less detrimental impacts on the environment and the health of the region's population. The call for adoption focuses on introducing sustainable or renewable energy sources into the household energy consumption mix in the region (Wassie, Rannestad and Adaramola, 2021). Efforts to solve the energy challenges in sub-Saharan Africa and around the world have resulted in a global coalition to develop policies that will encourage a adoption towards cleaner energy sources and enable the introduction of renewable energy sources into the household energy mix. Examples of such policies include the Kyoto Protocol (2005), the Paris Agreement (2016), and the UN SDGs to mitigate global dependence on fossil fuels and solid fuels and mitigate the effects of climate change (UN, 2018). However, despite these policies and efforts to increase access to cleaner energy sources in most parts of the world, the challenge of inaccessibility to clean, modern, and affordable energy is still prevalent (Kamausuor et al., 2011; IEA, 2017).

1.1. Research Problem

The energy resources in any region hold significant importance for achieving sustainable development within that region (Al-Shetwi, 2022). However, like many other regions worldwide, insufficient access to clean, modern and affordable energy poses a significant obstacle to sustainable development in Nigeria (Sambo, 2008). As the most populous country in the region, Nigeria possesses abundant energy reserves encompassing both fossil fuels and renewable sources (Wassie et al., 2021; Odukwe and Enibe, 1988). Despite this resource abundance, Nigeria is faced with substantial energy challenges, including electricity supply shortages, blackouts, grid collapse, and a lack of access to clean and affordable cooking fuel for nearly half of its population (Aliyu, Dada, and Adam, 2015; Oseni, 2017; Okoye and Omolola, 2019; Adewuyi et al., 2020).

Recent studies place Nigeria as one of the countries with the highest level of absolute energy poverty in the world (Rao et al., 2022; Sy and Mokaddem, 2022; Salman, Zha and Wang, 2022). As of 2021, over 85 million households in Nigeria remain without reliable electricity supply, while approximately 150 million households in Nigeria lack access to clean cooking fuel, accounting for 12% of the global energy access deficit (World Bank, 2023). According to the

IEA, the number of households with energy deficits in Nigeria has increased by over 6 million in the last decade due to population growth outpacing energy generation and access efforts (IEA, 2023). Additionally, there is a significant disparity in the energy access rate between urban and rural households in the country, with 84% of urban households having access to electricity supply compared to only 26% of rural households (Pelz et al., 2023). At the same time, the country struggles to transmit the 15,000 MW of electricity it should be able to, with actual transmission limited to less than 5,000 MW for over 200 million citizens (Heinemann et al., 2022; Adewuyi et al., 2020; Adoghe et al., 2023). This lack of reliable electricity access and clean cooking fuels undermines the delivery of basic services like healthcare, education, and business growth for households due to major sectors lacking energy supply (Sesan et al., 2013; Abubakar et al., 2022).

Unfortunately, efforts to achieve widening access to clean, modern, and affordable energy sources struggle to keep pace with Nigeria's surging demand for energy (electricity) (Pokubo, Pepple and Al-Habaibeh, 2024). To tackle this pressing energy challenge, the Nigerian government has set an ambitious target to promote household energy adoption to cleaner and more efficient energy alternatives like electricity, improved cookstoves, and the integration of renewable energy resources (solar, wind, tidal and geothermal) into the national grid by the year 2030 (Nduka, 2021; Dioha and Emodi in 2019). Various policies, frameworks, and projects have been implemented to address Nigeria's energy crisis further and promote household renewable energy adoption. Key policies include the National Energy Policy (NEP) 2013, Renewable Energy Master Plan (REMP) 2012, Vision 20:2020, Road Map to Power Sector Reform 2010, Renewable Electricity Policy Guideline (REPG) 2006, Nigerian Biofuel Policy and Incentives (NBPI) 2007, and National Renewable Energy and Energy Efficiency Policy (NREEEP) 2014 (Mohammed et al., 2017; Edomah, 2016; Emodi and Boo, 2015). However, these policies and other measures to encourage household adoption of renewable energy have yet to address the country's current energy crisis. This implies that the success of these efforts and policies relies on a comprehensive understanding of the underlying factors that drive household renewable energy adoption (Pokubo, Pepple and Al-Habaibeh, 2024).

Several studies have explored energy adoption in Nigeria. For instance, Baiyegunhi and Hassan (2014) analysed the shift in cooking fuel use among rural households in Kaduna State, identifying factors such as age, income, fuel prices, and cooking times as key influences on household energy choices. Similarly, Osunmuyiwa, Biermann, and Kalfagianni (2017) examined Nigeria's renewable energy adoption from a socio-technical perspective, focusing on the electricity, oil, gas, and renewable energy sectors. Their findings, in line with Osunmuyiwa and Kalfagianni (2017), highlighted the crucial role political actors play in advancing renewable energy adoption in Nigeria. While these studies contribute to the broader energy adoption literature, research on renewable energy adoption within the household sector remains limited. Most studies on Nigeria have focused on other sectors or specific energy sources, neglecting the complexities of energy adoption in the residential sector. This is particularly important, as households account for nearly 25% of global energy consumption and are responsible for 17% of global emissions (IEA, 2021). Emodi et al. (2022) examined energy adoption in rural and urban Nigerian households, finding evidence of a reverse adoption where households reverted to traditional fuels like firewood despite being financially capable of purchasing cleaner options such as LPG. However, their study primarily focused on economic factors like household income and energy prices as the main influences on household energy transition.

Given this context, it is clear that household renewable energy adoption in Nigeria is shaped by more than just socio-technical or socio-political factors. They involve a complex interplay of societal, political, cultural, economic, and environmental elements (Geels et al., 2017), which requires further research to fully understand and address the barriers to adopting renewable energy in the household sector. Current studies have overlooked socio-cultural factors like culture, household perceptions, and gender roles in Nigerian households' adoption of renewable energy. Research by Nwaka et al. (2020) and Ogwumike et al. (2014) highlighted that other factors significantly shape household adoption of renewable energy beyond economic, political, and environmental factors. However, these factors have not been adequately explored, leaving gaps in understanding the other factors that drive renewable energy utilisation in Nigerian households.

To bridge this knowledge gap, this thesis aims to investigate the feasibility of household renewable energy adoption by exploring the various factors influencing household energy choices, including household perceptions, cultural influences, and gender dynamics. While most existing studies emphasise economic factors such as fuel prices and income, this research seeks to provide a more comprehensive understanding by focusing on often-overlooked barriers and social aspects of renewable energy adoption. By examining how these barriers, including cultural behaviours and gender roles, affect energy decisions, this study will offer deeper insights into the barriers to and the slow pace of renewable energy adoption among Nigerian households. In addition, it will identify the key challenges households face in transitioning to renewable energy, analyse the obstacles to adoption, and evaluate how socio-cultural factors and gender shape this adoption. Through this approach, the study aims to provide a well-rounded perspective on the factors influencing renewable energy adoption in Nigerian households. Given the preceding discussion, this study aims to answer the research questions below and achieve the following objectives.

1.2. Research Aim

The aim of this study is to investigate the possibilities and potential for integrating renewable energy into the energy mix of Nigerian households. More importantly, this study aims to evaluate the potential for household renewable energy adoption by analysing the roles played by key stakeholders in the Nigerian energy sector. This includes a comprehensive examination of key policymakers and end users, focusing on understanding the factors influencing the adoption of renewable energy technologies for Nigerian households. By critically examining the adoption potential within Nigerian households towards renewable energy, this study will also identify the multifaceted factors influencing such adoption. It will also identify barriers hindering the adoption of renewable energy, explore household perceptions of renewable energy technologies, assess prevailing household energy challenges, and analyse the impact of governmental policies and initiatives in achieving a successful renewable energy adoption in Nigerian households.

This research is guided by the following questions and individual research objectives to achieve this aim.

1.3. Research Questions

The following research questions have been developed for this research such as

1. What are the current household energy challenges in Nigeria?
2. What renewable energy policies exist in Nigeria, and what underlying factors inhibit renewable energy policy implementation?
3. What are the main drivers and barriers of household renewable energy adoption in Nigeria?

1.4. Research Objectives

The study objectives of this research include:

1. To critically evaluate the West African energy landscape within the context of energy dynamics in West Africa and Nigeria.
2. To assess the progress of renewable energy development in Nigeria and identify the various renewable energy technologies employed in the Nigerian household energy mix.
3. To identify and discuss the renewable energy policies in Nigeria targeted at promoting renewable energy adoption.
4. To investigate the household energy challenges driving a shift towards integrating renewable energy technologies in Nigerian households.
5. To assess the public behaviour towards accepting renewable energy technologies in lieu of government subsidies on fossil fuels.
6. To identify the factors influencing household renewable energy adoption amongst Nigerian households.
7. To develop a framework for supporting renewable energy adoption and provide key recommendations to assist policymakers in Nigeria with developing strategies for a successful renewable energy adoption.

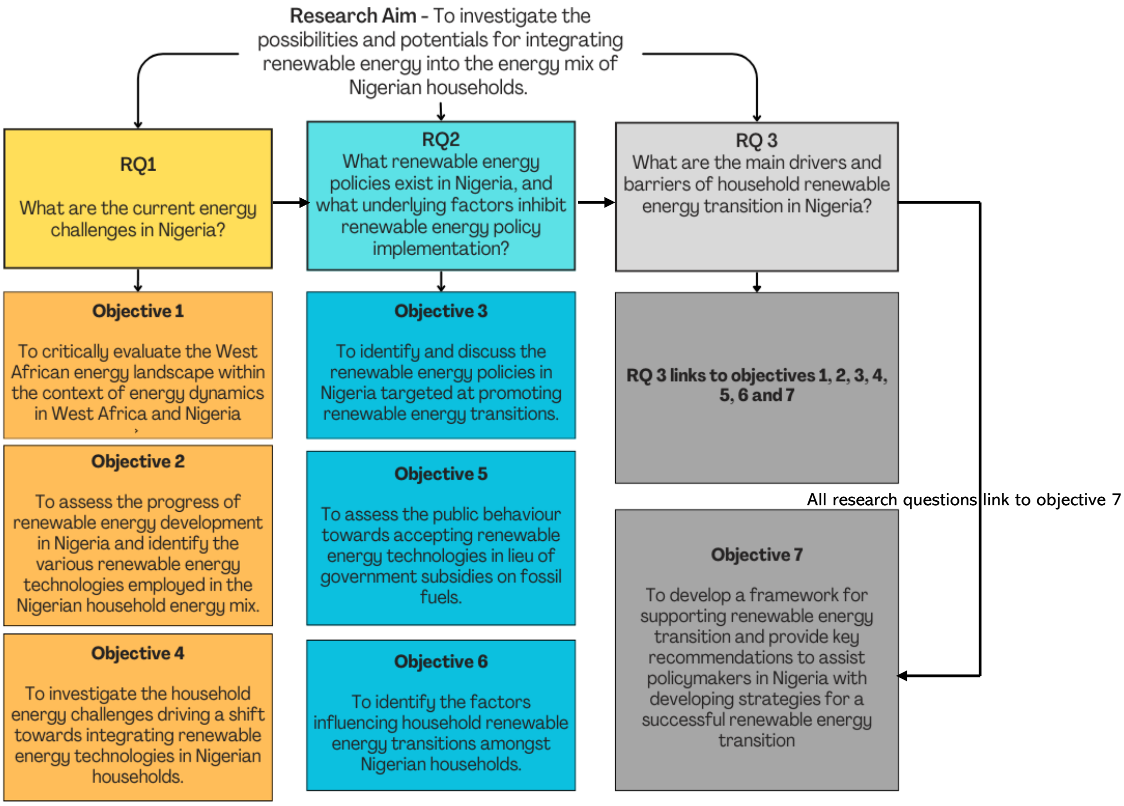

Figure 1. 1 Links Between Research Aims, Research Questions and Research Objectives

Source: Author Generated

1.5. Research Methodology and Methods

To ensure the validity of this research, selecting an appropriate research design and methodology is essential to achieving its aim. This study employs a mixed-methods approach to empirically assess the feasibility of adopting renewable energy in Nigerian households. A mixed-methods approach is considered suitable for this research as it facilitates triangulation by combining quantitative and qualitative data collection methods, allowing for a comprehensive exploration of the factors influencing household renewable energy adoption in Nigeria (Saunders, 2024; Wellman et al., 2023). This study adopts pragmatism as the guiding philosophical paradigm to ensure a robust investigation into the feasibility of renewable energy use in Nigerian households. Pragmatism is particularly suited to this research because it bridges the divide between objective analysis and subjective interpretation, enabling a comprehensive understanding of household energy transitions, complex social and technical dimensions (Kaushik and Walsh, 2019).

Pragmatism offers the flexibility to utilise quantitative and qualitative methods, integrating structured scientific approaches with the comprehensive exploration of human experiences (Shook, 2023). In this study, quantitative data, such as household energy consumption patterns and fuel choices, are collected through surveys conducted across Nigeria's six geopolitical zones. These data provide objective insights into existing energy behaviours. Simultaneously, qualitative data are gathered through semi-structured interviews with key stakeholders, including energy experts, policymakers, and researchers, to explore perceptions, attitudes, and the contextual factors influencing renewable energy adoption.

This mixed-methods approach, underpinned by pragmatism, ensures a balanced and holistic exploration of the research problem (Kaushik and Walsh, 2019). The objective analysis of quantitative data enables the identification of broad trends and patterns. In contrast, the interpretative analysis of qualitative data provides depth and context, offering a richer understanding of the factors driving or hindering renewable energy integration in Nigerian households. The integration of these methods allows for an in-depth understanding of whether either approach could be achieved independently. This research adopts a pragmatic stance, aligning with the principle that the methods chosen should be the most effective for addressing the research questions. Pragmatism's emphasis on adaptability and contextual understanding supports the investigation of complex social phenomena such as energy adoption, where multiple factors and perspectives interact. This philosophical framework is further elaborated in Chapter 3, with the data collection and analysis methods detailed in Chapter 5.

The household surveys and interviews constitute the primary data for this research. The quantitative data (household surveys) was analysed using SPSS, allowing conclusions to be drawn in response to answering the research questions of this research. The qualitative data (semi-structured interviews), after transcription, was analysed using NVivo to identify recurring themes aligned with the research objectives and answer the research questions. By adopting this comprehensive research design and philosophical framework, the study remains flexible, allowing for the inclusion of emerging constructs as they arise throughout the research process. An outline of the research methodology utilised in this research is illustrated in Figure 1.2 below.

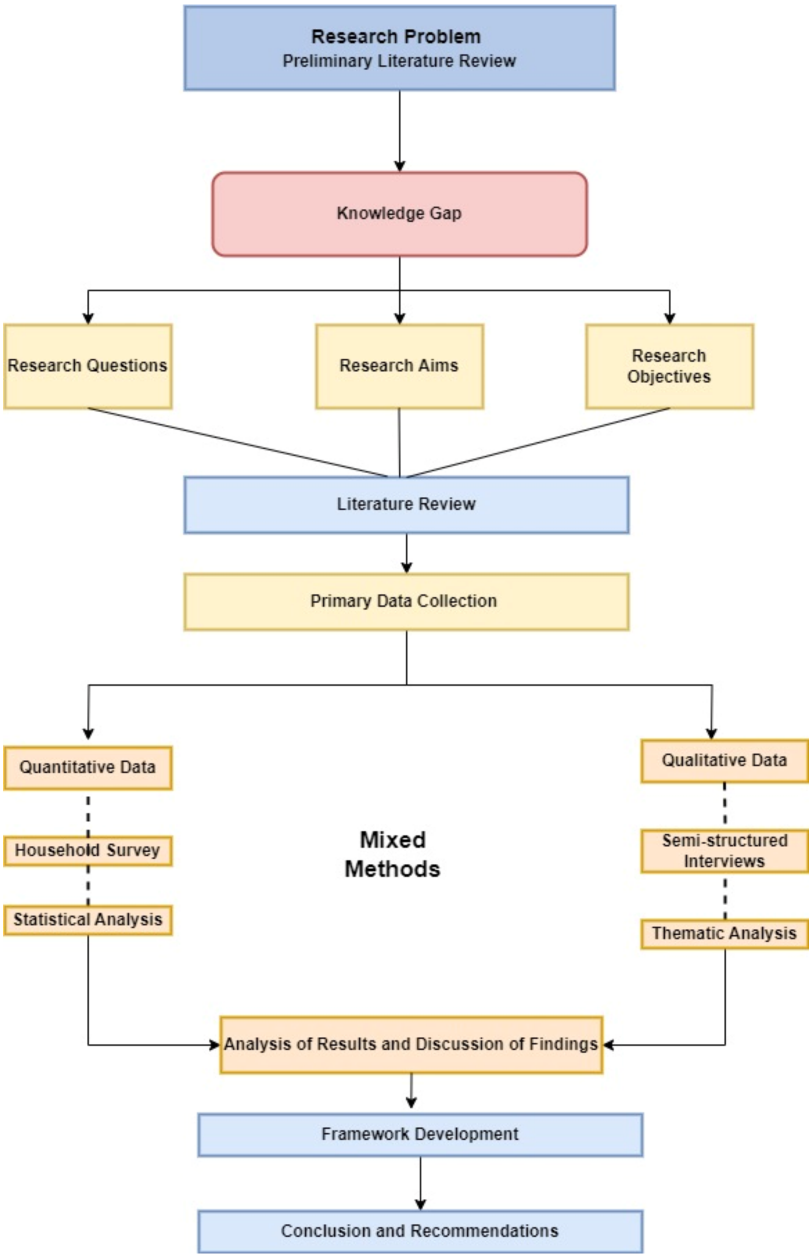

Figure 1. 2 Diagrammatic Representation of Research Methodology

Source: Author's Own

1.6. State of the Art and Relationship to Previous Studies

Notable studies have assessed the potential of renewable energy in Nigeria. For example, Shaaban and Petinrin (2014) examined renewable energy potentials in Nigeria but focused specifically on rural community energy needs. Similarly, Mohammed et al., (2017) studied Nigeria's current renewable energy technologies based on autonomous and microgrid technologies. However, the above studies were either specific to renewable energy technology or confined to particular areas of Nigeria.

On the other hand, Oyedepo (2014) studied the feasibility of energy efficiency and renewable energy in Nigeria while Emodi and Boo (2015) assessed the current state of energy resources and policies employed in Nigeria. Nevertheless, both studies made significant contributions to renewable development in Nigeria, but they fell short of considering renewable energy utilisation in Nigeria and barriers to the implementation of renewable energy policies. Although, Edomah (2016) analysed the barriers to sustainable energy development in Nigeria, focusing on general energy issues rather than renewable energy. Relevant literature concerning Nigeria concentrates primarily on renewable energy potentials for rural electrification, specific renewable energy resource potentials and the general renewable energy potential for Nigeria (Shaaban and Petinrin, 2014; Yamusa II and Ansari, 2015; Akinbami, 2001; Aremu and Akinoso, 2013).

Various studies have been conducted to investigate the transition from fossil fuel energy sources to renewable energy sources in Nigeria. Nwaneto et al. (2018) examined the economic implications of renewable energy adoption in Nigeria by considering the macroeconomic factors that drive the successful adoption of cleaner forms of energy across all sectors. Similarly, Osunmuyiwa and Kalfagianni (2017) explored the various conditions and pathways that hinder renewable energy adoption in all 36 states of Nigeria using a comparative qualitative analysis. However, both Nwaneto et al. (2018) and Osunmuyiwa and Kalfagianni (2017) examined energy adoption with a particular focus on political and economic factors that influence energy adoption in Nigeria without focusing on household energy adoption.

On a sectoral level, Edomah (2019) investigated the transition process of sustainable energy alternatives in Nigeria's manufacturing sector. The study examined the factors and motives that influence energy consumption in Nigeria's manufacturing sector. The study revealed that the pace of adoption in the Nigerian manufacturing sector is very slow, as the sector is heavily dependent on traditional biomass fuels for manufacturing activities. However, production cost reduction, changes in business motives, and market demand are the primary influencers of energy transition in the sector. Additionally, Edoman and Ndulue (2020) assessed the impacts of the COVID-19 pandemic on energy adoption in Nigeria by observing changes in electricity demand in Lagos state, Nigeria. The study revealed that due to governmental lockdown measures to control the spread of the virus, the shift to working and studying from home triggered changes in electricity consumption, causing a gradual energy adoption. Despite the momentary adoption, a surge in electricity demand was recorded in the residential sector of Lagos State. In contrast, electricity demand declined in other sectors due to a shift to working and studying from home.

Additionally, only a few studies have been conducted to assess the likelihood of sustainable energy adoption in households in sub-Saharan Africa and Nigeria. Extant studies concerning Nigeria mainly focus on investigating the feasibility of renewable energy development in Nigeria or in specific sectors, but rarely in the household sector. Also, such studies do not consider the complexities associated with such adoption, especially in a culturally diverse country such as Nigeria (Bazilian, Nakhooda and Van de Graaf, 2014; Lockwood, 2013; Meadowcroft, 2009). Baiyegunhi and Hassan (2014) investigated the adoption of cooking fuel in rural households by analysing the impact of socioeconomic variables on household cooking fuel choices. Dioha and Kumar (2020) employed an energy systems model to assess sustainable energy pathways in Nigeria's residential sector. Both studies (Baiyegunhi and Hassan, 2014; Dioha and Kumar, 2020) have made significant contributions to the literature regarding household energy adoption in Nigeria. However, it falls short of investigating the potential of household energy adoption to renewable energy from a holistic viewpoint by considering the various energy stakeholders across Nigeria's six geopolitical zones.

Similarly, extant studies on renewable energy development in Nigeria either focus on a particular type of renewable energy resource or are limited to specific regions of the country. Therefore, not taking into cognisance the comprehensive dynamics of renewable energy adoption in Nigeria, likewise assessing the possibilities of adopting renewable energy amongst a population that has become accustomed to energy subsidies.

Exploring the overarching aim of this research, this research provides new insight into the literature on household energy transition in Nigeria by examining the feasibility of households adopting renewable energy, the challenges to household renewable energy adoption, and the views of key energy stakeholders on household renewable energy adoption processes. In view of the above discussion, the predicted contribution to knowledge of this study is presented in the section below.

1.7. The Significance of the Study

Transitioning to cleaner, affordable energy sources like renewables has been recognised as one of the most effective pathways to reduce the rate of global temperature rise (IEA, 2017). However, the stakes are high due to the complexities of energy systems with respect to the economic, technological, and sociological dynamics of transitioning to renewable energy combined with the need to maintain an average global temperature of 1.5 ^{0}C (Hoicka, Conroy and Berka, 2021). As such, various studies have investigated the adoption process and the role of adoption theories in achieving sustainability. For example, Butu. (2017) applied transition theory to examine the transition process to renewable energy in rural communities in Nigeria. Similarly, Strachan et al. (2015) employed adoption frameworks from the adoption theory to investigate the state of community-based renewable projects in the UK. Meadowcroft. (2009) applied adoption theory to the process of governing long-term energy adoption.

While these studies have revealed that investigating the transition to renewable energy sources is best conducted within national economies, research on sustainability adoption in sub-Saharan African countries such as Nigeria is very scarce. As such, this research produces recent findings concerning renewable energy adoption within the household sector in Nigeria, where the likelihood of adoption borders between the need to increase access to clean energy and achieve net-zero carbon emissions.

This study aims to contribute significantly to academic literature and aid in policy design. This study seeks to fill the gap mentioned above by comprehensively investigating Nigeria's renewable energy technologies and policies, aiming to develop a framework for the practical development and acceptance of renewable energy in Nigerian households. The proposed framework will guide policymakers and all energy stakeholders in institutionalising renewable energy sources into their energy consumption mix to mitigate dependence on fossil fuels and solid fuels and assist in increasing access to clean energy.

1.8. Structure of the Thesis

Chapter 1 of the thesis introduces the research context, giving background information about the study and its motivation. This chapter presents the research problem, objectives, questions, and the significance of exploring the feasibility of household renewable energy adoption. The chapter also establishes the methodological approach and summarises the structure of the thesis. Chapter 2 presents an in-depth review of the energy dynamics in West Africa, focusing on energy use patterns across the region. This is then followed by a critical review of literature on the energy dynamics in Nigeria, discussing electrification rates and the socio-economic and environmental implications of current energy consumption patterns in the country. Chapter 3 discusses household-level renewable energy integration in Nigeria, exploring the current trends of adoption and barriers to renewable energy adoption. This chapter also evaluates the renewable energy potential in Nigeria and provides a review of the country's renewable energy policies. Chapter 4 outlines the research philosophy, design and methodological approaches used in the research. The rationale for adopting a pragmatic approach was discussed, followed by a justification for the choice of survey and interview methods used for data collection. In chapter 5, quantitative findings from household surveys were presented, exploring household energy use patterns, challenges and awareness of renewable energy use in households. Chapter 5 also presented the feasibility indicators for household renewable energy adoption in Nigeria. Chapter 6 presented qualitative findings from interviews with policy makers from the Nigerian energy sector. Chapter 7 complements chapters 5 and 6 by providing a comprehensive discussion of the conclusions from the quantitative and qualitative data analysis. This chapter shows the relationship between household energy consumption behaviours and systemic governance issues that hinder widespread adoption of renewable energy. Chapter 8 established a new framework for household renewable energy utilisation in Nigeria. The chapter also proposes a hybrid model of communication between the various actors to enhance responsiveness and implementation efficiency. Chapter 9 provides a conclusion to the study by summarising the key findings, contributing to knowledge, and offering recommendations. The chapter positions the proposed framework as a strategic tool for guiding policymakers in developing equitable household renewable energy transitions.

1.9. Summary

This chapter presents a detailed overview of the thesis. The chapter provides insight into the rationale behind the research, overview of the aim and objectives of the research. Afterwards the research questions for the research were outlined in line with the research objective to show relationship between the research objective and the research questions. Three research questions have been constructed for this research and then the proposed methodology for conducting the research to achieve the set research objectives was outlined. The chapter concluded by presenting showing the relation between this study and other study, stating the significance of the study, and outlining the proposed structure of the thesis.

Chapter 2. Literature Review: Overview of Energy Dynamics in West Africa

2.1. Introduction

This section provides a review of the energy dynamics and challenges in West Africa and in Nigeria. The chapter examines renewable energy integration in West Africa and Nigeria, discussing trends in energy generation and consumption patterns and providing insight into the energy resources available within the region. The literature analysis in this chapter revealed that despite the abundant renewable and non-renewable energy resources available in West Africa and Nigeria, the region struggles to meet the energy demands of households within the region. This significantly affects major sectors and inhibits the achievement of UN Sustainable Development Goal 7 (SGD 7) – Affordable and Clean Energy. The chapter also analyses the barriers to household renewable integration in West Africa, focusing on factors that slow the adoption process of renewable energy in Nigeria, providing in-depth insights into the empirical analysis of qualitative and quantitative data for this research. This section is divided into themes, beginning with an introduction to the energy dynamics in West African countries and then focusing more on the energy dynamics in Nigeria.

2.2. Overview of Energy Situation in West Africa

It is globally recognised that energy is one of the most significant drivers of economic growth and a catalyst for social and human development (Merem et al., 2017; Sovacool and Drupady, 2016). This is because access to adequate energy resources, especially clean and modern energy sources such as electricity, drives industrialisation, manufacturing, commercialisation, and infrastructural development in various countries (Nerini, Ray and Boulkaid, 2017; Ajayi, 2010; Ahmed, 2021). The International Energy Agency (IEA) also emphasises that access to clean and modern forms of energy is crucial for poverty alleviation, improving health conditions and driving economic growth in the poorest parts of the world (IEA 2019). Yet, most countries, particularly those in West Africa, lack access to clean and modern energy (IEA, 2019).

The Western African region, commonly known as the Economic Community of West African States (ECOWAS), is a block of 15 sovereign countries comprising of Nigeria, Ghana, Benin, Burkina Faso, Cape Verde, Côte D'Ivoire, The Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Senegal, Togo, and Sierra Leone (Auth et al., 2014). The ECOWAS aims to promote sustainable development across the region to foster economic, social and human capital growth by 2050 (ECOWAS, 2022). With a population of approximately 334.6 million people, West Africa accounts for one-third of sub-Saharan Africa's population and is highly diverse in demographics, culture, economy, and climate (World Bank, 2020).

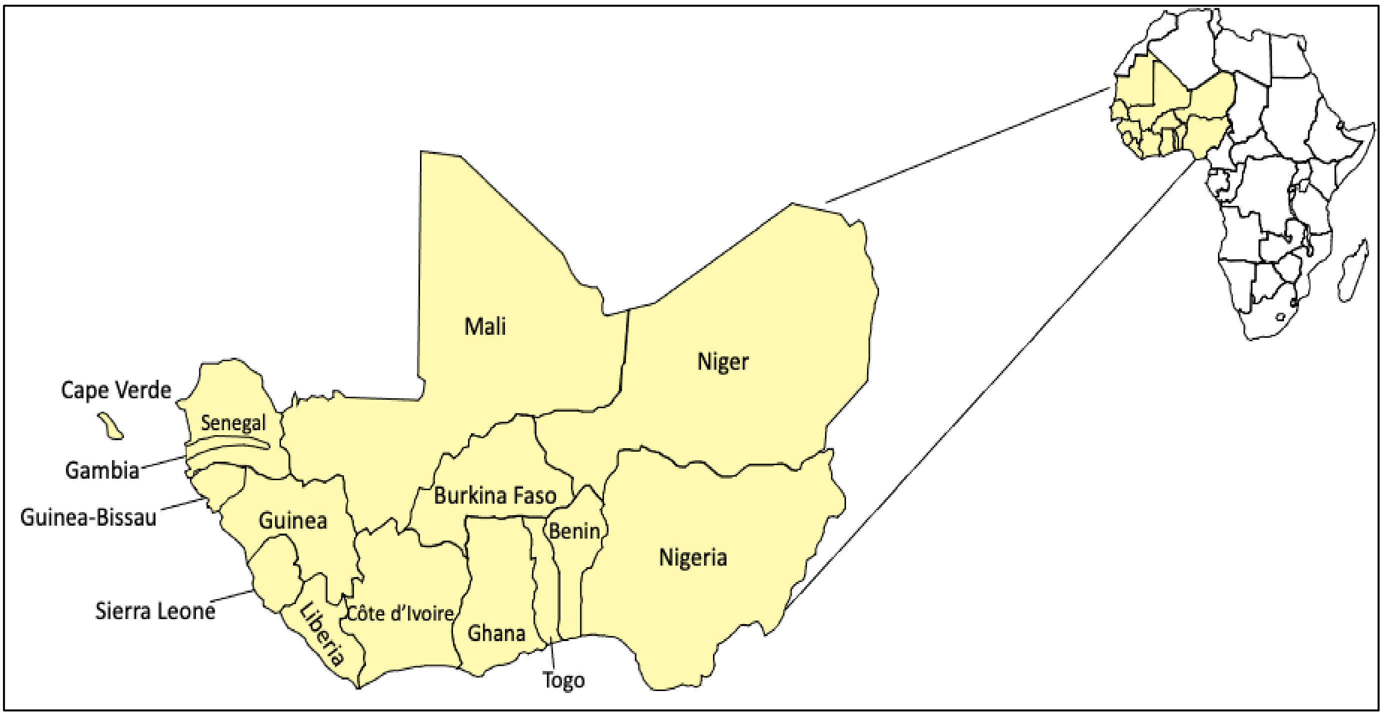

Figure 2. 1 Map of West Africa Showing ECOWAS Member States

Source: Author's Own.

The region is rich in energy resources, holding one-third of Africa's fossil fuel reserves, including an estimated 23,000 Megawatt (MW) of hydroelectricity capacity (Bazilian et al., 2013; Ofusu-Peasah, Antwi and Blyth, 2021; World Bank, 2021). The region is also endowed with renewable energy resources, including solar energy and hydropower potentials (Cole, Elliot and Strobl, 2014). Countries like Guinea, Nigeria and Ghana possess the region's largest share of hydroelectricity potential (Adeoye and Spataru, 2020). Crude oil and natural gas resources are located primarily in Nigeria, Ghana, Côte d'Ivoire, and Niger and are used to supply liquefied petroleum gas (LPG) across the region (WAPCo, 2021; Merem et al., 2017). However, despite the substantial energy resources in the region, West Africa still struggles to achieve energy security for its population (IEA, 2019; Ofusu-Peasah, Antwi and Blyth, 2021). The region ranks amongst the most deprived regions regarding access to modern energy, particularly electricity and clean cooking fuels (UN, 2014; World Bank, 2020). Additionally, grid-based electrification and the adoption of clean cooking fuels have progressed slowly in the region due to numerous challenges discussed in the following sections. These energy challenges are notably worse in Nigeria, the most populous country in the region, with approximately 85 million lacking access to electricity, affecting sectoral sustainable development and quality of life (IEA, 2021). Similar challenges persist across West Africa, with rural areas disproportionately affected by unreliable energy infrastructure and limited access to affordable, clean energy sources (ECREE, 2016; IEA, 2017).

Therefore, integrating renewable energy into the household energy consumption mix could be a viable solution to the energy challenges in West Africa. West Africa's abundant solar resources and technologies in wind, biomass, and small-scale hydropower could offer substantial potential to meet household energy needs sustainably (Obada et al., 2024). However, the integration of these technologies is slow within the region, resulting in a heavy dependence on conventional energy resources that contribute to climate change. Before formally discussing the integration of renewable energy into household energy in West Africa, it is crucial to examine the region’s energy dynamics. This includes assessing the rate of electrification, patterns of energy use in domestic activities (electrification and cooking) and the human behaviour towards current energy choices within the region. Understanding these factors is crucial for identifying the relevant factors that drive household renewable energy adoption in West African households.

2.2.1. Electrification in West Africa

Drawing from the previous section, West Africa has abundant renewable and non-renewable energy resources, yet the region remains one of the most energy-deprived regions globally (IEA, 2022). In most West African countries, the electricity sector cannot supply sufficient electricity to meet household demand, as only about 42% of households within the region have access to electricity, with rural areas having only an 8% electrification rate (IEA, 2019). These energy supply deficiencies hinder socio-economic development and increase the level of poverty and social inequalities (Cassti et al., 2023). To address these energy challenges, regional agencies such as the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) developed policies to integrate renewable energy into the current energy mix in the region. However, despite these initiatives, the region continues to experience a shortage of electricity supply and a slow adoption towards renewable energy integration.

Electricity in the region is mainly generated from centralised hydropower stations and transported via transmission networks and distribution lines to urban cities and rural villages (Gnansounou et al., 2007; Bissiri et al., 2020). But electricity generation via grid-based infrastructure in West Africa is plagued with a myriad of challenges, including ageing infrastructure, low system reliability, unpredictable hydrological conditions, vandalism, lack of investment opportunities, low generation capacity, dependence on fuel imports, reliance on fossil fuels and traditional biomass fuels (Gnansounou et al., 2007; Auth et al., 2014; Cervigni et al., 2015; Emodi and Yusuf, 2015; Adeoye and Spataru, 2018). These challenges threaten energy security within the ECOWAS region and inhibit electricity generation capacities for the region. With a generation capacity of 12GW, the peak demand for 14 ECOWAS member states stood at 25.6GW in 2018, showing a gap between electricity generation and demand (Adeoye and Spataru, 2018). This gap between electricity generation and demand is further intensified by high levels of technical losses, which significantly impact the rate of access to electricity for the region's population (Auth et al., 2014).

At present, just about 42% of the region's population has access to electricity, with only about 8% of the region's rural population having adequate access to electricity (IEA 2019; Adeoye and Spataru, 2020). Recent studies show that approximately 174 million people in West Africa lack access to electricity, contributing to household socio-economic challenges, as depicted in Figure 2.2 (Adeoye and Spataru, 2019).

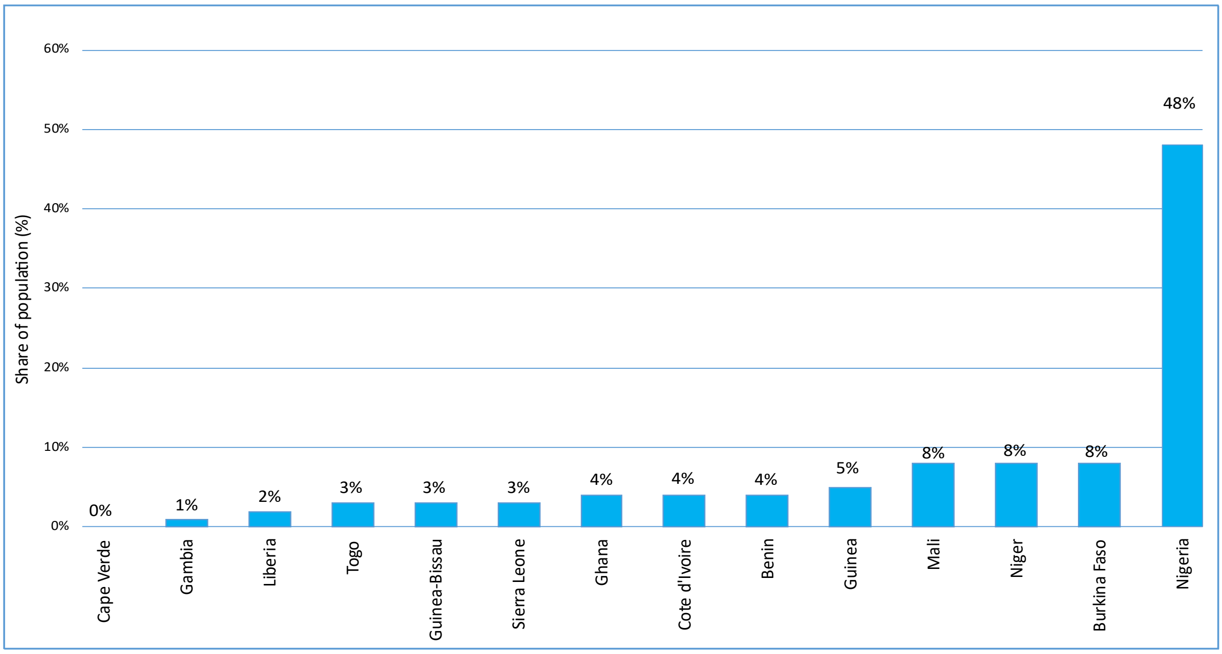

Figure 2. 2 Share of the Population Lacking Access to Electricity by ECOWAS Member States

Source: IEA (2019) and World Bank (2020).

This low access to electricity results in repeated power outages and electricity rationing that adversely affect sustainable development across all regional sectors (Kojima and Trimble, 2016; Maman and Yu, 2021). Most households within the region rely on generators that run on diesel and other heavy fuels to generate electricity for various economic and household activities (Ayodele et al., 2019). Country-level estimates within the ECOWAS regions show significant disparities between electricity access in rural areas compared to urban areas (Bissiri et al., 2020; Longa and Zwaan, 2021). In most ECOWAS countries, current grid systems only cover urban cities, leaving rural and remote villages without access to electricity, as shown in Figure 2.3 (Longa and Zwaan, 2021).

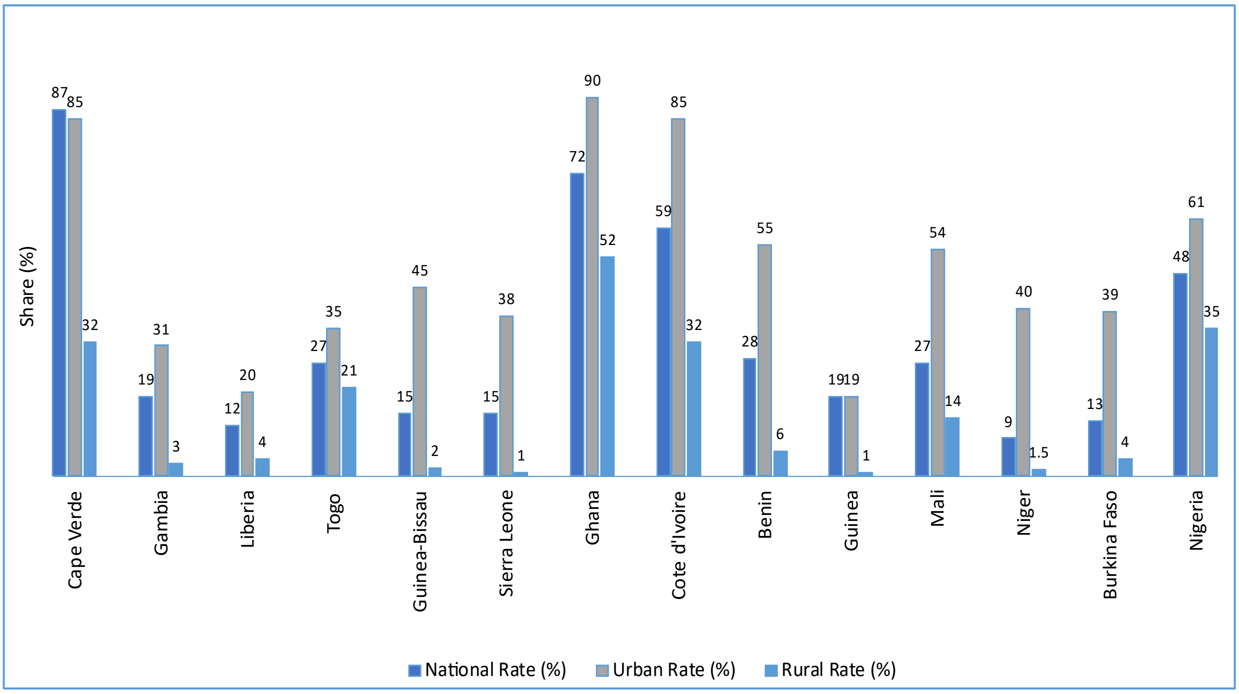

Figure 2. 3 Urban vs Rural Electrification Rates in the ECOWAS Region

Source: ECREE (2016) and IEA (2017).

Therefore, this shows that electrification through the current grid system within the region cannot ensure efficient electricity supply for households, resulting in an urgent need for renewable alternatives.

2.2.2. Cooking Fuel Use in West Africa

Cooking and electrification activities account for the highest share of energy use in West Africa, with almost 86% of the households relying on solid fuel (mainly charcoal and firewood) as the primary cooking fuel, as indicated in Table 2.1 (Auth et al., 2014). Country-level estimates show that countries such as Mali, Liberia, Guinea-Bissau, and Sierra Leone have approximately 98% reliance on charcoal and firewood as the primary cooking fuel for households (Adewuyi and Awodumi, 2017).

Table 2. 1 Population Depending on Solid Fuel in West Africa – 2018

Countries	**Population depending on solid fuel (Million)**	**% of the population using solid fuel in the general population**
Cape Verde	<1	0.18%
Gambia	2	87.7%
Liberia	2	98.2%
Togo	3	88.7%
Senegal	7	48.8%
Guinea-Bissau	2	98.0%
Guinea	13	97.8%
Burkina Faso	17	86.2%
Cote d'Ivoire	18	77.4%
Mali	19	98.0%
Niger	21	97.5%
Ghana	22	74%
Nigeria	178	80%

Source: IEA (2019) and World Bank (2021).

Table 2.1 reveals the high reliance on solid fuel (mainly charcoal and firewood) in West African countries. In summary, nine out of the eleven ECOWAS member states have over 80% of their population depends mainly on solid fuels. In comparison, between 74% and 77.4% of the population in two member states rely on solid fuels (Ghana and Cote d'Ivoire) with only Cape Verde having <1% of its population relying on solid fuels as cooking fuels. The lack of access to clean fuels in West Africa has had negative impacts on the environment, life, and health of the population within the region, particularly affecting women and children (Acheampong, Dzator and Shabaz, 2021; Frempong, Orkoh and Kofinti, 2021; IEA, 2019).

According to the IEA, lack of access to clean cooking fuels acts as a barrier to the social and economic development of women and children in developing countries because they spend more time gathering firewood and are responsible for cooking activities (ESMAP et al., 2020; WHO, 2021; Das, Pradhan and Nonhebel, 2019). The effects of reliance on solid fuels in West Africa also contribute to health challenges for people relying on these fuels. Findings from the literature show rising cases of various respiratory diseases resulting from exposure to household air pollution when using solid fuels (Dagnachew et al., 2020; Bachelor et al., 2019; Schlag and Zuzarte, 2008). Therefore, this indicates the health burden of household air pollution from solid fuel consumption within the ECOWAS region. The following sections present insight into the health and environmental implications of solid fuel reliance in ECOWAS member states.

2.2.3. Implications of Solid Fuel Dependence in West Africa

The World Health Organisation (WHO) reports that exposure to household air pollution significantly increases the risk of pneumonia in children, accounting for 50% of deaths in children under five due to lower respiratory infections (Oluwafemi et al., 2016; WHO, 2021). Further estimates suggest that approximately one-quarter of deaths from acute lower respiratory diseases are linked to household air pollution caused by using solid fuels for cooking. Additionally, burns and physical fatigue from using these fuels present further health risks (WHO, 2017; WHO, 2021; Deng et al., 2021; Lelieveld et al., 2015).

In the ECOWAS region, where the population stands at 334.6 million, about 77.1% (257.8 million people) are exposed to air pollution, particularly particulate matter (PM2.5) from cooking with solid fuels such as charcoal, animal waste, and firewood. This exposure results in around 173,396 deaths annually, with half of these fatalities being children (Troeger et al., 2018; Carrión et al., 2019). The impact is particularly severe in rural areas, where many households are off-grid, poor, and unable to afford cleaner alternatives like liquefied petroleum gas (LPG) or electric cookers (Merem et al., 2017; Ayodele et al., 2019). Approximately 90% of the population in these areas relies on solid fuels for cooking, as shown in Table 2.2 (Newell et al., 2021; Gafa and Egbendewe, 2021; Dagnachew et al., 2020).

Table 2. 2 Urban and Rural Reliance on Solid Fuel in ECOWAS States, 2018

Countries	**Urban (%)**	**Rural (%)**
Cape Verde	11	72.5
Gambia	91.1	>94
Liberia	>98	>98
Togo	>93	>94
Senegal	17.4	84.8
Guinea-Bissau	>98	>98
Guinea	>94	>94
Burkina Faso	81.8	97.2
Cote d'Ivoire	64.2	>95
Mali	>98	>98
Niger	>98	>98
Ghana	74.5	>86
Nigeria	40.8	>90

Source: IEA, (2021).

Table 2.2 demonstrates that in ECOWAS member states, the proportion of rural households relying on solid fuels for cooking is equal to or greater than that of urban households. This trend is consistent across the region, with rural areas showing a significantly higher dependence on solid fuels than urban centres. However, the table also indicates that many urban households in ECOWAS countries continue to rely on solid fuels for cooking, except for those in Cape Verde, Senegal, and Nigeria, where solid fuels are less prevalent.

Similarly, West Africa, as a rapidly developing region, has witnessed significant environmental and socio-economic changes in recent decades (Herrmann et al., 2020). A significant concern has been the loss of forest cover, which has accelerated because of overexploitation for fuel production (Skutsch and Ba, 2010). The unsustainable harvesting of wood for firewood and charcoal to meet cooking needs has led to widespread forest degradation (Doua-Bi et al., 2021; Balima et al., 2021; Failler et al., 2020). Between 1975 and 2013, forest cover in West Africa decreased by 37%, with Côte d'Ivoire alone losing about 60% of its forests (22,000 square kilometres) during this period (CILLS, 2016). Research indicates that the reliance on solid fuels for cooking, combined with population growth and unreliable electricity supply, exacerbates environmental degradation in the region (Steffan et al., 2015; Newell et al., 2021). The continued use of charcoal and firewood contributes to deforestation, soil erosion, biodiversity loss, and climate change (McLean, Hur, and Whang, 2021). Bond et al. (2013) highlight that charcoal and firewood usage accounts for 60%-80% of Africa's carbon emissions, contributing to global warming.

2.3. Energy Situation in Nigeria

2.3.1. Overview of the Energy Landscape in Nigeria

Commonly known as the giant of Africa, Nigeria is a country located in the Western part of Africa along the Gulf of Guinea, bordering Cameroon in the east, Benin Republic in the west, Niger in the north and Chad in the northeast (See Fig. 2.1). While the Southern part of the country lies by the Gulf of Guinea on the Atlantic Ocean (Oj0su, 1990). The country lies within latitudes $4^0 32'$ N and 14^0 North and longitudes $2^0 72'$ E and $14^0 64'$ East, covering a total land area of approximately 923,768 square kilometres (sq km), with a terrain that varies appreciably from tropical rainforest and coastal swamps in the south to semi-desert and savannah in the Northern part (Ojosu, 1990).

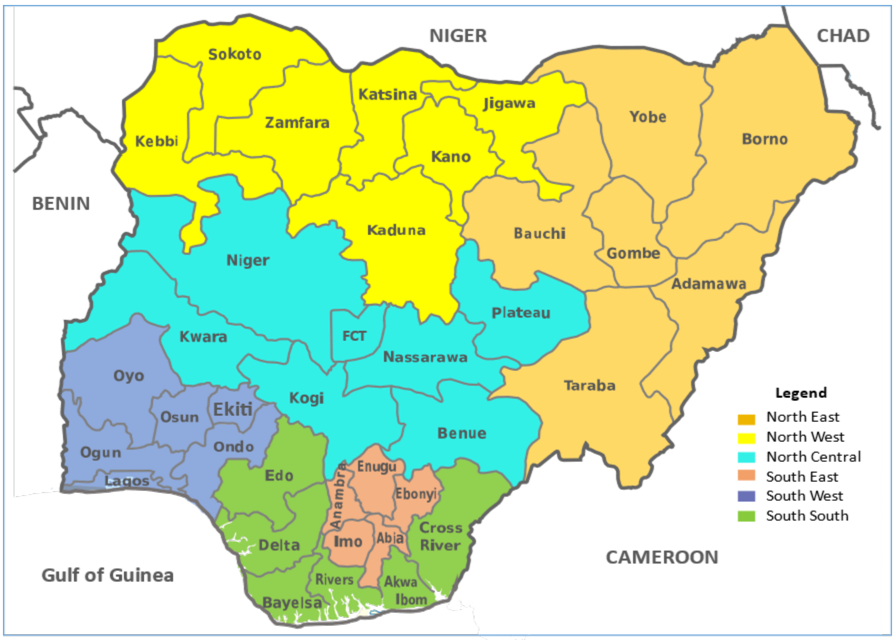

Figure 2. 4 Map of Nigeria

Source: Authors Generated.

With an estimated population of about 193,392,517 people as of 2017, Nigeria stands as the most populous country in Africa, with an annual population growth rate of about 3% (National Bureau of Statistics, 2018). Being the most populous country in Africa, Nigeria boasts substantial energy reserves, comprising both conventional (non-renewable) and non-conventional energy (renewables) resources, which makes the country a significant regional player in Africa and a key player in the global energy market (Okolie et al., 2019).

The energy resources abundant in the country are mainly categorised into non-renewable fossil fuel energy resources and renewable energy resources. The Non-renewable fossil fuel energy resources abundant in Nigeria include crude oil, tar sands, natural gas, nuclear power, and coal. Renewable energy resources in the country comprise wind, solar, hydropower (large and small hydropower), and biomass energy, as presented in Tables 2.3 and 2.4, which show an estimate of both non-renewable fossil fuel energy resources and renewable energy resources and their potential in Nigeria.

Table 2. 3 Fossil Fuel Energy Reserves and Their Potentials in Nigeria

Resource Type		**Reserves**	**Production**	**Consumption**
Non-renewable Fossil fuel	Crude oil	37.1 billion barrels	2.5 million barrels/day	450,000 barrels/day
	Natural gas	187 Tcf (trillion cubic feet)	6 billion Tcf	75.7% reinjected for crude oil production, gas lift and industries. 24.3% flared into the atmosphere
	Coal	2.7 billion tonnes	0	0
	Tar sands	31 billion barrels of oil equivalent	0	0.224 million tonnes
	Nuclear	Not assessed	0	0

Source: Sambo. (2010).

Table 2. 4 Renewable Energy Reserves in Nigeria

Resource Type		**Reserves**	**Production**	**Consumption**
Renewable energy	Solar	4.0 kWh/m²/day – 6.5 kWh/m²/day	6 MWh/day	An estimated 15MW solar PV installed nationwide
	Wind	2-4m/s at 10m height mainland	0	37 non-grid operational wind turbines
	Large Hydropower	11,250 MW	64.2 MW	64.2 MW exploited
	Small Hydropower	3,500 MW	1938 MW	1938 MW exploited
	Biomass Sewage waste	N/A	N/A	N/A
	Firewood	11 million hectares (ha) of forest lands	0.120 million tons/day	43.4 million tons/yr
	Animal waste	245 million assorted animals	0.781 million tons/day	0
	Energy crop residue	28.2 million hectares of cultivable land	8.2% cultivate; 0.256 million ton of assorted crops/day	0
	Agricultural residue	91.4 million ton/yr	91.4 million ton/yr	0

Source: Shaaban and Petinrin. (2014).

Clearly, from the Nigerian energy reserves presented in Tables 2.3 and 2.4, it is evident that Nigeria has abundant fossil fuel and renewable energy resources, making the country assert its position as a significant player in the global energy market. Proven crude oil reserves in the country are currently at 37.1 billion barrels, making Nigeria the second country in Africa with the largest crude oil reserves and ranking tenth with the world's largest crude oil reserves (Okolie et al., 2019).

According to the Central Bank of Nigeria (CBN, 2015), Nigeria gained a credible position in the global energy market by being the sixth-largest producer of crude oil in the world in 2015 and, in that same year, the fourth-largest exporter of natural gas globally. Natural gas reserves in the country currently stand at 187 trillion cubic feet, which makes Nigeria the ninth country in the world with the largest natural gas reserves and, as such, makes Nigeria an important gas province in the world (CBN, 2015). Other fossil fuel energy resources in Nigeria include tar sands, which are estimated to contain 31 billion barrels of oil equivalent, and coal, which has an estimated 2.7 billion tonnes of coal reserves. In addition to the large fossil fuel reserves in the country, Nigeria also has an ample quantity of renewable energy resources spatially distributed across the country. Solar energy is in abundance in Nigeria due to the location of the country that lies within a sunshine region with a solar potential averaging about 4.0kWh/m^2/day (equivalent of 12.6MJ/m^2/day) to 7.0 kWh/m^2/day (equivalent of 25.2 MJ/m^2/day) in the southern and northern parts of the country respectively (Idris et al., 2013). Solar radiation is widely distributed across most parts of the country, with an average sunshine of about 4.0 hours/day to 9.0 hours/day (Ogunmodimu and Okoroigwe, 2019). Therefore, it suggests the potential benefit of solar energy in Nigeria as an alternative energy source.

Furthermore, other renewable energy resources abundant in the country include wind energy, which has an average wind potential of 10m above the mainland, varying from 2.3 m/s to 3.4 m/s in the coastal areas and 3.0 m/s to 4 m/s in semi-arid and high land areas of the country (Ajayi, 2009 and Ajayi, 2010). Hydropower, which constitutes both large hydropower (LHP) and small hydropower (SHP), has a renewable energy potential of 11,250 MW and 3,500 MW, respectively. While biomass (non-fossil organic matter) such as firewood amounts to 11 million hectares (ha) of forestlands, animal waste, 245 million of assorted animals in 2001, and 28.2 million hectares of arable energy crops. These ample energy reserves assert Nigeria's position and importance in the global energy market and represent potential for sustainable development in Nigeria. Likewise, it creates the possibility of meeting the energy needs of the country.

Despite the country's energy reserves, Nigeria remains highly energy-deficient in terms of energy supply. It does not meet the growing energy demand of Nigeria’s growing population and rapidly developing economy. Hence, resulting in about 50% (over 96,000,000 people) of Nigerians lack access to modern energy, particularly electricity, combined with 80% of the population lacking access to clean cooking fuels and efficient cooking stoves (Gungah, Emodi and Dioha, 2019). Consequently, this deficiency in energy supply has resulted in frequent power rationing and recurrent blackouts, causing many households, industries, and businesses to rely on privately owned generators that use fossil fuels (petrol, diesel, and kerosene) to perform business and industrial activities. This is made worse by the fact that many households are also adopting firewood and charcoal to perform various domestic activities. This creates vast sustainability concerns regarding the fuel components in the Nigerian energy consumption mix. Most of the country’s households, businesses, and industries rely on conventional energy resources and traditional solid biomass fuels for energy consumption.

Therefore, it is evident that non-renewable energy resources, such as crude oil and natural gas, combined with combustible solid biomass fuels such as firewood and charcoal, dominate the Nigerian energy mix. These fuels are the primary fuels used to meet the energy demand of Nigeria's industrial, transportation, and household sectors. However, extant studies have proved that the unrestrained combustion and utilisation of fossil fuels and solid fuels have been considered major contributors to global climate change through the emission of greenhouse gases (GHG) and other pollutants that have detrimental effects on the environment and human health (Chafe et al., 2014, Akintan, Jewitt and Clifford, 2018; Kibria et al., 2019). Therefore, this underscored the need for Nigeria to find sustainable alternatives to mitigate fossil fuel dependence and introduce cleaner forms of energy into the country’s energy mix.

2.3.2. Nigerian Energy Mix

Nigeria is significantly unrivalled in terms of energy reserves when compared to other African countries. Therefore, it is unsurprising that energy exports constitute a fundamental source of revenue for the country (Ayadi, 2005; EIA, 2016). Statistics show fossil fuel energy resources, particularly crude oil and natural gas exports, account for approximately 83% of Nigeria's gross export revenue (OPEC, 2018). In 2014, crude oil and natural gas exports generated an estimated $87 billion as export revenue for the Nigerian economy, representing about 95% of Nigeria's export commodities (CBN, 2015; EIA, 2016). Therefore, crude oil and natural gas are the most dominant energy sources for energy generation in Nigeria's energy mix. As of 2005, the share of crude oil in the Nigerian energy mix was 57%, while natural gas and hydropower were 36% and 7%, respectively. Whereas the share of other fossil fuel resources (coal, tar sands), nuclear energy and renewable energy resources was insignificant in the country's energy mix, as the government is yet to access and harness other forms of energy into its energy mix (Oyedepo, 2014).

Contrary to the significance of crude oil in the Nigerian energy mix, its percentage share in the country's energy mix declined from 57% in 2005 to 21% in 2016, while natural gas gained the largest share of about 51.5% and hydropower stands at 27% in terms of energy generation in 2016 (SEforALL, 2016). However, despite the decrease in the share of crude oil in the Nigerian energy mix, fossil fuel energy sources (crude oil and natural gas) still account for the largest share of energy sources in the country's energy mix (72.5%). Therefore, this indicates an economy heavily dependent on fossil fuels for revenue and energy generation. As a result, the Nigerian economy is more susceptible to economic instability due to fluctuations in oil prices (Baek, Ikponmwosa and Choi, 2019). This is further worsened by the finite nature of fossil fuel resources and concerns over climate change, primarily driven by the emissions of GHG from the combustion of fossil fuels and the use of solid fuels for various household activities (Emodi et al., 2022). Therefore, fostering the need for interventions that will encourage the introduction of clean, modern alternatives into Nigeria's energy mix and facilitate a change in household energy consumption behaviour to minimise the health risks associated with conventional energy consumption.

2.3.3. Nigerian Energy Consumption Trends

Like in most countries, energy in Nigeria is considered a fundamental asset required for sustainable development. Growth in key economic sectors in any country is hinged on the amount and type of energy resources, energy infrastructures, and energy services utilised (Bekun, Emir, and Sarkodie, 2019). Therefore, the sustainable supply and consumption of efficient energy resources and services with improved access to clean cooking fuels fosters economic growth and human development.

In Nigeria, the types of primary energy resources consumed vary significantly from fossil fuels (crude oil, natural gas, and petroleum products) to solid fuels (firewood and charcoal) and renewable energy resources (solar, wind and hydropower). Energy consumption in the country spreads across various economic sectors in Nigeria, but the household sector accounts for the highest share of final energy consumption in the country compared to other sectors (see Figure 2.5) (Oseni, 2012; SEforALL, 2016).

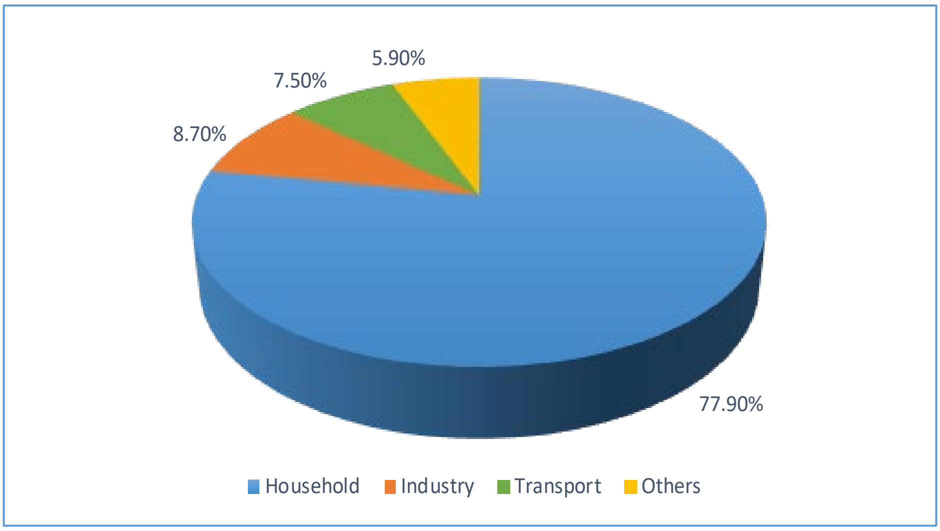

Figure 2. 5 Final Energy Consumption by Economic Sectors in Nigeria 2014

Source GIZ. (2015).

The household sector in Nigeria accounts for approximately 68% - 86% of the final energy consumed in Nigeria, and this is mainly due to rising population growth rates, increased rural migration to urban cities and slow development in other economic sectors (Oyedepo, 2014). Like in most developing countries, despite the abundant primary energy resources available in Nigeria, fossil fuels and solid fuel energy in the form of crude oil, natural gas, firewood, charcoal, and other biofuels account for the largest share of energy resources consumed in the country.

Despite the abundance of crude oil, natural gas and renewable energy reserves in Nigeria, solid biomass fuels, particularly firewood and charcoal, account for approximately 80% of the total primary energy consumed, representing about 99.3 million tonnes of oil equivalent (Mtoe) annually (SEforALL, 2016; Mohammed et al., 2017). Therefore, since the household sector has the highest share of final energy consumed in the country (see Fig. 2.2), it is evident that almost 90% of the 99.3 Mtoe of final energy consumed annually is consumed by the household sector. Hence, this implies that solid biomass fuel (firewood and charcoal) accounts for almost all the energy consumed in Nigeria's household sector. This creates serious sustainability concerns associated with deforestation and acute respiratory infections since the consumption rate of firewood and charcoal exceeds the rate of replanting of trees in Nigeria (Olarinde and Adeniran, 2018). Given a population of over 200 million people with an annual population growth rate of about 3%, almost 99% of this population uses energy mainly for cooking activities (Bisu et al., 2016). However, households' energy use in Nigeria is also used to perform other domestic activities such as lighting and operating electrically powered household appliances like refrigerators, televisions, fans, air conditioners, etc. However, since cooking accounts for the highest share of household energy use, most of the final energy consumed in most Nigerian households is used for cooking activities.

The energy sources required for cooking activities in Nigeria are diverse, as fuels like firewood, charcoal, kerosene, LPG, and electricity are used for cooking activities in households (National Bureau of Statistics, 2017). However, due to inadequate access to clean cooking fuels in Nigeria, most households rely solely on traditional fuels (firewood and charcoal) for cooking

(National Bureau of Statistics, 2017). Sadly, this situation has a detrimental effect on the ecological balance in Nigeria as about 80% of the Nigerian population (approximately 154,714,013 million people) depend heavily on firewood and charcoal for cooking activities (Bisu et al., 2016). This has resulted in the overexploitation of Nigeria's forestlands to provide enough wood to meet the energy demands of the country's rising population. Figure 2.6 illustrates Nigeria's final energy consumption by resources, showing the high percentage of solid biomass fuel usage within the country's energy consumption mix.

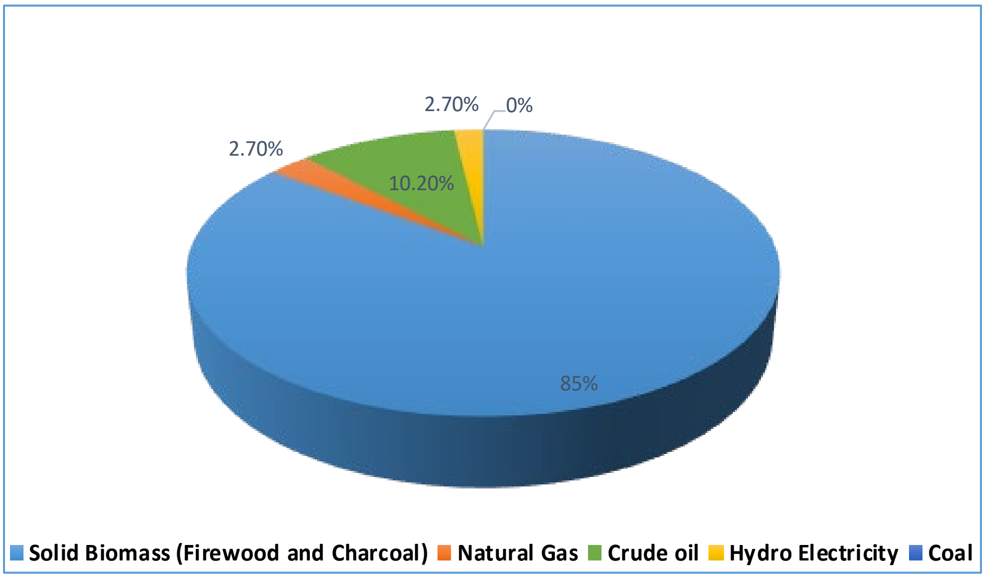

Figure 2. 6 Nigeria's Final Energy Consumption by Resource in 2013.

Source: GIZ, (2015).

The preceding discussion confirms that traditional fuels like firewood and charcoal hold a staggering share of the final energy sources consumed in Nigeria. In rare circumstances, other fuel sources such as sawdust, crop residue (cassava sticks), and animal waste are also utilised in households for domestic purposes, particularly for cooking activities. This consumption pattern presents unique challenges for households in Nigeria's urban and rural communities. But the challenge of inadequate access to clean energy is notably worse for rural dwellers, as rural communities have significantly lower access to modern cooking fuel like liquified petroleum gas (LPG) due to the unavailability of LPG stations in rural communities, high prices and low-capacity grid systems, poor road networks and unreliability of electricity supply.

This challenge has resulted in an almost 90% dependency on firewood and charcoal for rural dwellers, combined with reduced purchasing power for most rural dwellers, who often use firewood or charcoal and other fuels like kerosene at very high prices (Williams, 1998; Gungah, Emodi, and Dioha, 2019). This seriously threatens the energy security of rural dwellers, who are often poor and have Nigeria's lowest per capita income rates (Akinbami, 2001; Oyedepo, 2014).

This situation is similar regarding access to electricity, as electricity supply varies significantly between rural and urban households in Nigeria (see Figure 2.7). The percentage of urban dwellers having access to electricity exceeds that of rural dwellers. Recent estimates show that about 86% of urban households now have access to electricity compared to only 39% of rural households (Nwaka, Uma and Ike, 2020). Therefore, many rural households are disadvantaged in accessing modern energy sources. Therefore, it incites the need for sustainable alternatives such as renewable energy to ensure energy security and diversified energy sources.

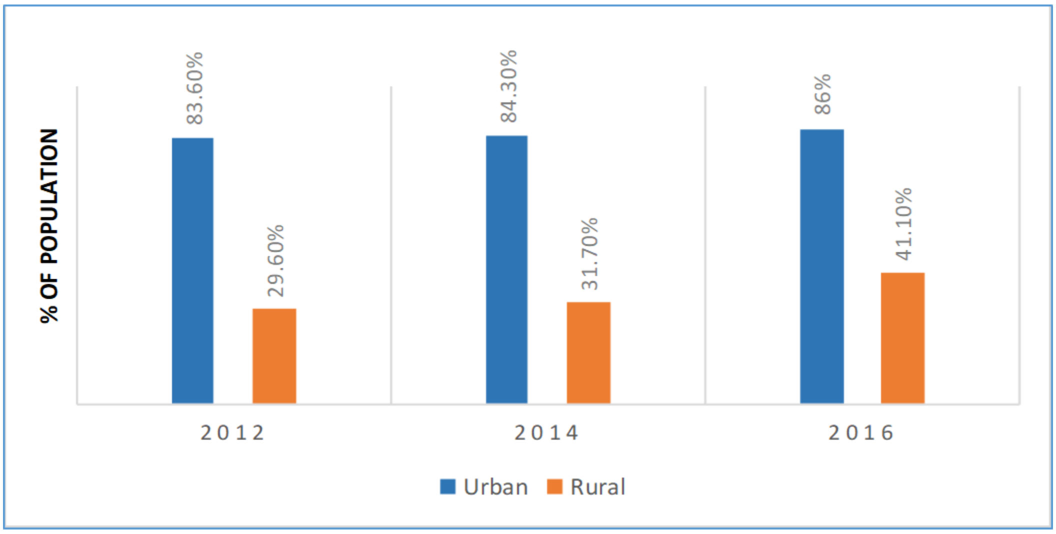

Figure 2. 7 Electricity Access between Urban and Rural Habitats in Nigeria.

Source: Sustainable Energy for All (SEforALL, 2019).

2.3.4. Implications of the Current Energy Consumption Trends in Nigeria

The energy consumption trends discussed above reveal that combustible solid biomass fuels, such as firewood and charcoal, dominate Nigeria's energy mix. This dependence raises significant environmental and health concerns, particularly related to climate change, deforestation, desertification, and the health risks associated with exposure to smoke from cooking with these fuels. The overreliance on firewood and charcoal for basic household activities, especially cooking, has led to serious health issues and increased pressure on Nigeria's forests (Babanyara, Usman, and Saleh, 2010). For example, current energy consumption patterns in Nigeria have resulted in various environmental issues, including rapid deforestation, desertification, and household air pollution (Babanyara, Usman, and Saleh, 2010). These problems stem from the heavy reliance on fossil fuels and solid biomass fuels. The combustion of these fuels emits greenhouse gases such as carbon dioxide (CO^2), nitrous oxide (N_2O), methane (CH_4), and particulate matter ($PM_{2.5}$), all of which contribute to air pollution and global warming (Nwofe, 2013). Studies have shown that the demand for firewood and charcoal for household cooking has driven deforestation, placing Nigeria among the countries with the highest deforestation rates worldwide, at around 5% annually (Fanosa et al., 2018). On average, 410,000 hectares of forest were lost annually between 2010 and 2015 (Fanosa et al., 2018).

Despite attempts to address this issue, Nigeria’s forest cover has declined. At the beginning of the 20th century, Nigeria had approximately 600,000 square kilometres of forest. Still, recent estimates suggest less than 6% of this remains (Figure 2.8), with only 38,000 square kilometres of forest cover left (Olanrewaju, Tilakasiri, and Bello, 2018). The high rate of deforestation has led to desertification, soil erosion, and a temperature increase of 1.1°C. These long-term effects highlight the need for a shift towards cleaner cooking fuels to reduce the reliance on firewood and charcoal in Nigerian households.

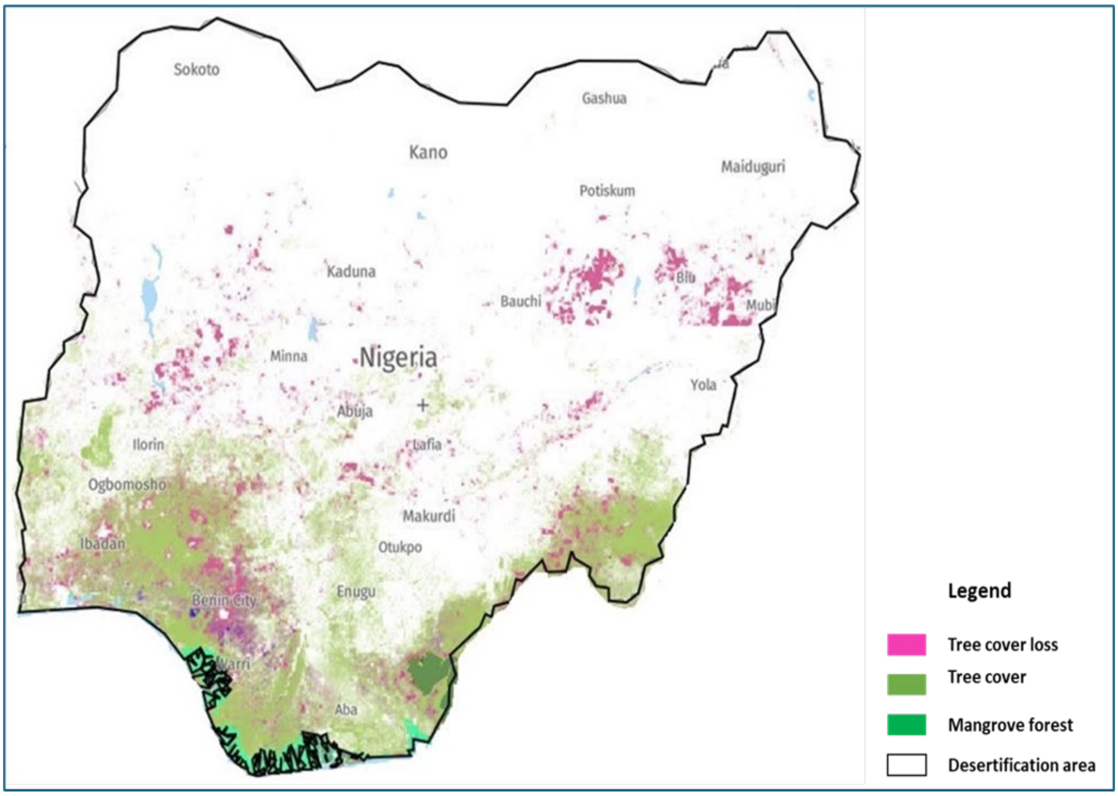

Figure 2. 8 Features of Deforestation and Tree Cover Loss in Nigeria.

Source: Global Forest Watch (2016).

Similarly, solid biomass fuels, which account for almost 80% of Nigeria's total energy consumption, pose serious health risks. Alongside the environmental consequences, the health hazards associated with using firewood in households are significant. According to the International Energy Agency (IEA, 2017), using inefficient cooking stoves with firewood in poorly ventilated spaces leads to household air pollution (HAP). This exposure to smoke and particulate matter ($PM_{2.5}$) contributes to Acute Respiratory Infections (ARI) such as bronchitis, pneumonia, and bronchiolitis and can even result in premature death (Chafe et al., 2014).

The Clean Cooking Alliance (2019) reports that approximately 64,600 deaths occur annually in Nigeria due to household air pollution, with over 23,000 child deaths resulting from exposure to particulate matter ($PM_{2.5}$). The health burden is disproportionately borne by women and children, who are typically responsible for gathering firewood and managing household cooking activities (Lim et al., 2013). Studies from Dutta et al. (2018) and Alexander et al. (2017) further emphasise that household air pollution has a more severe impact on women and children, leading to stillbirths, low birth weights, miscarriages, and other adverse pregnancy outcomes. These environmental and health impacts underscore the urgent need for Nigeria to transition towards cleaner, more sustainable energy sources for household use.

2.4. Summary

This chapter discusses the energy situation in West Africa with a particular focus on Nigeria. The chapter presented an overview of the energy landscape with 15 member states of the ECOWAS region. It highlights that the region possesses a range of energy resources, from fossil fuels to renewable energy resources such as solar energy and hydroelectricity. The chapter highlights that Nigeria, an ECOWAS member state, has an abundance of renewable energy and non-renewable energy resources but faces severe energy challenges due to fossil fuel dependence, ageing energy infrastructures and a slow transition to clean, modern energy. Therefore, Nigeria struggles with meeting the energy demands of its population, which is combined with the negative environmental and health implications of the current energy consumption patterns. The chapter stresses the need for a shift towards renewable energy alternatives to meet household energy demands, ensure energy security and mitigate the health and environmental risks resulting from the consumption of conventional energy resources.

Chapter 3. Household Renewable Energy Integration in West Africa and Nigeria

3.1. Introduction

Access to clean and modern forms of energy plays a pivotal role in achieving several UN Sustainable Development Goals (SDGs), including Goal 7 – Affordable and Clean Energy, Goal 5 – Gender Equality, Goal 3 – Good Health and Wellbeing, and Goal 1 – No Poverty (Chowdury and Naz, 2023; Ofori et al., 2023; Jeevanasai et al., 2023). However, about 58% of West Africa's population lacks access to clean, modern energy sources. In comparison, almost 80-90% of households in the region rely on solid fuels like charcoal and firewood for cooking, resulting in adverse environmental and health implications (IEA, 2019; Adjei-Mantey et al., 2023). To successfully integrate renewable energy into household energy consumption, there is a need for a comprehensive understanding of the factors that drive household energy choice, including the barriers to renewable energy adoption in West African households. Against this backdrop, this chapter begins with an overview of household renewable energy integration in West Africa, focusing on Nigeria as the most populous country in the region. This is followed by an extensive review of the household renewable energy adoption and its potential contribution to household energy access. The chapter ends with a discussion of the renewable energy policies aimed at encouraging household renewable energy adoption.

3.2. Overview of Household Renewable Energy Integration in West Africa

West Africa, a fast-developing region, experiences power outages and recurrent blackouts, which negatively impact the social and economic well-being of households within the region. This has resulted in an increased effort to improve the energy situation and increase access to clean, modern energy in the region, which will, in turn, improve the quality of life of its population (Ali and Qian, 2021). As of 2020, the electricity rate stood at 51%, but over 175 million households within the region remained without access to electricity, with about 85% of rural households still lacking access to electricity (Ackah and Graham, 2020). To address these challenges, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE)

Agency was established to promote regional integration of renewable energy sources into households. The ECREEE further developed the ECOWAS Renewable Energy Policy (EREP), which all ECOWAS member states adopted to increase the share of renewable energy such as wind, solar, biomass and small hydro into household energy mix to 10% by 2020 with a target of reaching 19% by 2030 (ECREEE, 2024a). The EREP policy led to considerable gains in integrating renewable energy into West African households, as about 1.8% of grid-based electricity generated in 2017 was from renewable energy sources (IEA, 2019). Recent estimates indicate that stand-alone renewable energy technologies and mini-grid solutions could supply electricity to 25% of households in the ECOWAS region, particularly those in rural areas, reaching 71.4 million households by 2020 and 104 million by 2040 (Ali and Quan, 2021).

The ECREE continues to play a key role in promoting renewable energy integration in West Africa, focusing on expanding access to electricity for underserved households and supporting the achievement of UN SGD goal 7. One key initiative of the ECREE is the formation of the ECOWAS Renewable Energy Facility (EREF), which provides funding for renewable energy – wind, solar and hydroelectricity development in rural areas within the region (Bokoro and Kyamakya, 2023). To advance the achievement of UN SDG 7 (Access to Clean and Affordable Energy), the ECOWAS Gender Mainstreaming in Energy Access Program (ECOW-GEN) was launched in 2013 (Maduekwe et al., 2019). This initiative addresses energy access challenges with a focus on gender equality (UN SDG 5), recognising that current household energy use in the region disproportionately affects women and children (Bagdi et al., 2023; Acheampong et al., 2024). Women and children in most West African households are primarily responsible for domestic tasks like gathering firewood for cooking (Acheampong et al., 2024). Therefore, they face increased vulnerability under current energy practices, which limit their socio-economic development opportunities (Amadu et al., 2022). Thus, the ECOW-GEN aims to tackle these gender-based disparities in energy access in West Africa. Additionally, the World Bank, in collaboration with the West African Development Bank (BOAD) and ECOWAS, jointly developed the Regional Off-Grid Electrification Project (ROGEP) to expand household electricity access using stand-alone solar systems (World Bank, 2019). Other initiatives include the ECOWAS Small-Scale Hydro Power Programme, ProCEM (Promotion of Climate-Friendly Cooking Energy Systems) and the West African Clean Energy Corridor (WACEC), all focused on promoting the integration of clean cooking fuels, large- and small-scale renewable energy resources into the household energy consumption mix in West Africa (ECREEE, 2024b). These initiatives and programmes show the efforts undertaken to solve the energy challenges in West Africa and promote access to clean, modern energy through the development of renewable energy technologies in the region.

The initiatives and projects discussed above indicate the potential benefits of renewable energy resources in solving some of the energy challenges experienced in the region. For example, Domegni and Azouma (2022) highlighted that integrating renewable energy resources, particularly solar energy, could reduce the cost of electricity for households via subsidised electricity tariffs from local renewable energy power plants. Solar energy could also increase the reliability of the electricity supply and improve economic activities, especially for women and girls who are often marginalised in West African societies (Gill-Wiehl, Ferrall and Kammen, 2022). Furthermore, renewable energy integration could promote energy justice for rural households and ensure inter- and intra-generational equity, reflecting on the renewable energy potentials in West Africa (see Table 3.1 and Figures 3.1) (Dong et al., 2023). These efforts aim to promote the integration of renewable energy sources into the household energy mix, which will, in turn, reduce the number of households without access to electricity in West Africa.

Table 3. 1 Solar Potential in West Africa

Countries	**Solar Potential (kWh/m²/day)**	**Wind Speed (m/s²)**
Cape Verde	4.89-5.68	1.3-4.1
Gambia	5.60-5.74	5.4-6.7
Liberia	4.62-4.98	1.9-3.4
Togo	5.00-6.15	2.3-3.2
Senegal	5.49-5.97	4.6
Guinea-Bissau	5.46-5.57	3.1-3.8
Guinea	5.02-5.66	2.0-3.4
Burkina Faso	5.57-6.15	1.4-2.7
Cote d'Ivoire	4.63-5.61	1.9-3.4
Mali	5.64-6.45	2.1-4.6
Niger	5.69-6.73	1.9-4.6
Ghana	4.02-6.07	2.2-3.5
Nigeria	3.69-6.29	2.0-3.5
Sierra Leone	4.74-5.34	2.2-3.2
Benin	4.89-5.68	1.3-2.7

Source: Adopted from Gyamfi et al. (2018), Abdelrazik et al. (2022), and Gunnel et al. (2023).

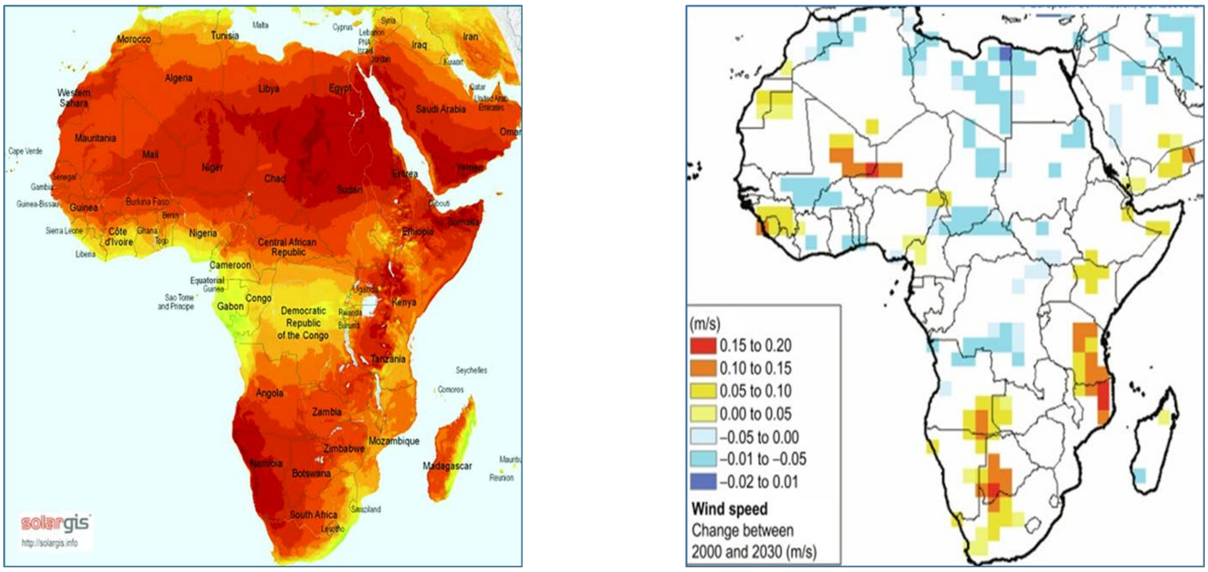

Figure 3. 1 Solar Potential and Wind Potential in West Africa

Source: Gunnell et al. (2021); Solagris. (2021).

However, the share of renewable energy in the region's household energy consumption mix is one of the lowest in the world (Espoir, Sunge, and Bannor, 2023). As such, this indicates underlying challenges in regional households' renewable energy adoption process in West Africa, resulting in the need for research into the barriers hindering renewable energy development and integration within the region.

The question of whether to adopt renewable energy as a solution to West Africa’s current household energy crisis remains open. This is because renewable energy adoption does not merely involve replacing non-renewable sources with renewable sources. Instead, renewable energy adoption involves a complex interplay of multiple factors, including social, political, cultural, economic, behavioural, and environmental factors (Geels et al., 2017; Sovacool, Hess and Cantoni, 2021). This requires a comprehensive understanding of the factors and challenges to household renewable energy adoption to assess the likelihood of households transitioning to renewable energy in West Africa. Recent studies suggest that renewable energy adoption for West African households offers potential energy cost savings, improves energy security and enhances household well-being. However, the adoption process faces several unique challenges (Espoir, Sunge, and Bannor, 2023). These challenges include socio-economic, political, policy, financial and human challenges, which complicate efforts to achieve a successful transition to renewable energy for households (Mutezo and Mulopo, 2023; Cantarero, 2020; Mirza et al., 2024; Bissiri et al., 2020; Brunet et al., 2022). Examining these challenges in the next section is crucial in assessing the potential benefits of household renewable energy integration in West Africa.

Given the above barriers to household renewable energy integration in West Africa, the severity of these barriers varies between countries in the region due to the sociocultural, demographic, geographical and political peculiarities in West Africa (Gafa and Egbendewe, 2021). Suggesting that households in different West African countries will face unique challenges and opportunities in relation to renewable energy integration, energy demand and consumption patterns. For example, Senegal, a low-middle-income country (LMIC) in the Sahel region of West Africa with grassland vegetation and many pastoralist households, relies mainly on animal waste as cooking fuel (Garcia et al., 2023). Meanwhile, Togo, a humid coastal country in West Africa with adequate wood forest vegetation, relies mainly on firewood for cooking (Mang-Benza et al., 2023). Therefore, this highlights the peculiarities in household energy demand and use in West Africa. However, this research focuses on Nigeria, the populous country in West Africa. Nigeria is representative of the peculiarities in West Africa due to its diverse socio-cultural background, economic activities, energy resources, population size, and climatic conditions. Nigeria's vegetation zones closely resemble those of many West African countries, with mangroves and rainforests in the southern regions and savanna vegetation, comprising Guinea, Sudan, and Sahel savannas, spanning the central and northern parts of Nigeria (Orijemie, Franca and Sowunmi, 2024). As a result, Nigeria serves as a valuable case study for understanding the complexities of household renewable energy adoption and integration in West Africa.

3.3. Overview of Household Renewable Energy Integration in Nigeria

Integrating renewable energy into the current household energy mix is crucial for West African countries, particularly Nigeria, due to the high dependence on fossil fuels for domestic household energy use (Mohsin et al., 2022). Nigeria is the largest economy in Africa, but continues to struggle to provide a clean, modern and reliable energy supply for its citizens (World Bank, 2024; Somoye, 2023). As discussed earlier, about 40% of households in Nigeria lack access to electricity, coupled with 75% of the population relying on solid fuel to meet their cooking energy needs (Somoye, 2023). This low access to clean, modern energy is made worse by a growing population, which creates a rise in energy demand in Nigeria (Dioha and Emodi, 2019). Despite the availability of renewable and non-renewable energy resources in Nigeria, the accessibility of energy to households is not commensurate with Nigeria's rising household energy demand. Consequently, this leads to a heavy reliance on diesel and petrol generators for household electricity generation and solid biomass like charcoal and firewood for cooking energy needs (Amzat, 2021).

Several studies have highlighted that the incomplete combustion of these fuels contributes to the emission of GHGs, environmental degradation and the acceleration of the impacts of climate change (Dagnachew et al., 2020; Mperejekumana et al., 2024). Extant studies also indicate that households in West African countries like Nigeria are primarily low-middle-income countries and are more vulnerable to the impact of climate change due to their dependence on conventional energy resources (Monyei, Akpeji and Oladeji, 2022; Pokubo, Pepple and Al-habaibeh, 2024). This vulnerability presents an urgent need for a shift towards cleaner, renewable energy fuels for household use in Nigeria. To address this challenge, the Nigerian government have set up policies to encourage household energy adoption towards renewable energy sources. The Nigerian government have set an ambitious target of achieving 90% access to electricity and replacing 80% solid fuel cookstoves by 2030 (SEforALL, 2016).

Further, to achieve the targets set above, the Nigerian government, through various agencies, have undertaken some renewable energy projects at the community level to integrate renewable energy into the household energy consumption mix. For example, the Nigerian Federal Ministry of Power (FMOP) and the Energy Commission of Nigeria (ECN) have developed several stand-alone and mini-grid renewable energy initiatives in various communities across Nigeria. Recently, the Jinko Powerhouse mini-grid solar farm (196 kWh - 100H inverter) was commissioned in Etomi community in Cross River state to power about 800 homes in the community (FMOP, 2024). Additionally, the Rural Electrification Agency (REA) in Nigeria in 2021 developed a 1.35MW solar hybrid power project to serve households in the southern part of Nigeria (REA, 2021). Since 2017, the REA has commissioned various solar power solutions projects in the six geopolitical zones of the country. The aim of these projects is to assess whether renewable energy could be a viable solution to the household energy challenges across various local communities in Nigeria.

The Nigerian government, through the Rural Electrification Agency (REA), recently launched the Economic Sustainability Plan (ESP) to mitigate the impact of COVID-19 and expand energy access in off-grid communities (REA, 2020). The ESP aims to deliver five million new solar connections, providing electricity to approximately 25 million people through Solar Home Systems (SHS) or mini-grid solutions (REA, 2020). Additionally, the plan seeks to boost local content in the off-grid solar value chain and generate 250,000 jobs within the Nigerian energy sector (REA, 2020). As part of this initiative, the REA is implementing the 5 million Solar Homes Scheme, a key programme designed to provide affordable and sustainable electricity to rural and underserved areas (REA, 2020). This initiative forms a vital component of Nigeria's broader efforts to increase energy access and promote renewable energy adoption nationwide. By leveraging solar power, the scheme aims to enhance energy reliability, reduce dependence on fossil fuels, and stimulate economic growth in remote communities. Furthermore, it aligns with Nigeria's renewable energy targets and commitment to sustainable development, as outlined in its national energy policies.

Although there have been considerable gains in the commissioning of various renewable energy projects in Nigeria, its impact on influencing household renewable energy adoption is still at a slow pace in the country. This raises concerns about how household renewable energy technologies, policies, and strategies are developed and implemented to drive household energy adoption in Nigeria. As mentioned earlier, the process of transitioning to renewable energy sources does not merely involve replacing non-renewable sources with renewable sources and varies between countries globally (Sovacool, Hess and Cantoni, 2021). For instance, in developed countries like France and the United Kingdom, where robust governmental policies and frameworks support energy adoption decisions, energy supply is mainly provided by energy suppliers (Whittle, Jones and While, 2020; Lamnatou, Cristofari and Chemisana, 2024). However, households in these countries are encouraged to install solar panels through the Feed-In-Tariff Scheme (FIT), which reduces the energy bills of households, and households receive payment for any excess energy produced and transmitted back to the national grid (Castaneda et al., 2020; Ofgem, 2024). This scheme promotes renewable energy utilisation at a household level in developed countries.

In contrast, households in low-middle-income countries like Nigeria are responsible for their energy choices due to limited government support to encourage the adoption of cleaner fuels (Oyeniran and Isola, 2023). This presents deep-rooted socio-economic, demographic, behavioural and cultural challenges to household renewable energy integration in Nigeria (Debnath et al., 2021). Additionally, the lack of robust governmental policies and a strong institutional framework in Nigeria hinders the achievement of the target of 90% access to electricity and replacing 80% of solid fuel cookstoves by 2030. Therefore, overcoming the above challenges requires an in-depth understanding of what renewable energy adoption entails, the factors that influence household energy adoption and household perception of renewable energy adoption. Gaining an in-depth knowledge of energy adoption, the diverse factors that influence it and household perception of energy adoption is crucial for Nigeria. Such understanding is necessary to deliver tailored approaches to energy adoption that recognise Nigeria's unique regional landscapes. There is a significant lack of information on household renewable energy adoption in Nigeria. Addressing this gap is one of the key contributions this study aims to make to the existing literature on household energy adoption in the country.

3.4. Current Status of Household Renewable Energy Integration in Nigeria

Household energy use is critical to global efforts to decarbonise current energy systems and achieve key UN Sustainable Development Goals (SDGs), including ensuring access to affordable and clean energy, promoting gender equality, and alleviating poverty (Pan et al., 2023). In Nigeria, the household sector accounts for the largest share of the total energy consumed in the country (see Figure 3.2) (IEA, 2022). This energy use primarily consists of traditional solid fuels for cooking and fossil fuel-powered generators for electricity generation, contributing to household air pollution (Atedhor, 2023). Therefore, it is suggested that cleaner fuels such as renewable energy sources and electricity be adopted to reduce household air pollution.

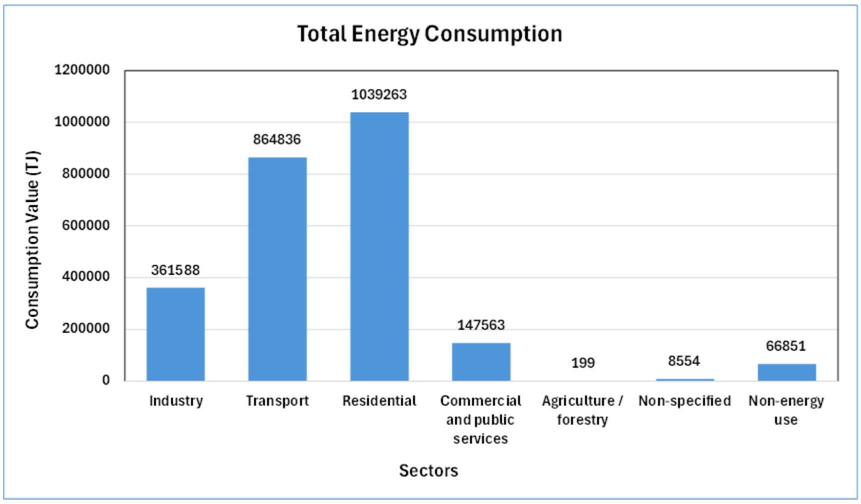

Figure 3. 2 Sectoral Final Energy Consumption in Nigeria

Source: Reproduced from (IEA, 2021).

The shift towards renewable energy sources has led to a significant change in the Nigerian energy sector. The country demonstrated its commitment to reducing its carbon footprint by signing up to the Paris Agreement in 2016 and the United Nations COP26 summit in 2021, underscoring its pursuit of transitioning to renewable energy technologies for households (Ogbonna, 2023). Nigeria also developed policies to encourage household renewable energy adoption and achieve a carbon-neutral economy by 2060. Examples include the National Renewable Energy and Energy Efficiency Policy (NREEEP) 2015, the National Adaptation Strategy and Plan of Action for Climate Change in Nigeria (NASPA-CNN) 2021 and the Nigeria Energy Adoption Plan 2022.

However, despite these policies and being the largest economy in West Africa with abundant energy resources, Nigeria continues to have one of the lowest electrification rates in the region (Tete et al., 2023). Nigeria's current electricity supply is insufficient to meet demand, with an estimated potential of 12,533 MW of electricity generation capacity, yet only about 4,500 MW is available for a population of over 200 million people (Adewuyi et al., 2020; Adoghe et al., 2023). The country's peak electricity generation of 5,400 MW in 2019 still falls far short of the estimated national demand of approximately 20,000 MW (Adewuyi et al., 2020). This shortfall has forced many households to rely on fossil fuel-powered generators, contributing to Nigeria's rising CO_2 emissions.

Around 96% of Nigerian households (approximately 192 million people) rely on traditional biomass fuels such as firewood and charcoal for cooking, further exacerbating environmental degradation through deforestation and increased carbon emissions. To address this challenge of electricity shortfall, Nigerian households frequently switch or alternate between different energy sources to meet their needs (Shari et al., 2022). Understanding this switching behaviour is often analysed through two prominent models: the Energy Ladder Model and the Energy Stacking Model (see Figures 3.3 and 3.4).

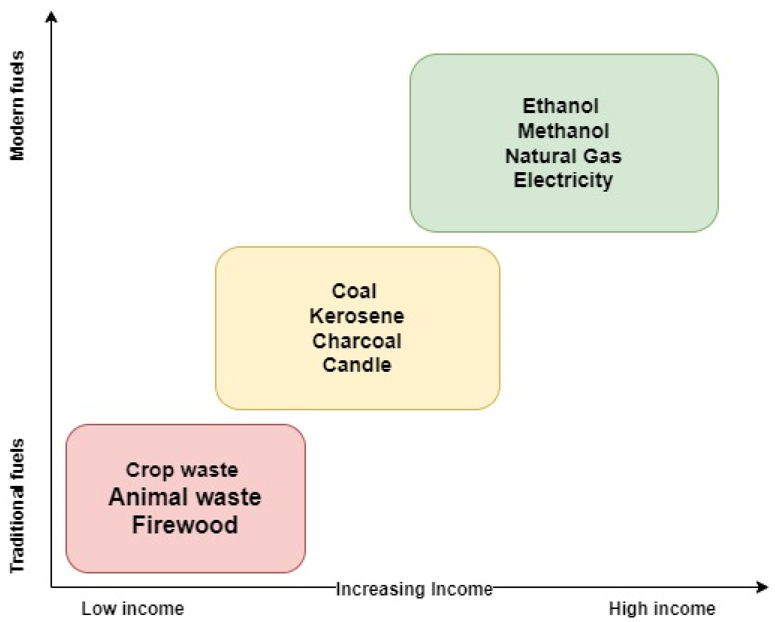

Figure 3. 3 Energy Ladder Model

Source: Reproduced from (Masera, Saatkamp, and Kammen, 2000).

The energy ladder model depicted in Figure 3.3 suggests that as households experience socioeconomic improvement, they move from traditional fuels to modern, cleaner ones in a linear, upward progression. This implies that with rising income, households are expected to move away from biomass fuels towards cleaner alternatives like liquefied petroleum gas (LPG) or electricity. However, this model has been criticised for oversimplifying household energy adoption, as it assumes that income is the sole driver of energy choice (Yadav, Davies, and Asumadu-Sarkodie, 2021; Heltberg, 2005). The model does not account for other socio-economic factors that may influence energy choices, such as fuel availability, cultural preferences, and government policies.

In response to these limitations, the energy stacking model (Figure 3.4) offers a more comprehensive explanation of household energy adoption behaviour in Nigeria. This model suggests that households do not transition in a linear fashion, but instead, they use a combination of traditional and modern fuels to meet their energy needs. For example, a household may use firewood for cooking while relying on electricity for lighting and refrigeration. The energy stacking model acknowledges the influence of multiple factors, such as fluctuating fuel prices, seasonal fuel availability, accessibility, convenience, and policy interventions, in shaping household energy decisions (Masera, Saatkamp, and Kammen, 2000).

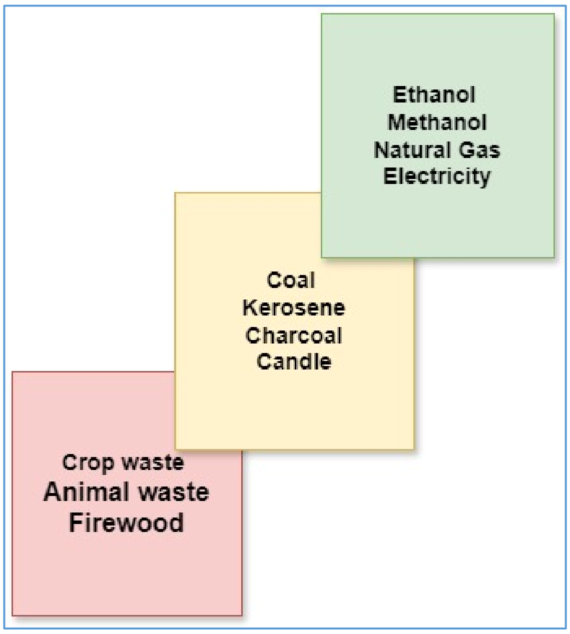

Figure 3. 4 Energy Stacking Model

Source: Reproduced from (Masera, Saatkamp, and Kammen, 2000).

The model further indicates that instead of the internal socioeconomic characteristics of households influencing household energy adoption behaviour alone, the presence of other external drivers, such as the price of fuel, regional cultural settings and institutional economic forces, drive household energy choices (Van der Kroon, Brouwer and van Beukering, 2013; Eludoyin and Lemaire, 2021). Nigerian households will often follow the energy ladder model, gradually transitioning from traditional biomass fuels to modern fuels as their socio-economic status improves (Baiyegunhi and Hassan, 2014; Nwaka, Uma, and Ike, 2020; Oyeniran and Isola, 2023). However, recent studies suggest that this progression is not always straightforward. Oyeniran and Isola (2023) and Emodi et al. (2022) found that some Nigerian households have experienced a reverse adoption, moving back to traditional biomass fuels. This reverse adoption is often attributed to declining household incomes, rising unemployment, and other socio-economic pressures that limit access to modern energy sources. This finding challenges the linear assumption of the energy ladder model, demonstrating that a complex interplay of factors beyond income alone shapes household energy adoption in Nigeria.

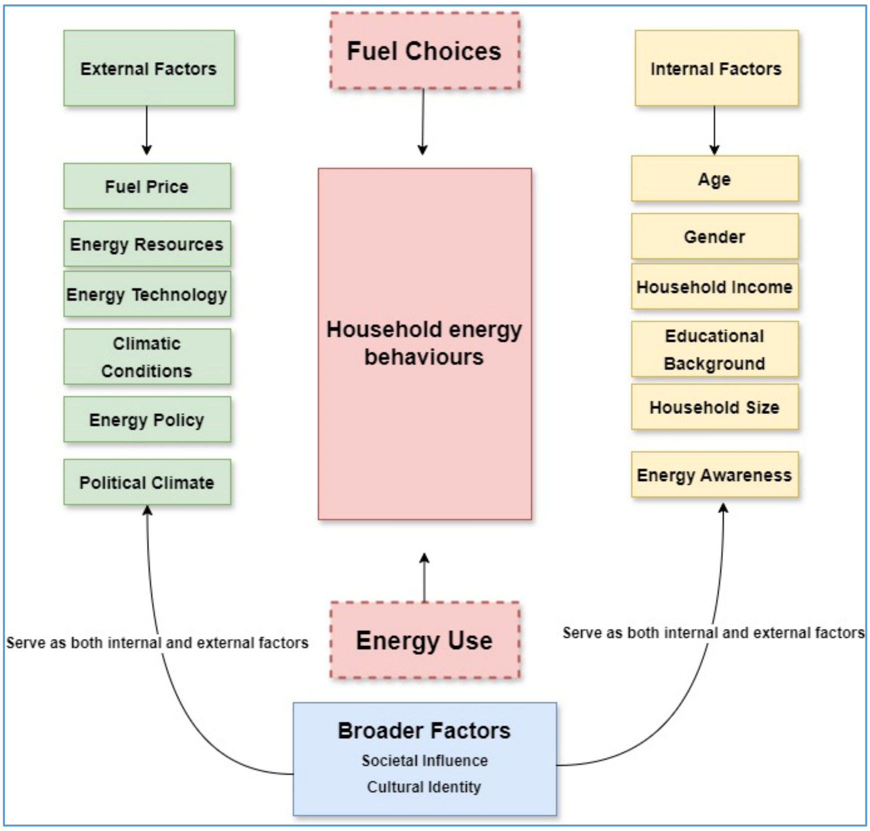

Figure 3. 5 Summary of the Key Factors Driving Household Energy Behaviour in Nigeria

Source: Reproduced from (Eludoyin and Lemaire, 2021; Elasu et al., 2023)

This stacking behaviour shows the prevalence of multidimensional factors, such as macroeconomic conditions and political factors, influencing household energy consumption behaviour. This stacking behaviour often serves as a means of survival for households with irregular incomes, safeguarding them against volatile energy markets while maintaining their cultural practices and also benefiting from the use of modern fuels (Akintan, 2014; Van der Kroon, Brouwer, and van Beukering, 2013).

In Nigeria, energy stacking is a common practice, with households using a mix of traditional and modern fuels based on availability, affordability, and accessibility. Studies have shown that households across income levels rely on a diverse portfolio of energy sources, including firewood, charcoal, kerosene, LPG, and electricity (Oyeniran and Isola, 2023; Kowsari and Zerriffi, 2011). For example, Maconachie, Tank, and Zakariya (2009) found that even middle-income households preferred firewood and charcoal over LPG for cooking due to the fluctuating prices of oil and limited access to LPG stations. This trend highlights the importance of considering multiple factors, such as fuel availability, price, and convenience, when analysing household energy adoption in Nigeria.

3.4.1. Implications of Nigeria's Household Energy Switching Behaviour

Nigeria's household energy switching behaviour, discussed in section 3.4, shows the dominance of energy stacking patterns and a reverse movement down the energy ladder to high-polluting fuels. This behaviour poses various challenges for policymakers in relation to their efforts to encourage renewable energy integration into Nigerian households (Adelaja, 2020). Suggesting that their efforts must recognise the various factors influencing household energy consumption behaviour. Drawing from these complexities in Nigeria's household energy consumption behaviours, future policy development must reflect the dynamics of household energy consumption behaviours (Painuly, 2001; Adelaja, 2020). This requires addressing the socioeconomic, political, financial and infrastructural barriers that hinder households from adopting renewable energy sources (Eludoyin and Lemaire, 2021). The Energy Ladder and Energy Stacking models (see Figures 3.3 and 3.4) provide an in-depth insight into understanding household energy transition in Nigeria. Yet, these models also highlight the need for an adoption process that considers economic, social, political and human factors at play (Van der Kroon, Brouwer and van Beukering, 2013; Kowsari and Zerriffi, 2011). Therefore, future government efforts and policy interventions should focus on solving the challenges of fuel availability and affordability of clean, modern fuels, including solar energy and LPG, for electricity and cooking use.

3.5. Barriers to Household Renewable Energy Integration in Nigeria

The current state of household energy adoption in Nigeria reflects a multi-faceted challenge where socioeconomic factors, political factors, energy availability, and policy constraints intersect (Adewuyi et al., 2020; Magazzino, Drago and Schneider, 2023). While there has been progress in renewable energy adoption at the policy level, the practical realities of household energy behaviour indicate a need for more targeted interventions. Extant studies highlight the challenges involved in switching energy systems, adding that these challenges arise from the long-term utilisation of familiar energy sources and technologies (Bouzarovski and Petrova, 2015; Sovacool et al., 2020). Qadir et al. (2021) suggested that identifying the challenges and barriers to integrating renewable energy sources in households is essential for developing targeted interventions to promote the integration of renewable energy sources. These barriers are often classified into different categories, ranging from socio-economic, financial, policy, political, institutional, cultural and psychological barriers. However, this study seeks to identify and examine the barriers to renewable energy adoption in Nigeria, a country characterised by its heavy reliance on crude oil exports and fossil fuel derivatives for energy generation and consumption. The following section examines the barriers to renewable energy integration in Nigerian households.

3.5.1. Socio-Economic Barriers

Socio-economic challenges such as income level, lack of economic diversification, unemployment, inequality, inflation, and poverty hinder households' ability to adopt renewable energy (Jewitt, Atagher, and Clifford, 2020; Gyamfi et al., 2018). Despite Nigeria's renewable energy potential (see Table 2.4), the country remains heavily reliant on non-renewable energy sources, particularly fossil fuels (Yunusa et al., 2024). As one of the largest oil producers in Africa, fossil fuels – crude oil continues to be Nigeria's most significant export commodity and a key source of revenue, thus complicating efforts to shift towards renewable energy adoption (Nalule, Anaman and Acheampong, 2022; Okoh, 2020; Okoh and Okpanachi, 2023). Fossil fuel resources, mainly crude oil, have been a significant driver of economic growth in the country, thus creating a bias against renewable energy integration on a macroeconomic level (Okoh and Okpanachi, 2023; Esmaeili et al., 2024). For example, electricity generation in Nigeria is heavily reliant on natural gas-powered plants, which poses serious challenges. Therefore, reducing fossil fuel consumption in the country's energy mix could threaten short-term economic growth, especially for sectors dependent on fossil fuels (Adeniyi and Isah, 2023).

The country's poverty levels further worsen this socioeconomic challenge, as over 80 million Nigerians live below the $1.90-a-day poverty line (World Bank, 2022). This presents affordability challenges as most households in the country cannot afford renewable energy technologies. The country's per capita energy consumption remains one of the lowest globally, with rural households most affected (Mgazzino, Drago and Schneider, 2023). Approximately 80% of rural households lack access to electricity, coupled with over 90% reliance on solid fuels, particularly firewood and charcoal, in rural areas (Somoye, 2023). Therefore, the poverty levels and economic situation of most Nigerian households, often characterised by low income and unemployment, limit the likelihood of adopting renewable energy despite its benefits. As a result, most households perceive their current energy sources, such as diesel or petrol generators and traditional fuels like firewood, charcoal, and kerosene, as being more available and affordable than renewable energy sources (Eludoyin and Lemaire, 2021; Pokubo, Pepple and Al-habaibeh, 2024). These socio-economic challenges of lack of economic diversification, income, quality and poverty have continued to make renewable energy adoption difficult for most households across the country. Consequently, this creates conflicting interests between maintaining economic growth through crude oil exports and addressing energy poverty by expanding access to clean, affordable modern energy (Nwozor et al., 2021). Therefore, this highlights the complexity of integrating renewable energy in Nigeria.

3.5.2. Financial Barriers

Financing renewable energy projects is one of the key barriers to integrating renewable energy into Nigeria's current energy mix (Adelaja, 2020; Akinbami, 2001). The high initial costs of investing in renewable technologies, such as solar panels, batteries, and infrastructure development, which are significant for harnessing Nigeria's significant solar potential, present major challenges, particularly in the early stages of development (Gyamfi et al., 2018). To achieve SDG 7 targets in Nigeria, the country would need an estimated $410 billion invested in the renewable energy sector by 2060, with an initial investment of $10 billion in the first year of implementation (Okoh and Okpanachi, 2023). Therefore, the substantial initial investment required to develop renewable energy resources makes providing renewable electricity in households more expensive, especially during the early phases of development (Ugwu, Ozor and Mbohwa, 2022). Thus, achieving widening access to clean, modern, and affordable energy for all households in Nigeria would require active engagement and participation from all stakeholders across the energy sector in the country.

Financial constraints are the most significant barriers to renewable energy adoption in Nigeria, where households are mainly responsible for providing their energy (Oyeniran and Isola, 2023). The high cost of installing renewable energy systems makes the adoption process more challenging. For example, Akuru et al. (2017) highlighted that installing a residential Rooftop Solar PV system would cost approximately $2,200. Given that 80 million Nigerians live below the $1.90-a-day poverty line, such an investment is unaffordable for most households in the country. Despite the vast renewable energy potential in Nigeria, particularly solar energy, to address the country's energy deficit, the high upfront costs of purchasing and installing these technologies make renewable energy inaccessible to many households, especially in rural areas (Adelaja, 2020; Akinbami, 2001). Also, the lack of incentives and affordable financing options, such as Feed-In-Tariff schemes or government loans found in developed countries, makes renewable energy adoption incredibly challenging for low-income households affected by energy poverty (Cantarero, 2020; Mperejekumana et al., 2024).

In addition to the high initial costs, Nigeria's energy market is distorted by extensive fossil fuel subsidies (Ozoegwu and Akpan, 2021; Adelaja, 2020). These subsidies on fossil fuels, particularly petroleum products like diesel and kerosene, are more financially attractive to consumers than renewable alternatives (Aliyu, Modul and Tan, 2018; Adeyanju et al., 2020). While subsidies make energy more affordable, the subsidies on fossil fuels have long undermined the competitiveness of renewable energy in the Nigerian energy market, discouraging investment in cleaner options (Matallah et al., 2023). This situation prolongs the dominance of non-renewable sources in Nigeria's energy mix despite renewable energy's long-term environmental and economic benefits.

3.5.3. Policy and Political Barriers

Policy and political barriers, such as a lack of political will and politicians' vested interests, hinder households' ability to adopt renewable energy in Nigeria (Timiyan, 2022). Nigeria's energy sector and policies have historically focused on achieving energy security using fossil fuels and hydropower plants, with limited emphasis on renewable energy (Oyedepo, 2012; Oyedepo, 2014; Nwozor et al., 2021). Additionally, the lack of supportive policies like the Feed-In-Tariff Scheme and problems with household metering further discourage households from transitioning to renewable energy options (Oyeniran and Isola, 2023). Changes in Nigeria's political landscape and inconsistent support for renewable energy projects have led to uncertainties, deterring long-term investment opportunities (Akuru et al., 2017).

Moreover, the country's dependence on crude oil revenue has always created a deep-rooted resistance to renewable energy policy development due to an economy largely dependent on fossil fuels (IEA, 2020; Oyedepo, 2012). The oil and gas industry in the country has been accused of hindering the implementation of effective renewable energy policies, thereby slowing down the achievement of widening access to clean, modern and affordable energy for all Nigerians (Adeyanju et al., 2020; Adeniyi and Isha, 2023). This shows a lack of political will to develop and implement effective regulatory frameworks, policies and incentives that will encourage household adoption from conventional energy sources to renewable energy options. In fact, Akuru et al. (2017) and Adeyanju et al. (2020) argue that barriers to household renewable energy integration are neither socio-economic nor socio-technical, but instead mainly political, suggesting that corruption and vested interest within the political class hinder renewable energy adoption in Nigeria. For example, since the privatisation of the electricity sector in Nigeria, fraudulent practices have been reported in the sector, negatively impacting the industry from electricity generation and transmission to household distribution (Obiorji and Iwuoha, 2022). Bribing government officials for licences or producing high-estimated bills for unmetered customers are some of the fraudulent activities plaguing the electricity sector in Nigeria (Adoghe et al., 2023; Roy et al., 2023). While these issues of unethical billing and metering challenges mainly affect households, with a population of over 200 million people, the scale of these problems has a significant deteriorating impact on the sector, hindering the integration of renewable energy into the household electricity consumption mix (Ogunleye, 2017; Roy et al., 2023).

3.5.3. Human Behavioural and Cultural Barriers

Behavioural and cultural barriers are significant drivers of household energy adoption towards renewable energy in any country. These barriers focus on individual or household behaviours and perceptions towards shifting from conventional fuels such as kerosene, firewood, and charcoal to cleaner alternatives like solar, wind and biomass energy (Sovacool et al., 2020). However, global attention on carbon neutrality and renewable energy adoption has largely focused on socio-economic challenges, overlooking the role of household culture and behaviours in achieving carbon neutrality (Acheampong, Opoku and Dogah, 2023). This study addresses this gap by examining how household perceptions and cultural factors impact renewable energy adoption in Nigeria, which is discussed in subsequent chapters.

From section 3.4 above, most Nigerian households, whether rural or urban, do not progress up the energy ladder in a linear motion to cleaner fuels but rather reverse back to conventional and traditional fuels (See Figures 3.3 and 3.4) (Oyeniran and Isola, 2023; Emodi et al., 2022). The reason for this behaviour is mainly due to some socio-economic challenges like fossil fuel subsidies, household income level, inflation and unemployment (Jewitt, Atagher, and Clifford, 2020). In Nigeria, household behaviour and cultural attitudes also play a significant role in adopting renewable energy into the household energy consumption mix (Eludoyin and Lamaire, 2021). Most households in Nigeria, particularly rural households, depend on traditional solid fuels like firewood, kerosene and charcoal, which are perceived to be more reliable and accessible compared to renewable energy (Oyeniran and Isola, 2023). In contrast, renewable energy sources like solar and wind energy are considered expensive and challenging to maintain (Ezekwem and Muthusamy, 2023). Additionally, several studies have indicated that the level of household awareness of the long-term environmental and health benefits of utilising renewable energy is low in Nigeria, which further supports their perception of renewable energy sources (Ayodele et al., 2021).

Aside from human behaviour being a barrier to renewable energy adoption in Nigeria, it is worth noting that culture often shapes human behaviour and their interpretation of objects (Reckwitz, 2002; Maduekwe et al., 2019). Hence, placing cultural norms around energy use, especially during cooking activities in Nigeria, culture can be a significant barrier and driver of household energy adoption. In most Nigerian communities, cooking with firewood and charcoal is primarily influenced by local customs and traditions, where the taste and familiarity of food prepared using these fuels are valued (Jewitt, Atagher and Clifford, 2020; Akintan, Jewitt and Clifford, 2018). Additionally, Sovacool and Griffiths (2020) added that smoke from cooking with firewood and charcoal carries cultural significance for food preservation and ensuring building health.

For example, firewood and charcoal are traditionally used to smoke fish, given the electricity challenges in the country. In contrast, the smoke from cooking with firewood and charcoal is seen as a strengthening agent for mud bricks in rural areas. In Nigeria, the value of smoke for food and building preservation outweighs the health burdens, such as stinging eyes and acute respiratory infections from burning firewood and charcoal (Bede-Ojimadu and Orisakwe, 2020; Jewitt, Atagher and Clifford, 2020). Therefore, changing these deep-rooted cultural perceptions of solid fuel use in Nigeria would not only require encouraging the adoption of cheaper, cleaner, renewable energy alternatives but also extensive public awareness of the reliability and health benefits of utilising renewable energy.

3.5.4. Infrastructural Barriers

Nigeria’s energy infrastructure constitutes an additional barrier to integrating renewable energy into the country’s national grid for household electrification (Edomah, 2020). Nigeria’s electricity infrastructure is outdated, burdened with frequent outages and significant technical losses that disrupt electricity supply to households (Edomah, 2020; Ugwoke et al., 2020; Okoh and Okpanachi, 2023; Ogbonna et al., 2023). Much of the electricity infrastructure in the country was built in the 1950s with single transmission systems, resulting in low transmission and distribution of electricity to households (Oyedepo, 2012; Adoghe et al., 2023). In the 1950s, Nigeria’s national grid could meet the country’s peak demand for electricity in the household sector (Makwe et al., 2012; Sambo, 2008). However, with an increase in population growth, the current electricity demand outweighs the capacity of these ageing infrastructures, limiting the transmission and distribution of electricity to households. These infrastructural barriers make integrating renewable energy sources like solar and wind energy difficult, and dual transmission and stable grid systems are required for a consistent and reliable electricity supply (Jacobson, 2021).

Another infrastructural challenge limiting renewable energy integration into Nigeria’s energy mix is the low electricity generation capacity and a heavy reliance on fossil fuels for power production (Edomah, 2020). Presently, 80% of the country's electricity generation capacity comes from natural gas plants coupled with a small number of hydroelectric plants (Owebor et al., 2021). However, poor gas transmission pipeline networks, frequent maintenance downtime, poor working conditions of refineries and conflicting political interests make gas supply to power stations a significant challenge (Oyedepo, 2012; Adewuyi et al., 2020; Peng and Poudineh, 2017). Furthermore, the intermittent nature of renewable energy sources such as solar energy and wind energy, requiring daylight hours and windy weather conditions, implies that energy storage systems, grid upgrades and expansion would be needed to achieve a gradual adoption to renewable energy in Nigeria (Hassan et al., 2023; Pommeret and Schubert, 2022). However, Nigeria's current electricity grid system lacks the technical capacity to accommodate these requirements for renewable energy integration.

To overcome these barriers, a coordinated effort among energy stakeholders, supported by effective policy design, is necessary to promote renewable energy integration in Nigerian households. This approach should focus on new policies that drive government reforms, enhance investment in renewable energy projects, and increase public awareness of these technologies. In this context, Nigeria has introduced several policies and strategies to facilitate the shift to renewable energy in the household sector. The subsequent sections examine some of these key policies and strategies.

3.6. Renewable Energy Potentials in Nigeria

Access to clean, modern, and affordable energy is essential for Nigeria's sectoral development and progress toward achieving SDG 7 (Castor, Bacha, and Nerini, 2020; Nerini, Ray, and Boulkaid, 2017). However, the current energy system in Nigeria has struggled to meet rising demand, pushing many households in the country to rely heavily on conventional energy sources (IEA, 2019; World Bank, 2020). This reliance contributes to global warming, increasing the impact of climate change on the country’s population (Braungardt, Bergh, and Dunlop, 2019; Skovgaard and Asselt, 2019; Johnsson, Kjarstad, and Rootzen, 2019). Given these challenges, this section provides an overview of Nigeria's renewable energy potential and policy development that could support the nation’s shift to renewable sources.

Research shows that Nigeria has abundant untapped renewable energy resources that could alleviate its current energy challenges (see Section 2.3 and Table 2.4) (Mohammed et al., 2017; World Bank, 2018; Adelaja, 2020). Nigeria's renewable resources include solar, wind, and hydropower. Yet, the development of these renewable energy sources remains slow, with renewable energy technologies mainly limited to small-scale solar PV for households and solid biomass for cooking (Adelaja, 2020). Studies estimate Nigeria’s large hydropower potential is at 11,250MW, with an annual generation capacity of over 36,000 GWh, while small hydropower could produce around 3,500MW annually (Oyedepo et al., 2018). Despite this potential, only 24% of large hydropower and 4% of small hydropower capacity are currently used for electricity generation (Ugwu, Ozor and Mbohwa, 2022). Fully harnessing

Nigeria’s renewable energy resources could significantly address household energy challenges. Therefore, the following sections will examine the country’s renewable energy potentials, focusing specifically on solar, wind, and hydropower (both large and small), as these sources show the greatest viability and integration potential within Nigeria’s energy mix.

3.6.1. Solar Energy Potentials in Nigeria

Nigeria, a country in West Africa, is located between latitudes $4^0 32'$ N and 14^0 North and longitudes $2^0 72'$ E and $14^0 64'$ East between the Equator and the Tropic of Cancer (Ogbonnaya et al., 2019). Being geographically close to the Equator implies that the country is positioned within a sunshine belt area to fully harness solar radiation from the sun. A large amount of solar radiation falls upon the country's 923,768 sq km land area, with average sunshine ranging from 4.0 – 6.5 kWh/m^2/day (see Table 2.4). Other studies investigating solar energy potentials in Nigeria have revealed that the average solar irradiation in the country could be higher, averaging between 15.01 – 25.01 MJ/m^2/day (Osinowo et al., 2015). However, with an average solar energy radiation of 18.9 MJ/m^2/day in Nigeria, there is the potential to harness approximately 17.459 TJ/day or generate 4.2 million MWh/day of electricity (Ogbonnaya et al., 2019). Figure 4.1 below illustrates the spatial solar radiation across parts of Nigeria.

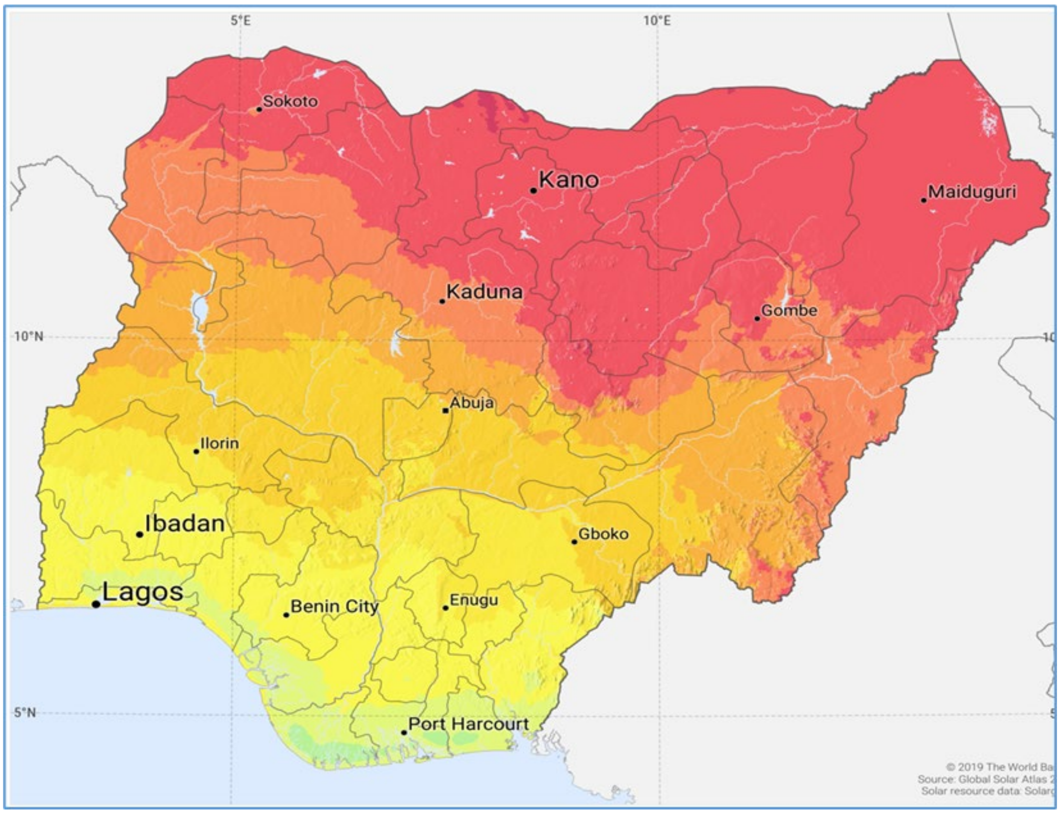

Figure 3. 6 Spatial Solar Radiation Across Nigeria

Source: Global Solar Atlas. (2017)

The country's average daily sunshine can last up to 6 hours per day, with solar radiation spatially distributed across most parts of the country (as seen in Figure 3.6). However, northern Nigeria experiences more extended sunshine and higher solar radiation than the southern parts. In the northern regions, solar radiation can reach up to 7.0 kWh/m^2/day, while the southern regions have an average of 4.0 kWh/m^2/day (Ogunmodimu and Okoroigwe, 2019). From Figure 3.6 above, it is evident that the solar radiation levels in Nigeria can potentially accelerate sustainable energy development in the country. However, despite the abundance of solar radiation in Nigeria, introducing solar energy into the Nigerian energy mix has been met with setbacks and slow development.

Although the use of solar energy within households has existed over the years, households have been harnessing the sun's power as solar dryers to dry farm produce such as fish, maize, cassava, and meat (Udomkun et al., 2020). Presently, solar energy in Nigeria is mainly used on a small scale for rural electrification, household lighting, and powering streetlights, where most solar energy projects are privately funded by households (Mohammed et al., 2017). However, a few governmental projects have been commissioned to provide solar-powered electricity in rural communities, power machines that pump water, and power streetlights in villages and government schools. Examples of such projects include the installation of solar streetlights and a feasibility study of installed renewable energy projects in Aniocha North Delta State by the Niger Delta Development Commission in Nigeria (NDDC) (NDDC, 2017). However, whilst these projects exist, integrating solar energy into the national grid has yet to gain traction despite Nigeria's huge solar energy potential.

3.6.2. Wind Energy Potentials in Nigeria

Wind energy is also a sizable renewable energy resource available in Nigeria. Unlike conventional energy sources like fossil fuels, wind energy is free from greenhouse gas emissions that can potentially impact the environment (Ajayi, 2009). As highlighted in section 2.3, wind speeds at a height of 10 meters increase from the southern region to the northern region in Nigeria, with average speed reaching up to 1.4m/s to 4.5m/s (Ajayi, 2010; Adaramola and Oyewola, 2011).

As with solar energy, the average wind speed in Nigeria varies across the different regions of the country, with some states having a lower average wind speed than others. According to Ogbonnaya et al. (2019), states with the lowest average wind speed in Nigeria include Rivers, Ondo, Ekiti, Osun, Delta, Taraba, Kogi, Adamawa and Gombe states. At the same time, states with sufficient wind speed for electricity generation include Enugu, Abia, Anambra, Akwa Ibom, Imo, Ogun, Lagos, Kwara, Niger and Kebbi states. However, wind energy for large-scale power generation is mainly found in key northern states such as Sokoto, Zamfara, Katsina, Kano, Bauchi, Kaduna, and Yobe. A possible explanation for this is that these northern states are closer to the Sahara Desert, which has been found to have a very high wind regime that could be used for electricity generation (Sawadogo et al., 2020). Undeniably, these findings reveal that the northern parts of Nigeria have sufficient wind potential for electricity generation, as most of the states in the north have an average wind speed higher than 2.5m/s.

As such, Figure 3.7 shows the average wind speed distribution across the region of Nigeria.

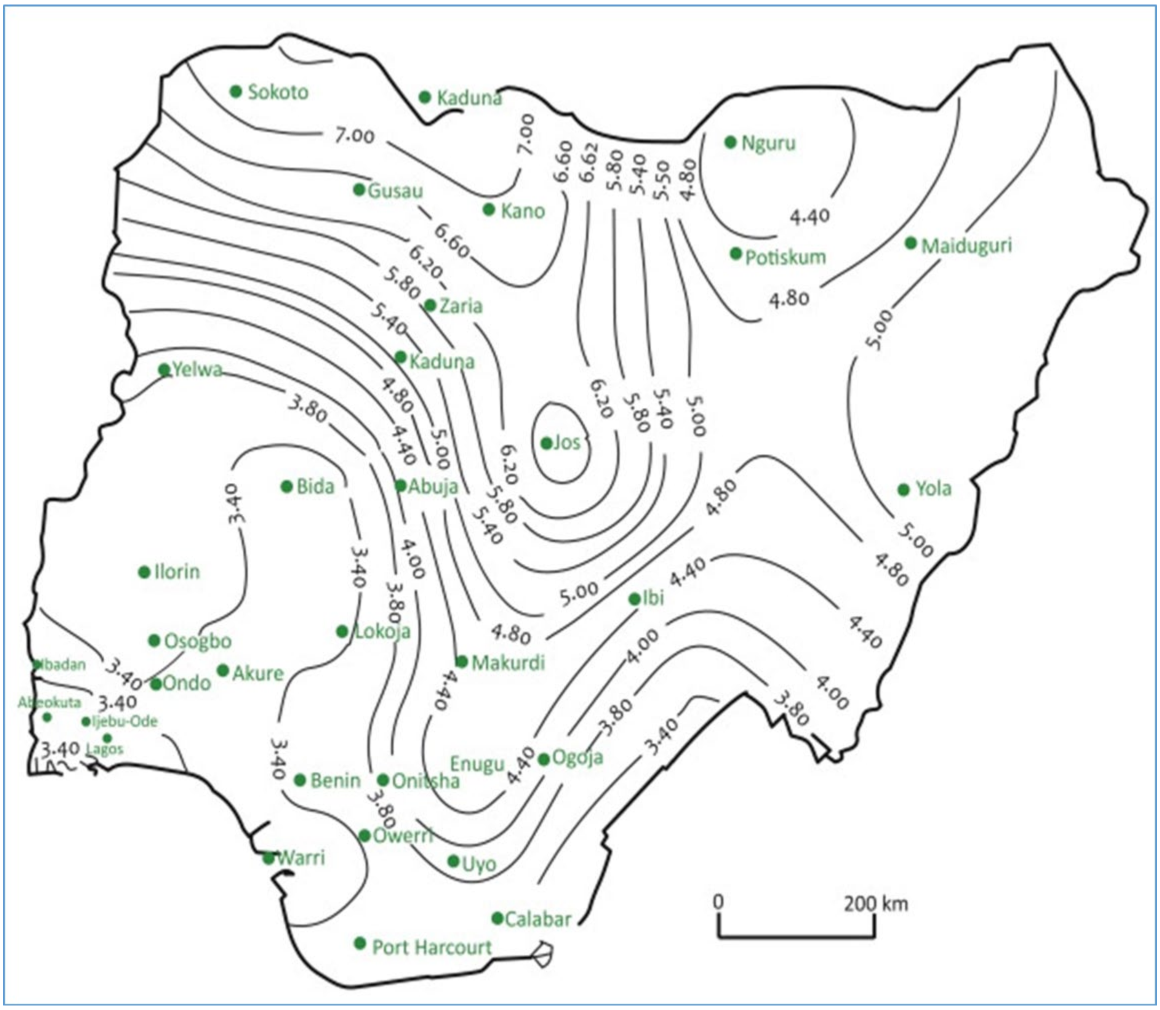

Figure 3. 7 Distribution of Wind Speed in Nigeria

Source: Reproduced from Brimmo et al. (2017) and Ajayi (2010).

Figure 3.7 reveals that the average wind speed is relatively lower in the southern regions of Nigeria, but in the northern region, which has a much higher wind energy potential for electricity generation to meet the growing energy demand in Nigeria. However, wind energy for electricity generation remains scarce in Nigeria, as no functional wind farms or turbines are used for either small- or large-scale electricity generation in the country (Mohammed et al., 2017). Although a few wind turbine projects have been commissioned in the northern parts of the country (Sokoto, Kastina and Bauchi states) that generate about 5 kW and 1 kW of electricity used in pumping water in rural villages (Mohammed et al., 2017). Additionally, a few studies have investigated suitable locations for installing wind farms and turbines in Nigeria, citing most northern states as the appropriate locations for wind farms and turbines due to the high wind speed in these regions. Figure 3.8 illustrates suitable locations for the installation of wind farms in Nigeria.

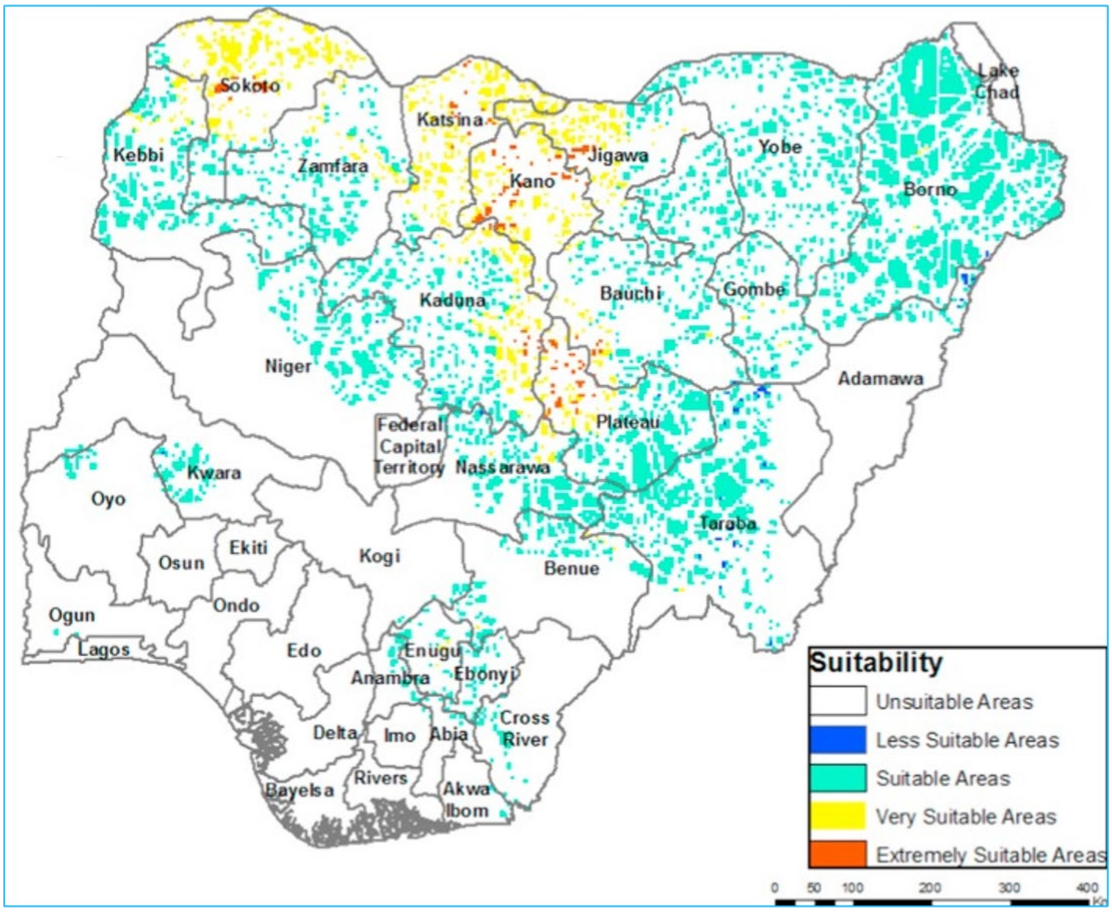

Figure 3. 8 Suitability Map for Wind Farm Locations in Nigeria

Source: Ayodele et al. (2018)

The suitability of northern states as possible locations for wind farm installation offers enormous investment opportunities, as wind energy is commonly seen as an economically feasible energy source due to its low cost (Brimmo et al., 2017). However, despite the potential benefits of wind energy in Nigeria, the viability of wind energy to mitigate the dependence on fossil fuels and provide alternative renewable energy sources remains a technology yet to be harnessed.

3.6.3. Hydropower Potentials in Nigeria

As mentioned above, Nigeria is endowed with substantial hydropower potential. Studies show that the country's hydropower potential is approximately 11,250 MW for large hydropower (LHP), with a yearly electricity generation capacity of over 36,000 GWh. In contrast, small hydropower (SHP) is estimated to generate about 3500 MW annually (see Table 3.2) (Oyedebo et al., 2018). Of all the renewable energy resources available in Nigeria, hydropower is the only renewable energy resource that has contributed significantly to electricity generation in Nigeria. (Ogunmodimu and Okoroigwe, 2019). Other sources, like solar and wind, have yet to be fully exploited. A common explanation is that hydro-powered plants and gas turbines remain Nigeria's most significant energy sources for electricity generation.

The use of hydropower for electricity generation in Nigeria has been an age-long technology that dates back to the colonial era during the 1970s until the present (Ebhota and Tabakov, 2018). From a hydrological viewpoint, Nigeria is blessed with hydropower resources due to the availability of rivers, streams and waterways that can generate hydroelectricity for most parts of the country. The Federal Ministry of Power in Nigeria highlighted in a recent review that the potential to generate clean electricity in Nigeria can be fully exploited by using water resources from the Niger, Benue, and rivers in the Niger Delta region of the country (Federal Ministry of Power, 2016). Figure 3.9 shows Nigeria’s waterways with the site of hydropower plants.

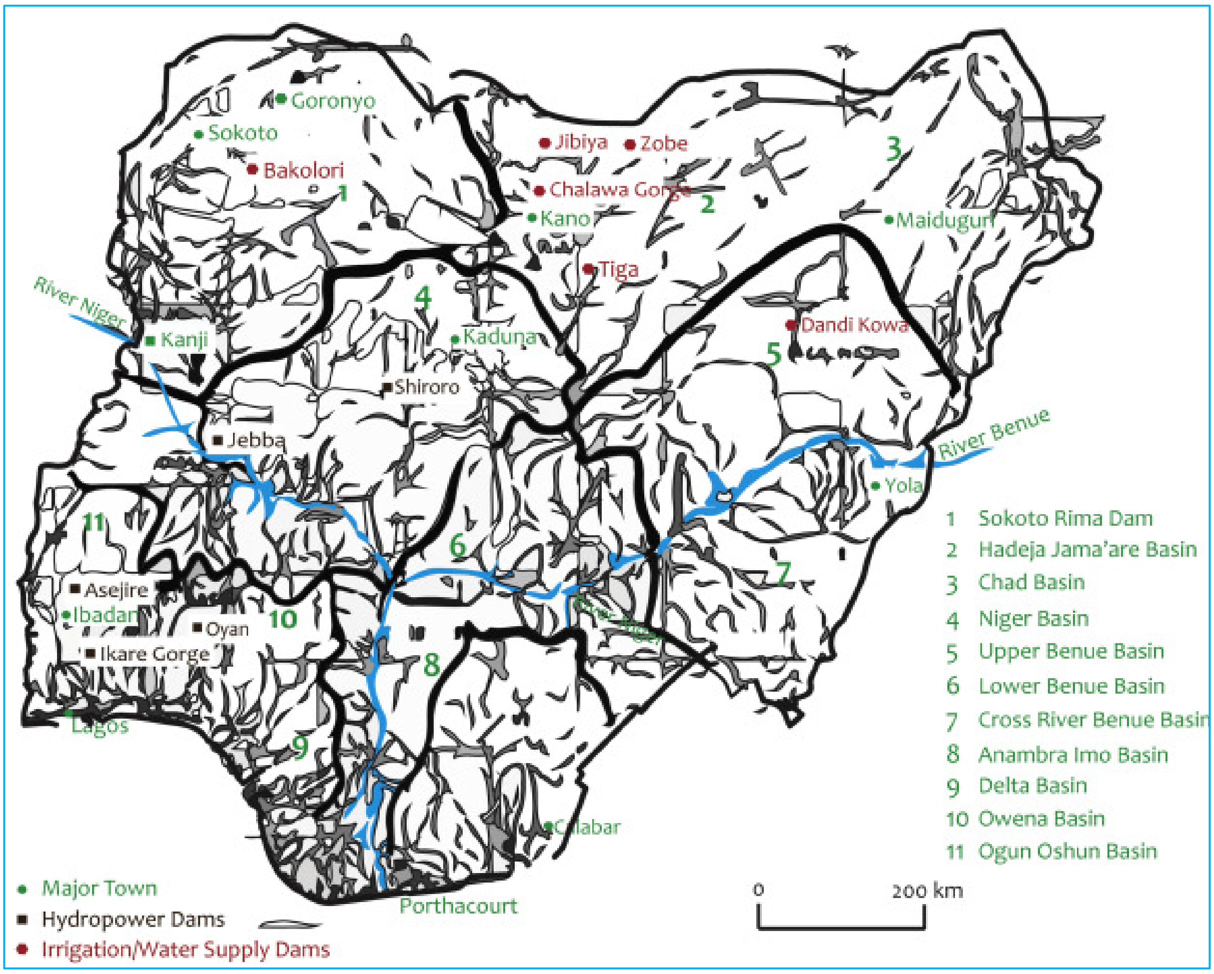

Figure 3. 9 Nigeria's Hydropower Potentials

Source: Reproduced from National Inland Waterways Authority (2022) and Brimmo et al. (2017).

With over 180 river dams and an estimated 12 billion cubic meters/year of irrigation and water supply, hydropower accounts for almost 39.5% of Nigeria's electricity generation capacity (Ogbonnaya et al., 2019; Ohimain, 2015). Hydropower offers many benefits for Nigeria, as it can generate clean energy for the country, as water is carbon-free. Hence, hydropower could mitigate reliance on conventional energy resources for electricity generation. However, an assessment of the current installed electricity generation capacity from hydropower is only at 14% in Nigeria, as only three dams are fully operational – Kainji Dam, Jebba Dam and Shiroro Dam (Brimmo et al., 2017). At the same time, other small hydropower stations are yet to be fully operational due to financial constraints, lack of investment, lack of technical know-how and limitations in research. Table 3.2 shows the different hydropower potentials in Nigeria.

Table 3. 2 Small Hydropower (SHP) Potential in Nigeria

STATE	RIVER BASIN	POTENTIAL CAPACITY (MW)
Niger	Niger	117.6
Kwara	Niger	38.8
Kaduna	Niger	59.2
Bauchi	Lower Benue	42.6
Taraba/Adamawa	Upper Benue	162.7
Plateau	Lower Benue	110.4
Benue	Lower Benue	69.2
Kastina	Sokoto Rima	8
Sokoto	Sokoto Rima	30.6
Kano	Hadejia-Jam'are	46.2
Borno	Chad	20.8
Rivers	Cross River	28.1
TOTAL CAPACITY		734.2

Source: Okedu, Uhunmangho and Odje, (2020).

Table 3.2 and Figure 3.10 highlight the expansive river networks in Nigeria. Some of the rivers (River Niger and Benue) pass through most of the states in the country as such key sites for exploiting their potential through small hydropower plants. Small hydropower technologies could be more beneficial for clean, modern energy generation in rural communities in Nigeria because of their low investment cost when compared with large hydropower systems. Additionally, electricity transmission in Nigeria has been incapable of covering most parts of the country; thus, small hydropower offers good opportunities for rural electrification. Despite Nigeria's vast renewable energy potential, the development of renewable energy projects (solar farms, wind farms, or hydropower plants) is needed to mitigate the country's reliance on fossil fuels. The development and deployment of these technologies have been confronted with many challenges. Some of the challenges include:

a) Lack of human and technical knowledge
b) Lack of local and foreign investment
c) Research limitations for future technological advancements
d) Lack of community engagement
e) Low-level awareness of the potential benefits of renewable energy
f) Lack of enabling policies
g) Political unrest in the Northern and Southern parts of the country
h) Vandalism
i) Bureaucratic barriers – overlap in regulatory organisations for energy development.
j) Ageing facilities – National grid, transmission network.

To address these challenges, the Nigerian government has developed renewable energy policies that enable the country to exploit the various renewable energy resources available. The following section will present an overview of some renewable energy policies in Nigeria.

3.7. Overview of Renewable Energy Policies in Nigeria

Modern forms of energy, such as electricity, unarguably contribute to the growth in various sectors, such as manufacturing, commercial, and IT industries and the overall livelihood of people. However, in regions where access to modern forms of energy, such as electricity, is low or not available, the overall living standards of people will be adversely impacted (Ogbonnaya et al., 2019; Adewuyi, 2020). This seems to be the case in Nigeria, as the availability of various energy resources, ranging from fossil fuels to renewable energy technologies, has not created increased access to electricity and clean cooking fuels for households in the country (Emodi, 2016).

To mitigate these challenges, renewable energy resources have the potential to provide multiple benefits to Nigeria in terms of achieving the United Nations Sustainable Development Goal (SDG) 7 – access to affordable and clean energy for all (UN, 2018). This is particularly important for a country like Nigeria because achieving SDG 7 can be an enabler towards achieving other sustainable development goals such as goal 1 – No poverty, goal 12 – responsible consumption and production, and goal 9 – industry, innovation, and infrastructure (UN, 2018; Ogbonnaya et al., 2019). Adopting renewable energy into the Nigerian energy consumption mix would also contribute to mitigating the impacts of climate change from energy generation using fossil fuels and solid biomass fuels (Oyedepo, 2014). Energy sources with very low carbon emissions are likely to work in Nigeria, as case studies of low-carbon energy development have been recorded in different countries (Kilinc-Ata, 2016; Pacesila et al., 2016). This is because Nigeria has abundant renewable energy resources such as hydro, wind, solar, biomass and tidal wave that could be introduced into the country's energy mix to improve current energy generation capacity (Ndomah, 2019).

In view of the potential benefits of renewable energy in meeting the gap in energy supply in Nigeria, the Nigerian government has developed a growing interest in committing to various international policies on achieving low-carbon energy generation capabilities, including the Kyoto Protocol, the United Nations Framework Convention on Climate Change, and the Paris Agreement (Gungah, Emodi and Dioha, 2019; Merril et al., 2015). On a regional level, Nigeria commits to the West African Power Pool (WAPP) with other ECOWAS countries to achieve a common market for a reliable and affordable electricity supply within the ECOWAS region (WAPP, 2011; Missouri et al., 2020). To drive renewable energy development in the country, the Nigerian government also set up the Energy Commission of Nigeria (ECN) to regulate, plan and formulate various energy policies that would aid the development of sustainable energy technologies for the country. Table 3.3 presents a summary of these policies.

Table 3. 3 Renewable Energy Policies and Frameworks in Nigeria

Policy Document	Year Of Issue
National Energy Policy	2003
National Electric Power Policy	2001
National Economic Empowerment and Development Strategy (NEEDS)	2004
Renewable Electricity Policy Guideline (REPG)	2006
Vision 20:2020	2010
Renewable Energy Master Plan (REMP)	2005/2012
National Biofuel Policy and Incentives	2007
National Renewable Energy and Energy Efficiency Policy (NREEEP)	2015
Draft Rural Electrification Strategy and Plan (RESP)	2015
Multi-Year Tariff (MYTO)	Nd
National Adaption Strategy and Plan for Action Climate Change for Nigeria (NASPA-CNN)	2021

These policies and frameworks were created to promote renewable energy resources in Nigeria and act as a roadmap for adopting these cleaner energy sources. An overview of the key policies is presented below.

3.7.1. National Electric Power Policy (NEPP) 2001

This policy was the first of its kind in Nigeria, as the Federal Government of Nigeria had embarked on a significant reform in the Nigerian power and energy sector. This policy document was introduced in 2001 due to key recommendations from feasibility studies conducted by the Electrical Power Implementation Committee (EPIC). The EPIC was the only organisation responsible for reforms and changes in relation to the power sector (Emodi and Ebele, 2016). Upon creation of the NEPP in 2001, the policy document introduced a three-phase agenda to ensure total reform of Nigeria's power sector. The first phase was to unbundle and privatise the country's National Electric Power Authority (NEPA) and introduce private investors through the Independent Power Producers (IPP) scheme.

Secondly, the policy document aimed to increase participation and competition in the power sector. The third phase aimed to intensify market conditions to drive price competition for full-cost electricity supply pricing (Emodi and Ebele, 2016). In summary, the basic objective of this policy was to:

a) Promote and attract local and foreign investment opportunities.
b) Create a platform for private investors from Nigeria to trade in the power sector.
c) Ensure transparency and openness in the power sector.
d) Create market competition by allowing private investors through privatisation schemes.
e) Act as a guide for future policy development.

However, despite the NEPP being Nigeria's first energy policy, it does not capture renewable energy as a means of electricity generation.

3.7.2. National Energy Policy (NEP), 2003

The National Energy Policy (NEP) came into existence when there was a dearth of energy policies in Nigeria. The Energy Commission of Nigeria (ECN), the regulatory body tasked with developing renewable energy policies, facilitated the development of the NEP document in 2003 (Shaaban and Petinrin, 2014). This policy document gained approval from the Federal Government of Nigeria in 2003 and was drafted as a tool to guide the sustainable utilisation of all energy resources in Nigeria. The document was drafted with the objective of ensuring the optimum exploitation and development of fossil fuel and renewable energy reserves to achieve national development and attract private investors (Sambo, 2010). The key elements of the policy document are as follows:

a) To exploit the various energy reserves available in Nigeria through the inclusion of both fossil fuel and renewable energy reserves into Nigeria’s energy mix.
b) To extensively develop the national grid strength for the purpose of increasing electricity access, particularly to rural communities and the rest of the population, by 2020.

c) To achieve electricity generation from multiple energy resources available in the country.
d) To ensure the full exploitation of renewable energy reserves in Nigeria.
e) To attract foreign direct investment in the energy sector and achieve international development with renewable energy technology, particularly in hydropower.
f) To ensure energy security through a sustainable energy supply using diverse energy resources.
g) To provide an energy supply to the population that will be affordable for all citizens.
h) To create a national energy mix where the share of renewable energy is higher.
i) To increase the utilisation of both small and large hydropower in electricity generation.
j) To increase electricity access for rural communities by using small hydropower plants.
k) To reduce the country's carbon footprint by developing hydropower capacity.

Interestingly, the NEP was the first policy document to seek to include renewable energy in Nigeria's current energy mix.

3.7.2. National Economic Empowerment and Development Strategy (NEEDS), 2004

The National Economic Empowerment and Development Strategy (NEEDS) policy was developed in 2004 by the National Planning Commission (NPA) (World Bank, 2005). This policy document aimed to enhance Nigeria's developmental goal of achieving sustainable socio-economic development and reducing poverty levels in the country (CBN, 2004). The NEEDS was developed based on three key strategies:

a) Increased social development—The NEEDS policy document focuses on improving Nigerian citizens' social and economic welfare through increased inclusiveness and empowerment (CBN, 2004). It seeks to improve the standards of living of all Nigerians to move above the current poverty line. Reducing poverty could increase household expenditures, in turn increasing purchasing power for cleaner fuels.
b) Drive development in the non-oil private sector—The NEEDS policy also focuses on fostering development in Nigeria's renewable energy sector. To achieve this, the policy document aims to create renewable energy agencies that will monitor and

regulate the introduction of renewable energy into the country's energy mix (Emodi and Ebele, 2016).

c) Improve governance and reorientation—One of NEEDS's fundamental objectives is to create transparency and improved governance in the decentralisation of the power sector in Nigeria (CBN, 2004). Another main aim is to instil a credible value orientation to combat corruption practices in the energy sector.

In relation to renewable energy development in Nigeria, the NEEDS policy was considered a major step towards introducing renewable energy into the country's energy mix.

3.7.3. Renewable Electricity Policy Guideline (REPG), 2006

The Renewable Electricity Policy Guideline (REPG) was developed by the Federal Ministry of Power and Steel, Nigeria, in 2006. The policy document presents guidance on renewable energy resources used for electricity generation in Nigeria (Emodi and Ebele, 2016). The overall objective of the REPG aligns with the government's vision to promote electricity generation from renewable energy. The key objectives to be achieved by the REPG include:

a) Increase electricity generation to achieve Nigeria's economic and social development targets.
b) Increase national employment rate through job creation because of development in the renewable energy sector.
c) Drive competition in the supply of electricity from renewables.
d) Increase rural electrification through mini-grid systems using solar, hydropower or wind energy.
e) Drive reduction of household indoor and outdoor air pollution through affordable, clean, modern cooking fuels.
f) Create policy guidelines for renewable energy electricity supply.

3.7.4. National Biofuel Policy and Incentives, 2007

Generally considered the first of its kind, the National Biofuel Policy and Incentives were established to promote the use of biofuels from agricultural produce in cars. The policy was approved by the Federal Executive Council (FEC) in 2007 and gave a mandate to the Nigerian National Petroleum Corporation (NNPC) to establish an enabling environment for the development of ethanol fuel in Nigeria (Ohimain, 2013; Verla et al., 2021). The key purpose of this policy was to mitigate Nigeria's dependence on imported crude oil products (gasoline and diesel), combat climate change and develop a biofuel industry that will create employment for Nigerians (Ohimain, 2013).

The policy focused on producing automotive ethanol from biofuel resources such as cassava, sugarcane, maize, and rice while also aiming to produce biodiesel from palm oil, coconut oil, soybean, and sunflower (Verla et al., 2021). In general, the policy was put in place to achieve the following objectives, including:

a) To fully harness biofuel energy resources as an alternative to fossil fuel-based energy sources, which have been known to contribute to climate change.
b) To create a favourable market condition that will attract foreign investment in the Nigerian biofuel industry
c) Developing the biofuel industry will ensure additional revenue generation for the government through taxes.
d) To promote job creation, upskilling, and empowerment for most Nigerians, especially those in rural communities.
e) To ensure improved farming activities by conducting agricultural studies and modern farming techniques.

3.7.5. Renewable Energy Master Plan (REMP), 2005 and 2012

The Renewable Energy Master Plan (REMP) was drafted by the Energy Commission of Nigeria (ECN) and the United Nations Development Programme (UNDP) in 2005 and later revised in 2012 (Emodi and Ebele, 2016). Like the Renewable Electricity Policy Guideline (REPG), the REMP aligns with Nigeria’s vision to create a road map to increase the role of renewable energy in generating power to achieve sustainable development (IEA, 2021). The REMP’s general purpose is to enable the Nigerian government to mitigate the risk associated with climate change from burning fossil fuels and meet the country’s growing energy demands (Akuru and Ogbonnaya, 2010). The key objective of the policy is to ensure the following:

a) To increase Nigeria’s share of renewable energy in electricity generation from 13% in 2015 to 23% by 2025 and 36% by 2030, using mainly large hydropower.
b) To diversify Nigeria’s energy mix for electricity generation by increasing installed generation capacity using solar, wind, biomass, hydropower, and thermal energy technologies.
c) To reduce the environmental and health risks associated with fossil fuel dependence, especially for women and children.

3.7.6. National Renewable Energy and Energy Efficiency Policy (NREEEP), 2015

The National Renewable Energy and Energy Efficiency Policy (NREEEP) outline the Nigerian government's commitment to fully harness Nigeria’s renewable energy resources to drive sustainable development across all sectors of the economy. The NREEEP was developed on the backbone of the National Energy Policy in Nigeria and the Millennium Development Goals (MDGs) by the United Nations in 2015 (ECN, 2014). The NREEP policy document recognises the various barriers that can negatively impact Nigeria's development and utilisation of renewable energy resources. To address these challenges, the NREEEP considers the development of renewable energy technologies to be multi-dimensional in nature and provides a model for the sustainable and efficient use of renewable energy resources in Nigeria.

In relation to the energy resources and technologies available in Nigeria, the NREEEP focuses mainly on solar, wind, biomass, hydropower, geothermal, and tidal energy resources to improve their efficiency as alternative energy sources. The general objective of the policy is presented below:

a) To foster sustainable development of Nigeria's energy resources by diversifying energy resources used for energy generation to ensure energy security.
b) To foster efficiency in energy supply using an optimal energy resource mix.
c) To achieve high levels of electricity access for more than half of Nigeria's population that is without access to electricity and clean cooking fuels
d) To drive increased investment and participation of private sector investors in the renewable energy and energy efficiency sector.
e) To ensure the provision of affordable, reliable, and adequate supply of renewable energy that is cost-reflective and environmentally friendly.
f) To create trade and project development opportunities within ECOWAS, Africa and worldwide.
g) Accelerate the collaboration of all key stakeholders in Nigeria's renewable energy and energy efficiency market.
h) To develop Nigeria's renewable energy sector by creating suitable financial strategies that would encourage the active involvement of private investors.
i) Create location-specific and cost-reflective renewable energy consumption trends to improve energy efficiency.

3.8. Summary

From the analysis captured above, it is evident that Nigeria has abundant renewable energy resources that can serve as alternative fuels to mitigate fossil fuel dependence. Renewable energy resources available in the country include solar, wind, large and small hydropower, and biomass. To ensure the sustainable development of these renewable energy resources, the Nigerian government has developed policies that could guarantee the full exploitation of these resources. However, despite the policies in place, the country's development of renewable energy resources is faced with multiple challenges, such as a lack of technological skills to harness the resources and failure to enact policies as laws.

Chapter 4. Research Methodology

4.1. Introduction

This chapter presents an in-depth analysis and evaluation of the research methods for this study, beginning with a discussion of the research philosophy, research design, methodological stance, research approaches, data collection methods and sampling techniques adopted for this research. The chapter also analyses the characteristics of the research philosophy that guides this research. It will also present justification for the chosen research methods and approaches employed in this study, coupled with an analysis of the research design strategy, sampling, and data collection methods used to investigate and achieve the research aim. This chapter also accounts for the limitations and problems of the chosen research methods that allow for continuous research.

Choosing an appropriate research methodology for this research is crucial as it contributes to its credibility and validity. Choosing a suitable method in any study clearly outlines the philosophical views guiding the researcher, theoretical underpinnings, research methods and approaches, and data collection techniques required to conduct any research.

4.2. Research Philosophical Paradigm

The framing and identification of a philosophical paradigm in research is imperative. Understanding and exploring the philosophical paradigm of research cannot be overemphasised in any research (Dalton et al., 2022). Proctor (1998) suggested that the philosophical paradigm of research guides the structure of inquiry in any research and shows the interrelation between a researcher's ontological, epistemological and methodological stance. However, defining the term 'research paradigm' or 'philosophical paradigm' is inconsistent and ambiguous, as the term is considered to have different meanings across different fields of study (Weaver and Olson, 2005; Thomas, 2017). According to Denzin and Lincoln (1994), a research philosophical paradigm is defined as a researcher's philosophical viewpoint that provides a set of rules that guide research. Another definition by Weaver and

Olson (p.2, 2005) defines research philosophical paradigm as “a set of philosophical underpinnings from which specific research approaches (e.g., quantitative or qualitative methods) flow. Kukichi (2003) considers the research paradigm to be a researcher’s perceived worldview within the research context.

Despite these inconsistencies concerning the precise definition of research paradigms, common factors highlight the importance of exploring, understanding, and adhering to a particular philosophical paradigm in any research. Weaver and Olson (2005) highlighted that adopting a specific research paradigm predetermines the structure of knowledge development in research and establishes the approaches required to obtain knowledge. This indicates that the philosophical paradigm of research influences how knowledge is processed and how data from the processed understanding is obtained and interpreted, requiring the researcher to have sufficient knowledge of their chosen philosophical viewpoint regarding their research. Studies (Slife and Williams,1995 and Crossan, 2003) further claim that a research philosophical paradigm plays a vital role in any research and is known to be a bridge between the research questions, research design process, methodological approaches, data collection methods, methods of data analysis and interpretation of data in research. This indicates that in any research, the choice of methodological approaches, techniques, and research design is almost entirely dependent on the philosophical underpinnings or research paradigm adopted by the researcher (Mackenzie and Knipe, 2006).

Easterby-Smith et al. (2012) added that exploring and understanding various philosophical paradigms is significant in relation to adopting an appropriate research methodology for any research. Thus, this research requires careful consideration of a range of philosophical perspectives, as there is a need to justify and clarify the central paradigmatic stance guiding this research.

4.2.1. Philosophical Paradigm for this Research

Given the significance of understanding the philosophical paradigm guiding this research, evaluating the researcher's beliefs, views, and focus is vital. Philosophical paradigms mainly adhered to in any research comprise positivism, interpretivism, transformative, realism, and pragmatism research paradigms (Mackenzie and Knipe, 2006) (See Figure 4.1).

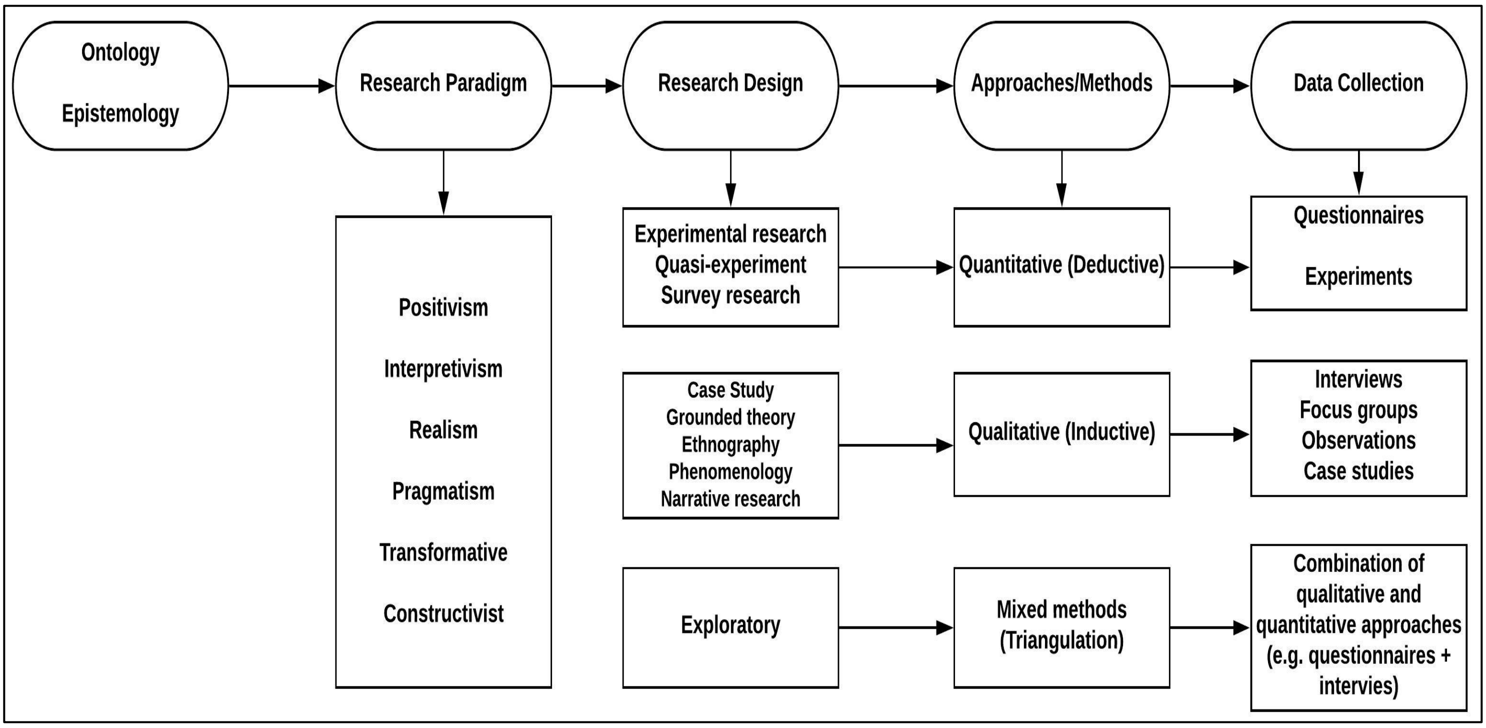

Figure 4. 1 Flow and Impact of Research Paradigm on Research Methodology

Source: Adopted from Bryman (2012).

However, in most social science research, two main philosophical paradigms are often considered: interpretivism and positivism (Neuman, 2007). A positivist paradigm in any research assumes adopting an empirical and scientific approach to studying social reality (Crossan, 2003). Rubin and Rubin (p.2, 2012) provided a helpful insight into the positivistic stance, adding that “positivists assume that there is one correct version of reality and that it can be discovered using quantitative measurement tools”. This assumption underpins knowledge as objective and unconnected to human behaviour and mind (Crossan, 2012).

Therefore, adopting a positivistic stance would imply that the inquiry structure in any research is based on objective and quantifiable truths that would require scientific, experimental, or standardised data collection techniques and statistical data analysis (Saunders, Lewis and Thornhill, 2023). Hence, this suggests that a positivist paradigm assumes a quantitative approach to knowledge development using techniques such as experiments and surveys to obtain data (see Figure 4.1).

In contrast, interpretivism holds a different reasoning. The interpretive paradigm assumes that reality is a social construct and can only be developed through meanings, perceptions, and beliefs (Saunders, Lewis and Thornhill, 2012; Cuthbertson, Robb and Blair, 2020). An interpretivist argues that, rather than adopting a traditional scientific approach towards investigating a phenomenon, a researcher should seek to understand the meanings, perceptions, and interpretations of the research participants (Bryman, 2012). This indicates that an interpretive paradigm involves a structure of inquiry that is based on subjectivism, human experiences and perceptions, which contrasts with the positivistic paradigm that is based on objective, measurable and quantifiable truth. This indicates that an interpretive paradigm assumes a qualitative approach towards knowledge development and involves the use of techniques such as interviews, focus groups and observations (see Fig 4.1).

Given that positivism and interpretivism are the two main philosophical paradigms in social sciences research, they are both mutually exclusive, resulting in the emergence of alternative paradigms that offer greater flexibility (Kakkuri-Knuuttila, Lukka and Kuorikoski, 2008; Sanchez, Bonache and Paz-Aparicio, 2023; Clark et al., 2021). Pragmatism is one such philosophical paradigm that allows for greater flexibility in research (Shook, 2023). As a philosophical paradigm, pragmatism aims to bridge the gap between structured scientific methods of understanding knowledge and reality (Creswell, 2011). This results in the naturalistic, flexible approach of modern methodologies, offering researchers greater freedom to solve problems (Creswell, 2013; Kaushik and Walsh, 2019). This paradigmatic stance claims that researchers must adopt a flexible and empathetic stance towards developing knowledge (Bryman, 2016; Leonard and Willig, 2021). Pragmatism suggests multiple approaches to developing knowledge and investigating reality (Kelly and Cordeiro, 2020). Thus, this implies that combining different approaches results in a broader understanding of the phenomena being studied (Nowell, 2015). Pragmatism is based upon the assumption that researchers should adopt philosophical stances or methodologies that "work best" when investigating a research problem (Kaushik and Walsh, 2019; Brown and Duenas, 2020). This philosophical paradigm strongly aligns with the idea that knowledge and reality are shaped by human beliefs and behaviours, which are, in turn, influenced by social constructs (Morgan, 2014). Pragmatism further suggests that these social constructs are rooted in human experiences, recognising the role of context and adaptability in understanding complex social phenomena (Yefimov, 2004).

Given pragmatism's multiple-approach nature and its ability to combine different approaches in research, it is closely associated with a mixed-methods research approach, combining both qualitative and quantitative methods (Nowell, 2015; Kelly and Cordeiro, 2020; Liu, 2022). Several studies indicate that pragmatism, through a mixed-methods approach, enables qualitative and quantitative data to comprehensively understand a research problem (Morgan, 2013; Thompson and McKinley, 2023; Mitchell, 2018; Gillespie, 2024). This approach offers flexibility, allowing researchers to select methods that most effectively address different aspects of the issue (Thompson and McKinley, 2023).

Given the above discussion, this study views pragmatism as a suitable philosophical stance to guide the investigation of the feasibility of utilising renewable energy in Nigerian households. Pragmatism allows for the use of objective data, such as household energy consumption patterns, with subjective insights into the perception of renewable energy adoption from households and policymakers. By adopting a pragmatic stance, this research remains flexible, using qualitative and quantitative methodologies to investigate the factors influencing household energy adoption in Nigeria.

Table 4. 1 Differences between Positivism, Interpretivism and Pragmatism Research Paradigms

Meta-theoretical Differences	**Positivism**	**Interpretivism**	**Pragmatism**
Ontology: researcher's perception of reality.	The researcher's view of reality is independent and neutral of human perception, unrelated to what is being investigated (social actors).	The researcher's view of reality is subjective and based on social constructs.	The reality for the researcher is often complex and based on multifaceted factors.
Epistemology: researcher's perception of acceptable knowledge.	The object of study or phenomena being investigated is based on objective and measurable facts/reality rather than preconceived ideas and human beliefs.	The social phenomena being investigated are subjective and influenced by the beliefs, experiences, and values of researchers and other social actors.	The object of study or knowledge is determined by practicality, combining objective and subjective reasoning.
Research Motive (Causality)	Aimed to identify and show the causal relationships between variables and test hypotheses to explain general regularities in the investigated phenomena.	Aimed at understanding and deriving deep meanings of what is being investigated subject to human perceptions and experiences.	It seeks to address real-world problems flexibly, adapting the best methods based on the researcher's experience.
Hypothetical Reasoning	Science-based approaches involve testing hypotheses or laws and deducing facts or data from analysis to determine whether a hypothesis is falsified or truthful.	Inductive approaches towards deriving in-depth meanings from evidence based on human perception.	Mixing both inductive and deductive reasoning. Allowing for greater flexibility in research.
Methods	Mainly quantitative – Statistics, measurable units, structured design and large samples.	Qualitative – relatively small samples with in-depth investigation, emerging design.	Mixed methods – combining both qualitative and quantitative research methods.
Validity	Datasets should develop a hypothesis and identify regularities in human behaviour; results should be generalised for prediction and understanding.	Description and analysis of data are contextual; theories are then developed to foster in-depth understanding.	Relevance and applicability of solutions to research problems.
Reliability	Results can be replicated and reproduced.	Results produce informative/interpretive awareness based on subjective human beliefs and experiences.	The reliability of results depends on the consistency and adaptability of findings within a particular context.

Source: Compiled from Easterby-Smith et al. (2012); Saunders, Lewis and Thornhill (2012); Rubin and Rubin (2012); Kaushik and Walsh (2019).

4.2.2. Suitability of Pragmatism for this Research

Drawing on the limitations of positivism and interpretivism, this research adopts pragmatism as a suitable philosophical paradigm for this research. Positivism, with its focus on empirical, scientific approaches and quantifiable data (see Table 4.1), is limited in its ability to explore the behavioural aspects of this research, such as household perception of renewable energy integration amongst Nigerian households (Crossan, 2003; Sovacool, Axsen and Sorrell, 2018). Therefore, while positivism ensures objectivism and rigour, it lacks the freedom to capture and explore in-depth human perceptions and views on household fuel choices as households seek to adopt cleaner fuels in Nigeria (Headley, Jones and Carter, 2024).

In contrast, interpretivism being subjective would allow for the exploration of in-depth human perception of renewable energy integration and the socio-cultural barriers hindering household renewable energy adoption in Nigeria (Abreu, Pereira and Gerasio, 2023; Ellsworth-Krebs, Reid and Hunter, 2015; Bercht, 2021). However, adopting an interpretivist stance alone is unsuitable for this research as interpretivism focuses mainly on qualitative exploration, overlooking the significance of quantitative data, such as statistical trends in household energy consumption patterns (Kaushik and Walsh, 2019). This research seeks to investigate the likelihood of households adopting renewable energy sources in Nigeria and to identify the factors influencing this adoption. Hence, a quantitative dataset enabling statistical analysis is essential to complement qualitative insights into household perspectives on renewable energy adoption.

Therefore, pragmatism emerges as an ideal philosophical paradigm for this research, as it combines qualitative and quantitative approaches. Specifically, the research explores household renewable energy adoption using a mixed-methods approach supported by pragmatism (Kaushik and Walsh, 2019). Studies by Webb (1989), Crossan (2003), and McBeath (2024) further highlighted that the differences between interpretivism and positivism are often overemphasised, and that pragmatism allows the convergence of interpretivism and positivism, enabling a more rigorous analysis and interpretation of data.

This research, therefore, adopts a pragmatic stance to investigate the complexities of household renewable energy adoption in Nigeria, using qualitative data from policymakers through semi-structured interviews and quantitative data gathered using household surveys. The exploratory and explanatory nature of this research benefits from the adaptability of pragmatism, allowing new themes to emerge, thus offering a balanced engagement with the research participants (Kelly and Cordeiro, 2020). Additionally, a pragmatic stance accommodates the research aims to investigate the likelihood of household renewable energy utilisation in Nigeria using quantitative and qualitative data, evidenced in similar studies on energy adoption using mixed methods, further reinforcing the suitability of pragmatism for this research (see Table 4.2).

Table 4. 2 Summary of Existing Approaches in Similar Studies

Authors	**Subject Area**	**Methods**
Edomah (2016)	Barriers to sustainable energy development in Nigeria.	Exploratory research using quantitative and qualitative approaches.
Amri (2017)	Examining the relationship between renewable and non-renewable energy consumption and GDP in Algeria	Review literature and documentary evidence (qualitative). As well as the use of an econometric (quantitative) model.
Sergi et al. (2018)	Institutional challenges to renewable off-grid solutions- case study of off-grid energy in Kenya and Tanzania.	Qualitative assessment of literature and quantitative evaluation of energy investments.
Neto-Bradley et al. (2021)	Energy Adoption in Urban Households Using Mixed Methods	Mixed-methods clustered approach

Source: Author's Compilation.

4.3. Research Design and Methodology

Saunders, Lewis and Thornhill (2012) suggested that selecting an appropriate research design is crucial to the validity of any research as it establishes the theoretical foundations, methodological structure and procedural analysis required for undertaking any research. An appropriate research design justifies the methodology, approaches, procedures, and frameworks for collating and analysing data, contributing new knowledge to any research (Cater and Little, 2007; Noyes et al., 2019). To ensure an alignment of the research processes, the research aim, objectives, methodology, and data collection methods must align to effectively answer the research question in research (Herman and Webb, 2007; Thomas, 2017; Creswell, 2021). A research design is a structured plan that directs research (Denzin and Lincoln, 2017; Creswell and Creswell, 2018). Therefore, a well-defined research design considers the research questions, aims, and objectives, guiding the researcher in determining the necessary data, collection methods, and analysis procedures (Paradis et al., 2016; Levy, 2017).

Drawing on the adoption of pragmatism for this research, a mixed-methods design is used to investigate the feasibility of integrating renewable energy into the Nigerian household energy mix to drive the adoption of renewable energy. Therefore, this study combines quantitative and qualitative approaches to data collection, specifically using a concurrent mixed methods design, where both data types are collected simultaneously (Saunders et al., 2021; Creswell, 2015). Creswell et al. (2003 and Creswell (2015) suggested that the kind of mixed methods design used in any research depends on the level of significance placed on quantitative compared to qualitative data, the integration of both data during analysis and the theoretical underpinnings of the study. There are three types of concurrent mixed methods design: concurrent triangulation, concurrent nested, and concurrent transformative mixed methods (Creswell, 2015). All three concurrent designs involve collecting quantitative and qualitative data simultaneously, although most studies typically prioritise one form of data over the other (Mulisa, 2022). In concurrent triangulation design, quantitative and qualitative data are collected simultaneously with equal priority to interpret relationships among variables better (see Figure 4.2) (Creswell et al., 2003). In a concurrent nested design, quantitative and qualitative data are collected simultaneously, but one type of data, often qualitative, is given priority (Creswell, 2018; Creswell et al., 2003). Meanwhile, the concurrent transformative design, which is theory-driven, aims to support advocacy or social change and accommodates diverse perspectives (Creswell et al., 2003).

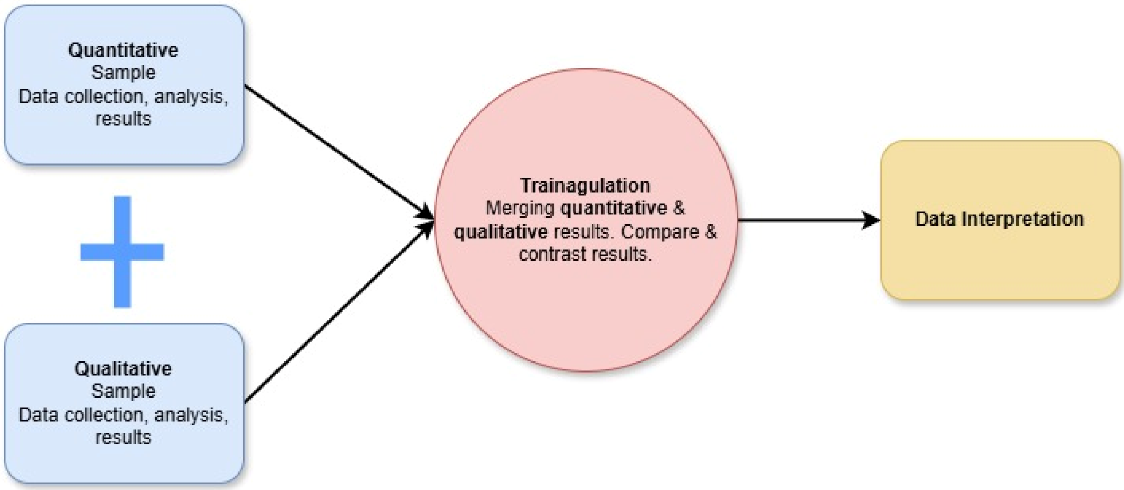

Figure 4. 2 Concurrent Triangulation Mixed Methods

Reproduced from Creswell et al. (2008); Levanon, Lavee and Strier. (2021)

Given the exploratory nature of this research, a concurrent triangulation mixed methods design was adopted. The study combined quantitative household surveys with qualitative interviews to corroborate and cross-validate findings. For this study, data were initially collected and analysed separately, then followed by the merging of findings, allowing for a comprehensive, multidimensional understanding of the research problem (Creswell and Creswell, 2018; Akotia, Awuzie, and Egbu, 2023; Wilson, Ramella, and Poulos, 2022). The concurrent triangulation design relies on the strengths of both qualitative and quantitative data, allowing for depth through narrative interviews alongside the precision of quantitative measurements (Amadi, 2023). The combined approach allows the study to answer the research questions on renewable energy integration among Nigerian households. By concurrently using both qualitative and quantitative methods, the research benefits from a comprehensive view that supports broad exploration and detailed insight (Ostlund et al., 2011).

This study gathered quantitative data through surveys to identify trends in household energy consumption and attitudes towards renewable energy in Nigeria. Concurrently, qualitative data were collected through interviews with key policymakers to explore the underlying factors influencing these attitudes and the potential barriers to renewable energy adoption. A concurrent triangulation mixed methods design is considered suitable for this research because it enables the immediate integration of quantitative and qualitative insights, offering a holistic view of the feasibility of renewable energy in Nigerian households (Saunders and Thornhill, 2011; Ostlund et al., 2011; Hassan et al., 2024). This approach supports the triangulation of findings, as qualitative insights provide context to the quantitative trends, enhancing the overall depth, reliability, and richness of the data (Saunders and Thornhill, 2011; Saunders et al., 2021). The concurrent triangulation mixed methods design aligns with the research questions, data collection methods, and analysis strategies, as illustrated in Figure 4.3.

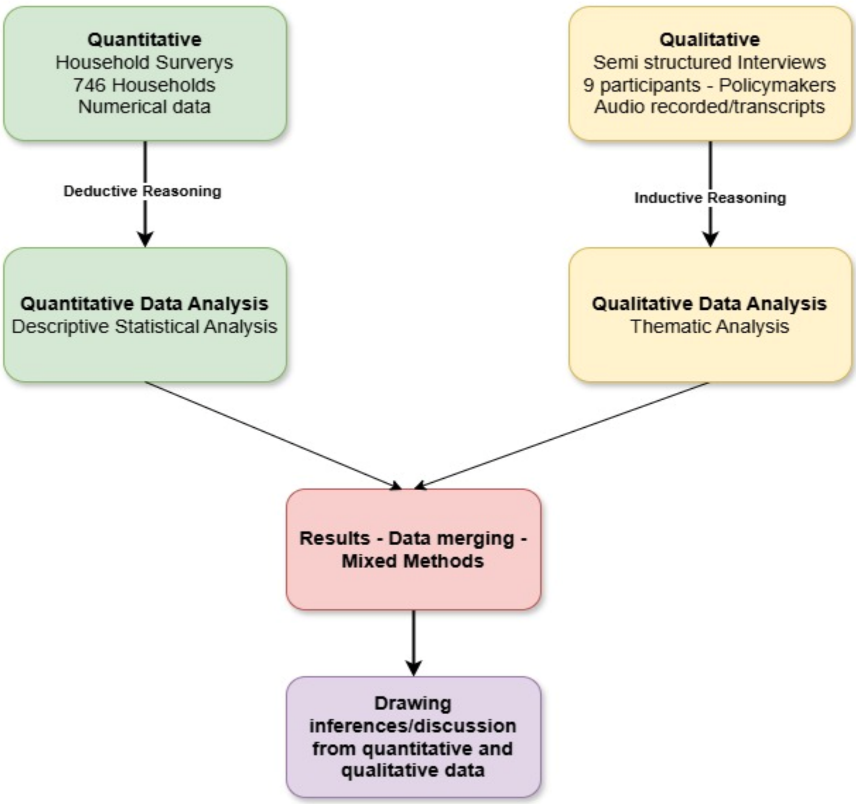

Figure 4. 3 Concurrent Triangulation Mixed Methods Design for this Study

Source: Author Generated.

This integrated approach allows both deductive and inductive reasoning to work, providing a comprehensive exploration of the renewable energy landscape in Nigeria and enabling the development of a robust framework to support its integration (see Figure 4.3) (Saunders and Thornhill, 2011). The rationale for choosing a concurrent mixed methods approach is that it combines deductive and inductive reasoning (Saunders et al., 2021). The exploratory nature of this research, using a concurrent mixed methods design, offers an initial quantitative perspective on renewable energy feasibility in Nigeria, which is then enriched through qualitative insights. This approach provides the depth needed to address the research questions and contribute meaningfully to understanding Nigeria's renewable energy landscape.

This study employed deductive and inductive reasoning to provide a comprehensive approach to understanding the feasibility of renewable energy integration in Nigerian households. Deductive reasoning is mainly associated with quantitative research (See Fig. 4.3), informed by the initial phase of data collection (Casula, Rangarajan and Shields, 2021). The study began with established inferences drawn from the literature on renewable energy adoption in Nigeria, such as the potential impact of human, policy and socioeconomic barriers to renewable energy integration. This deductive approach guided the development of the survey questions for this research, aimed at testing theoretical underpinnings and providing measurable data to confirm or refute key hypotheses. In the quantitative phase, qualitative methods of inductive reasoning were used to derive deep insights into renewable energy adoption amongst Nigerian households.

In contrast to deductive reasoning, inductive reasoning is often linked to qualitative research, allowing this study to move from specific observations to broader generalisations by exploring themes that emerged naturally from participants' responses in the research (Bazen, Barg and Takeshita, 2021). Through semi-structured interviews with key policymakers in Nigeria, this research gathered in-depth perspectives on the socio-cultural factors, policy perceptions, and other context-specific influences that were not fully captured in the survey data. This inductive phase enabled the identification of new patterns and themes directly related to the lived experiences of energy stakeholders in the Nigerian energy sector.

The combined use of deductive and inductive reasoning in this study mitigates the limitations that might occur if only one approach were used (Bazen, Barg and Takeshita, 2021). This dual approach enables a comprehensive investigation of the study's aim, objectives, and research questions. Therefore, a flexible and reflexive methodology has been designed to address the research questions effectively, ensuring that the study is grounded in a cohesive research philosophy, paradigm, and methodology. The combination of deductive and inductive approaches enriched the research findings. Deductive reasoning ensured that the study was grounded in theory, while inductive reasoning allowed for flexibility, enabling the emergence of insights unique to the Nigerian context. Combining deductive and inductive reasoning aligns with the chosen research design. It strengthens the study's methodology, supporting both the empirical rigour and contextual depth necessary to address the research questions effectively. Figure 4.4 below shows the relationship between the research design and methods of this research. This figure illustrates the links between the research aim, research questions, objectives and the approaches used to address the research objectives for this study.

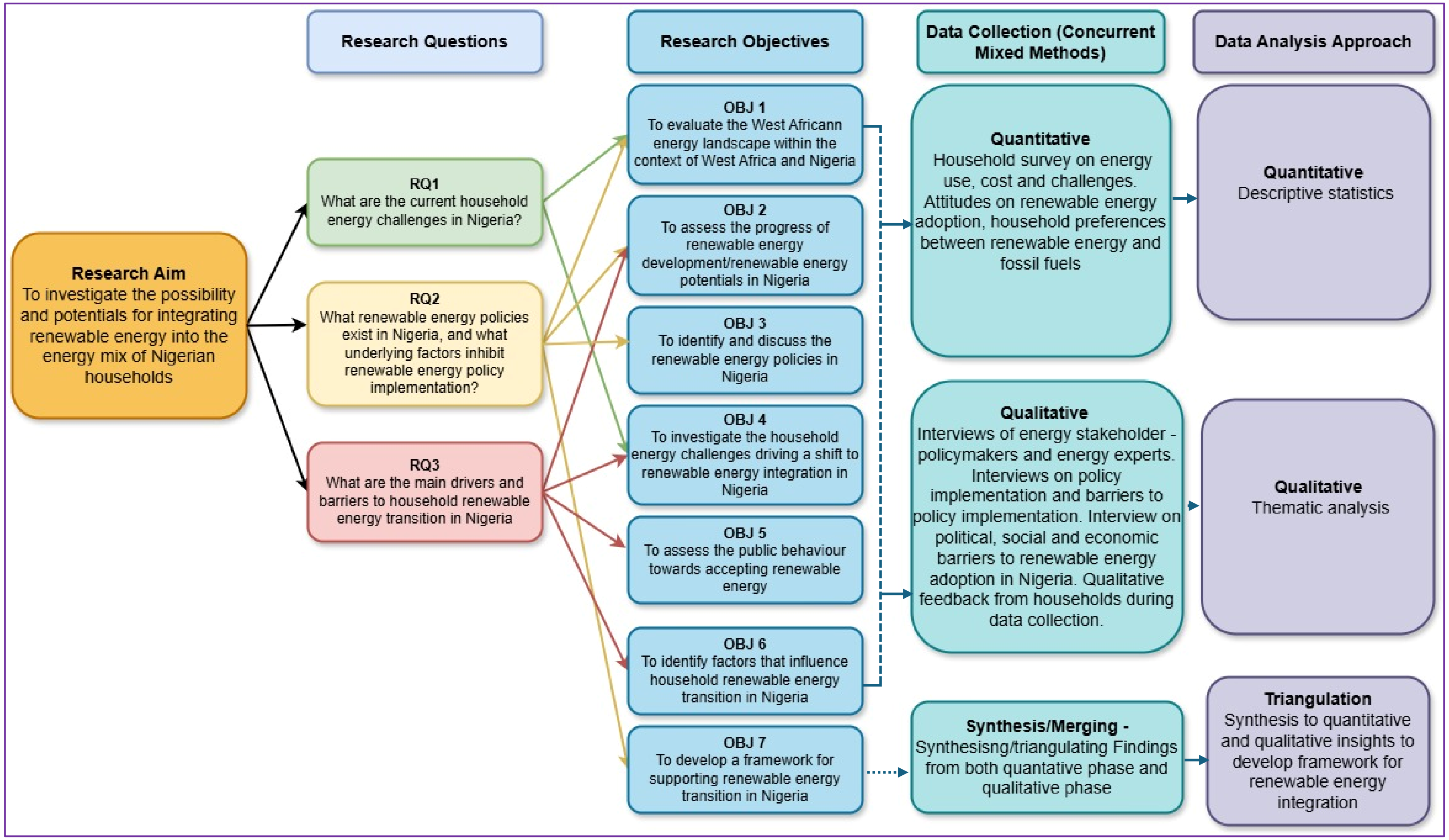

Figure 4. 4 Relationship between the Research Aims, Objectives and Research Design

Source: Author Generated

4.4. Research Data Collection Approach

The accuracy of the data collection techniques used in research is fundamental to its credibility and validity, as errors in data collection can invalidate the study findings (Johnson, Adkins and Sheila, 2020). For this research, data collection was done in two phases involving the simultaneous distribution of quantitative household surveys and qualitative semi-structured interviews. The household survey for this research was informed by themes identified from the literature review and previous studies on household energy dynamics to ensure an alignment with existing knowledge gaps in Nigeria's renewable energy adoption landscape (Edomah, 2016; Sovacool et al., 2018). This section will discuss the research instruments used for data collection in this research, expanding on the quantitative and qualitative data gathered during the data collection process, sampling techniques, survey and interview design and the methods used to analyse data collected to achieve the research aim.

4.4.1. Research Instruments

This research uses two main data collection methods: quantitative household surveys and qualitative semi-structured interviews with policymakers in the Nigerian energy sector. The quantitative survey and qualitative semi-structured interviews are the primary research instruments used to collate data on household energy consumption trends and insight into barriers to renewable energy integration in Nigeria. The combination of quantitative surveys and qualitative semi-structured interviews offers a rigorous data collection process that captures the research process's breadth and depth (Le et al., 2024; Ostlund et al., 2011). The survey captured broad, quantifiable data on household energy use patterns, fuel choices and key demographic information. The semi-structured interviews were used to gain insight into the complex, context-specific factors that could influence household renewable energy integration. By combining these two data collection methods, the research instruments seek to effectively achieve the research objectives through rigorous analysis of data gathered on household energy dynamics and policy implications in Nigeria.

4.4.1.1. Sampling Technique

Given the practical limitations of sampling a large, geographically dispersed population sample like Nigeria, a convenience sampling technique was adopted during survey distribution (Oke and Arowoiya, 2022; Jager, Putnic and Bornstein, 2017). The type of convenience sampling used during the survey distribution was a non-probability sampling approach, which allowed participants who were geographically accessible and willing to participate in the study (Jager, Putnic and Bornstein, 2017). This allowed for insights to be captured from various households across the six geopolitical zones of Nigeria, providing a comprehensive overview of the current household energy dynamics in the country.

To complement the quantitative data for the study, qualitative semi-structured interviews were conducted with key energy stakeholders within the Nigerian energy sector. These semi-structured interviews provided an in-depth understanding of Nigeria's socio-economic, political, policy, cultural and human-related barriers and drivers of household renewable energy integration. To achieve this, an in-depth knowledge of the contextual factors that hinder and drive renewable energy integration in Nigeria, purposive sampling was used in selecting participants for the semi-structured interviews. Purposive sampling, or judgment sampling, was explicitly used in this research to choose participants based on their knowledge and experience in renewable energy technologies (Campbell et al., 2020; Apostolopoulos and Liargovas, 2016). Using the purposive sampling technique in qualitative research focuses on selecting individuals with substantial knowledge and insight to maximise resource efficiency, highlighting the value of participants who are accessible, willing, and capable of articulating their thoughts and experiences (Unuigbe, Zulu and Johnson, 2020).

For this research, adopting a purposive sampling method ensured that the interviews captured diverse views on household renewable energy adoption, including insights from energy stakeholders who were directly or indirectly involved in renewable energy initiatives. However, various types of purposive sampling techniques are used in research, including homogeneous sampling, maximum variability sampling, case sampling, deviant case sampling, extreme case, critical case sampling and expert sampling (Campbell et al., 2020; Robinson, 2014). However, for this research, homogeneous purposive sampling is used as it allows for a focused selection of participants who have specific characteristics relevant to renewable energy integration in Nigerian households. Selecting participants with similar characteristics, such as households who use or do not use renewable energy, policymakers involved in renewable energy initiatives, and professionals in the Nigerian energy sector, ensures that diverse insights are gathered about the key issues being investigated.

The convergence of convenience sampling for the quantitative household survey and purposive sampling for the qualitative semi-structured interviews in this research facilitates both the breadth and depth of data collection (Sovavool, Axsen and Sorrell, 2018; Andrade, 2020). Andrade (2020) highlighted that combining purposive and convenience sampling is valuable when sociocultural and other contextual factors influence the outcome of the research. This combined approach is relevant to this research as exploring household renewable energy integration in Nigeria is largely influenced by various socioeconomic, cultural and policy factors (Geels et al., 2017; Sovacool, Hess and Cantoni, 2021).

4.4.1.2. Quantitative Survey Design

The survey was one of the primary instruments for collating data on household energy use patterns, attitudes towards renewable energy, and key socio-demographic information of participants for this research. It was designed and informed by theoretical insights from literature and modelled using guidelines from previous research by Edomah (2016) and Sovacool et al. (2018). Both studies (Edomah, 2016; Sovacool et al., 2018) guided the questions and themes that were significant in investigating household energy dynamics in Nigeria. To ensure a comprehensive design, the survey included open and closed-ended questions, giving participants the freedom to provide structured and contextual responses (see Appendix). The survey was designed and distributed digitally to ensure it was accessible and easy to complete. The survey was also structured and designed to capture key demographic information such as participants' educational background, household geographical location (urban or rural), and household type to ensure the representativeness of the data. Participants were selected using a convenience sampling technique to minimise bias and ensure non-overlapping of sampling groups. Given the practical limitations of sampling a large, geographically dispersed population sample like Nigeria, a convenience sampling technique was adopted during survey distribution (Oke and Arowoiya, 2022; Jager, Putnic and Bornstein, 2017). The sample size included 746 households from the six geopolitical zones of Nigeria and was determined to be statistically significant for a population of approximately 193 million people, with a 95% confidence level and a margin of error of ±4%. This diverse sample allowed the survey to capture various household perspectives and behaviours on energy consumption, reflecting the socio-cultural and regional diversity of Nigeria.

Sample size = $$\frac{\dfrac{z^2 \times p\,(1-p)}{e^2}}{1+\ \left(\dfrac{z^2 \times p\,(1-p)}{e^2 N}\right)}$$

Where N = Population size

e = Margin of error

z = z-score

P = Sample proportion.

The confidence level in sampling represents the likelihood that the sample population reflects the population's attitudes, while the margin of error connotes the percentage range within which a participant’s response may deviate from the sample's response.

However, out of the total number of questionnaires distributed for this study, only 746 responses were valid (n=740). Figure 4.5 illustrates the geographical distribution of the household survey for this research.

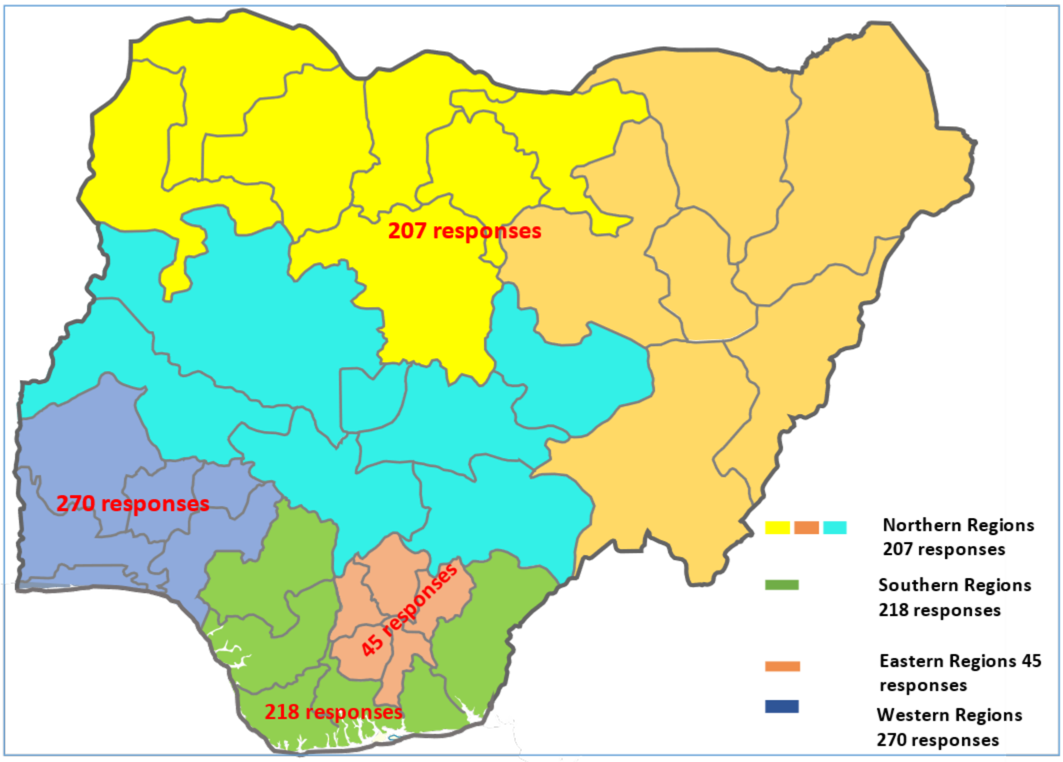

Figure 4. 5 Geographical Distribution of Households Used in the Survey

Source: Author Generated

4.4.1.3. Survey Data Analysis

The data derived from the survey distribution for this research was used to investigate household energy consumption patterns and attitudes towards renewable energy and identify the factors influencing renewable energy adoption in Nigeria. The data analysis for this research involved three stages: ensuring the quality of the data, identifying patterns, and testing whether findings align with the research objectives. Using Statistical Package for Social Sciences (SPSS) version 27, the analysis involved several steps to ensure data quality, identify trends, and test hypotheses aligned with the research objectives. An initial descriptive statistical analysis was conducted to summarise and present key socio-demographic characteristics of the data. This preliminary analysis provided an overview of the sample population, showing socio-demographic factors such as age, educational level, gender and household geographical distribution. The descriptive analysis also determined significant trends in household energy consumption behaviours and awareness of renewable energy technologies. The descriptive analysis of data is essential as it provides an initial understanding of the data, thus establishing the foundational context for a more detailed data analysis (Green et al., 2023).

Following the descriptive data analysis, a chi-squared test of independence was conducted on the data to assess the association between categorical variables (Shenoy, 2021). The chi-squared test was performed to specifically examine whether socio-demographic factors were significantly associated with household attitudes toward renewable energy adoption. By reviewing these categorical variables, the Chi-Square test will reveal significant associations between variables, providing insights into socio-economic factors that may influence the likelihood of adopting renewable energy technologies in Nigerian households. Conducting a Chi-Square test could offer insights into the potential barriers or drivers within different demographic segments, contributing to a nuanced understanding of the factors driving renewable energy perceptions (McHugh, 2013).

Correlation analysis was also performed to examine the relationships between continuous variables in the survey data to ensure data quality. Pearson correlation was applied to investigate the strength and direction of linear relationships, such as between household income, fuel price and renewable energy adoption levels. Additionally, Spearman's rank and Kendall's tau correlations were used for ordinal and non-normally distributed data, ensuring the analyses were appropriate for each variable type. This stage of analysis enabled a deeper exploration of potential associations, revealing, for example, whether higher income levels or fuel prices correlated positively with greater interest in renewable energy. By combining descriptive statistics, chi-squared tests, and correlation analyses, this multi-stage data analysis approach provided a comprehensive understanding of household energy behaviours, attitudes towards renewable energy, and the socio-demographic factors impacting energy choices (Zhang, He and Zhang, 2019). Together, these analyses enabled the study to draw evidence-based conclusions and formulate targeted recommendations for supporting renewable energy adoption within Nigeria, offering valuable insights for policy, energy sector stakeholders, and households.

4.4.1.4. Qualitative Semi-Structured Interview Design

The semi-structured interview for this research has been carefully designed to gain in-depth insights into the socio-economic, financial, policy, and political factors that impact renewable energy integration in Nigerian households. Reflecting on themes identified in the literature, the interview was structured around key themes such as energy challenges, renewable energy potentials and policies, barriers to renewable energy adoption and renewable energy awareness in Nigeria. Semi-structured interviews were chosen due to their adaptability, allowing the researcher to pursue structured questions while also enabling participants to expand on topics they felt were important (Ruslin et al., 2022; Dempsey et al., 2016).

Drawing on the guidance highlighted in Creswell and Creswell (2018), this study's interview design involved audio recording using a recording device, with prior consent sought from the interviewees. The interview guide was carefully structured, including an introduction, core content questions with probes, and closing instructions, following the design principles recommended by Creswell and Creswell (2018). Ethical approval was obtained from the NTU Research Ethics Committee before the interviews commenced, confirming the study's adherence to ethical standards. Prior to conducting the semi-structured interview for this research, a pilot study was carried out to assess the effectiveness of the interview guide and adjust it for clarity and coherence (Malmqvist et al., 2019; In, 2017). Conducting a pilot study was beneficial and productive, enabling the collection of in-depth, relevant data aligned with the research objectives (Malmqvist et al., 2019).

4.4.1.5. Pilot Study

To ensure the relevance and effectiveness of the interview guide, a pilot test was conducted with a small group of energy stakeholders in the Nigerian energy sector. Piloting the interview guide is an essential step in qualitative research, as it can reveal areas where the guide may lack clarity or where adjustments are needed to enhance the study's overall effectiveness (Lim, 2024). The pilot study was designed to test and validate the interview guide, ensuring it would facilitate meaningful, in-depth responses relevant to the research objectives. For the pilot study, semi-structured online interviews were conducted via Skype and Microsoft Teams with five energy stakeholders in Nigeria between 1st and 13th August 2018 (Creswell & Creswell, 2018). During this phase, the data collection instruments were tested among a smaller group of participants to assess the wording and clarity of questions and to determine whether they could generate comprehensive data aligned with the study's objectives (Nowell et al., 2017). Participants were also asked to provide feedback on the usability and effectiveness of the tools and their adherence to standard design principles (Nowell et al., 2017). Conducting the pilot study provided relevant insights that enhanced the research. Some critical issues identified during the pilot study were the complexity of some of the interview questions and spelling errors that could have led to misinterpretation and misunderstandings for the pilot study participants.

The pilot study provided valuable feedback from participants, where three interviewees pointed out issues with structuring some questions, as they believed could affect understanding of the question. While two other interviewees identified spelling errors that could alter the meaning of questions. The questions were simplified and revised to address these issues to ensure consistency, clarity, and ease of understanding for future participants. The pilot study was also important in tailoring the interview to reflect the socio-cultural complexities of Nigerian household and their energy situation. Additionally, the researcher collected and transcribed the pilot qualitative data, which was then analysed both manually and using NVivo software. The pilot study findings led to amendments in the semi-structured interview guide, which was subsequently validated as suitable for addressing the research questions. The following section outlines the sample size and recruitment technique and details how participants were selected for the study.

4.4.1.6. Interview Protocol and Qualitative Data Analysis

Thematic analysis was chosen as a suitable data analysis method for analysing the qualitative data from semi-structured interviews due to its ability to identify and interpret patterns in qualitative datasets (Sovacool, Iskandarova and Hall, 2023; Aslam and Rana, 2022). The analysis began with the data familiarisation phase, where the researcher first transcribed the data and became familiar with it by listening to the audio recordings, reading transcripts, and extracting preliminary ideas (Braun and Clarke, 2012). This familiarisation phase enabled the researcher to develop an in-depth understanding of the data, which led to the identification of recurring themes, laying the groundwork for coding (Gale et al., 2013). This was followed by the data coding phase, which was conducted in two stages. The first stage consisted of an inductive coding phase, where the researcher thoroughly read the transcript line by line without any preexisting theoretical assumptions, identifying recurring themes and any relevant statements made by participants (Naeem et al., 2023). An inductive coding process was employed due to the exploratory nature of the research, involving the application of a concurrent triangulation mixed-methods approach (see Section 4.3). This inductive coding process allowed the coding process to move from specific observations to broader generalisations by exploring themes that emerged naturally from participants' responses after the interviews (Bazen, Barg and Takeshita, 2021). This inductive phase enabled the identification of new patterns and themes directly related to the experiences and knowledge of energy stakeholders in the Nigerian energy sector. Codes were assigned based on substantive things such as emotions, impressions and behaviours (Naeem et al., 2023; Saldana, 2021).

As this process progressed, the codes were refined and sub-coded under broader themes; some were relabelled to capture key themes more accurately. The inductive coding process enabled the researcher to capture new emerging themes, particularly around socio-cultural barriers and other barriers to renewable energy integration in Nigerian households. The research also employed a deductive approach to complement the inductive coding process. This involved developing predefined themes from literature reviews on household energy dynamics in Nigeria (Clarke and Braun, 2017). The predefined themes that were developed from this stage included those related to socio-economic, financial, policy and political barriers to renewable energy adoption in Nigeria. This allowed for the immediate identification of predefined themes that are aligned with existing literature on household renewable energy integration in Nigeria, ensuring consistency and comparability.

In the second stage, the interview transcripts were exported into NVivo to organise and structure codes systematically. NVivo enabled the efficient management of the interview data and generated cross-referencing of codes across the interview transcripts to produce new themes (Niedbalski and Slezak, 2023). As additional transcripts were coded, the coding became more refined, and then a point of saturation was reached where no new codes or categories were generated, and a final coding sheet was developed.

Developing the final coding sheet in organising the data enabled the researcher to systematically group similar responses and identify patterns within the empirical data (Nowel et al., 2017; Gale et al., 2013). This coding sheet provided a clear record of evidence, demonstrating transparency and rigour in the data analysis process. Once the coding sheet was finalised, it was applied to all transcripts within NVivo to ensure consistency. After completing this systematic coding process, the analysis moved to the interpretative stage, where explanations and insights were drawn from the data, answering the research questions and contributing to a comprehensive understanding of the factors influencing renewable energy adoption in Nigeria.

The interview protocol and coding process were conducted by following the six-step thematic analysis framework proposed by Braun and Clarke (2006), which involved the following.

a) Familiarising with the data phase
b) Generating initial code
c) Identifying themes
d) Reviewing themes
e) Defining and categorising themes
f) Charting themes into a framework and reporting

Table 4.3 provides a summary of the thematic procedures used in the research.

Table 4. 3 Summary of the Thematic Analysis Procedures Used in this Research

Stages	**Overview of Stages**	
	Iterative Analysis	**NVivo Analysis**
Familiarisation with qualitative data	The researcher transcribed, read, and re-read qualitative data. Initial insights were noted, highlighting key themes such as "energy challenges," "public awareness," and "barriers." Reflective notes were generated to inform the thematic analysis process.	Uploaded transcribed data into NVivo to continue further reading and reflection on data.
Generating initial codes	Initial insights were noted, highlighting key themes such as "energy challenges," "public awareness," and "barriers." Inductive coding was mainly used to note categories relevant to the research questions.	The researcher developed codes for highlighted phrases from the interview, which led to initial themes identified from criteria-based literature reviews on barriers to renewable energy integration.
Searching for themes and sub-themes	Developed initial codes and refined codes into themes and sub-themes until saturation was reached.	Codes were organised into primary themes (e.g., Energy Challenges) and sub-themes (e.g., inadequate electricity supply, high cost of renewable energy technology, weak manpower capacity).
Reviewing identified themes	Connections were made between themes and analysed to identify subcategories and associations.	The themes were reviewed and re-examined using NVivo to ensure accurate categorisation and representation of data, with emphasis on the relationship between socioeconomic, financial, policy-political, and human factors and renewable energy adoption.
Defining and naming themes	Further refinement of themes was done to define themes and develop a matrix of themes and codes.	Each theme was reviewed and named to reflect its essence, and a coding matrix was developed to structure themes like "policy challenges" and "public perception" aligned with the research objectives.
Interpreting/writing of findings	To frame a discussion of findings, selected extracts for each theme and sub-theme were used in the findings section of the thesis.	Data extracts were presented and discussed to show key findings, linking the themes and sub-themes to the research questions. Findings were discussed and presented, reflecting on previous studies within the field of renewable energy adoption in Nigerian households.

Source: Synthesised from Braun and Clarke (2006); Clarke and Braun (2017); Creswell and Creswell (2018).

4.5. Reliability and Validity

Ensuring reliability and validity is crucial to this study, which combines quantitative and qualitative approaches to achieve an in-depth understanding of household renewable energy integration in Nigeria. By combining quantitative and qualitative research approaches, the research adopts a mixed-methods design, leveraging the strengths of each method to answer the research questions and achieve the research objectives. However, ensuring reliability and validity in mixed-methods research requires coherence and consistency in data analysis and rigour to gain credibility and reliability of results (Creswell et al., 2008). Researchers conducting mixed-methods research must pay careful attention to reliability and validity issues concerning methodological alignment with data handling and analysis to increase analytical and systemic rigour in their study (Sovacool, Axsen and Sorrell, 2018; Rose and Johnson, 2020).

For this research, reliability focuses on the consistency of the measures used in data gathering, handling and analysis, as well as the reproducibility of results (Polit, 2014; Abowitz and Toole, 2010). However, with the research being mixed-methods, reliability was approached differently and separately across the qualitative and quantitative parts of the research. In the qualitative stage of this research, reliability is often associated with the dependability and consistency of the measures used in qualitative data analysis (Rose and Johnson, 2020). A systematic and iterative approach was employed to handle the data from semi-structured interviews and achieve reliability. The audio-recorded semi-structured interviews were manually transcribed, allowing for familiarisation with the data and ensuring key themes from participant responses were captured. NVivo software was also used to enhance reliability by producing more structured coding that was consistently applied to the interview data. The researcher also adopted a reflexive approach during the thematic analysis to acknowledge the shortcomings and biases involved in conducting qualitative research (Braun and Clarke, 2024). This reflexive approach required the researcher to re-read and re-examine the initial codes and themes generated to ensure that they were consistent with the data and reflected the participants' views on the questions asked during the interview. The study also ensures reliability by recording events and keeping a record of decisions made during the research process while maintaining transparency in data coding and interpretation (Amin et al., 2020). Validity and credibility were ensured during the qualitative phase by conducting a pilot study to test and validate the interview process. The pilot study provided clarity and relevance of the interview process to align with the research questions by using responses from participants to answer the research questions (Nowell et al., 2017).

In the quantitative stage of the research, the reliability and validity of the study are to be achieved by developing the survey from insights gathered from established frameworks and constructs in previous studies. To ensure consistency, the researcher analysed the reliability and validity of the scales using SPSS. Cronbach's alpha was calculated for each construct, which resulted in seven items being hypothesized: availability of fuel (2 items with Cronbach α of 0.91), price of household energy source (3 items with Cronbach α of 0.94) and household income (3 items with Cronbach α of 0.98). Employing Cronbach's alpha ensured that each item with each measure showed an acceptable level of reliability (Okolie et al., 2021; Pokubo, Pepple and Al-Habaibeh, 2024). Additionally, standardised protocols were followed during the distribution of surveys. Validity was also ensured by aligning the survey design and questions asked to key themes from literature, such as socio-economic dynamics, renewable energy awareness and perceptions.

4.6. Ethical Considerations

To ensure transparency and credibility in the research process, researchers must adhere to established ethical and moral guidelines (Saunders, Lewis and Thornhill, 2015). Ensuring ethical adherence is crucial to the integrity and validity of the research results and ensuring confidentiality for the research participants (Petrova, Dewing and Camilleri, 2014). This research involves human participants, therefore requiring the researcher to safeguard the interests of the research participants while conducting the research. A crucial aspect of preserving the research participants is obtaining informed consent before conducting the research (Saunders, Lewis and Thornhill, 2015).

Therefore, to ensure adherence to ethical standards, all participants involved in the survey and semi-structured interview process were informed about the aim of the research, its objective, and their role and rights if they chose to participate.

The consent process entails providing participants with an information sheet about the research, allowing them to ask questions, ensuring voluntary participation, obtaining written consent via a consent form, and maintaining detailed documentation of the process. The process of obtaining and recording valid consent will follow established ethical guidelines and best practices to ensure individuals' voluntary and informed participation. Participants were also presented with online and written consent forms for the online surveys and face-to-face interviews, which they were required to sign and give their consent indicating their agreement to participate in the study. The researcher ensures freedom of participation by allowing participants to ask questions and seek clarification about any aspects of the study they do not understand. Participants were also informed that their responses to both survey and interview questions would remain anonymous and that the data derived from the data collection processes would be solely for research purposes. Participants were also informed of their right to withdraw from the research process when needed.

Privacy and confidentiality measures were strictly adhered to throughout the research process. As the participant information sheet for the survey and interview indicated, the participant's information will be protected following all General Data Protection Regulations (GDPR), and the findings will only include summarised responses and selected extracts from the anonymised data. To ensure compliance with ethical standards, both data collection methods did not collate any data relating to the personal information of participants as unique identifier codes were given to each participant involved in the survey and interview (e.g., RP01 for survey participants and INT01 for interview participants) (Audette, Hammond and Rochester, 2020). To ensure the confidentiality of participant data both during the research and in the release of its findings, the researcher will separate identifiable and non-identifiable information and anonymise the data. All collected data, including physical copies (transcripts and research notes), will be stored securely in locked cabinets.

Electronic data (interview recordings, transcripts, and survey responses, anonymised as needed) will be stored on the researcher's password-protected NTU computers using NTU OneDrive, with controlled duplication and no unauthorised access. Electronic and physical data will be promptly scanned and stored on the NTU Datastore after transcription to ensure confidentiality. Digital transcripts and copies will be password-protected, complying with UK GDPR/DPA 2018 regulations, emphasising transparency and consent. Additionally, before the commencement of data collection, the research received ethical approval from the Nottingham Trent University (NTU) Research Ethics Committee. This approval detailed the process of adhering to the NTU research ethics guidelines and ensuring that participants were treated fairly and respectfully.

4.7. Limitations and Reflection on Methodological Approach

Despite the measures taken to ensure the credibility, reliability and validity of the research process, some limitations exist. For example, quantitative data in any research allows for generalisable insights (Polit and Beck, 2010). However, the use of convenience sampling is likely to introduce bias, potentially affecting the validity of the study (Galloway, 2005). Also, in the qualitative phase, social desirability bias could influence participants' responses to interview questions, given the nature of the research (Bergen and Labonte, 2019). To minimise these limitations, the researcher ensured framing both survey and interview questions from a neutral perspective. However, these limitations remain limitations to consider for future research.

Additionally, the quantitative survey design in section 4.4.1.2 shows that the quantitative data is skewed towards the eastern region. This regional skewness resulted from the logistical and accessibility challenges encountered during the data collection process in the eastern region of Nigeria. Additionally, the difference in cultural factors and regional perspectives on research participation affected the participation rate of participants in this region. Most eastern participants assumed the distribution of the electronic survey was a scam to defraud them, hence losing trust. To mitigate the impact of the skewed data on the reliability of the findings for this research, the sampling approach was adjusted to capture various demographic characteristics and energy consumption trends of survey participants. Additionally, weighted analysis was considered to mitigate the impact of the skewed data on the research findings (Gopisetty and Sama, 2024). While this method tries to reduce bias and improve the robustness of the data, the limitations still remain, suggesting that the data does not capture the diverse views and experiences of households across Nigeria.

4.8. Summary

This chapter provided an in-depth justification for the research methods and approaches employed to conduct this research. The researchers ensured that all methods used were in alignment with the research aim and objectives. The exploratory research adopted a mixed-methods approach toward conducting the inquiry for this research. Questionnaires were distributed across the six geopolitical zones in Nigeria, and face-to-face interviews were conducted with key energy stakeholders from the energy sector in Nigeria. Having provided detailed documentation of the research design and methodology, the next chapter presents the findings from the data collection stages of this research.

Chapter 5. Analysis of Data from the General Questionnaire amongst Households

5.1. Introduction

This chapter presents empirical findings from the survey that was distributed to the general population in Nigeria to achieve the research objective and answer the third research question. The results from the survey were extrapolated, and a discussion of the results is presented below. The survey's main aim was to obtain data that would specifically achieve research objectives 1, 4, and 5 and answer research questions 1 and 3, as shown in Table 5.1 below. The survey was administered using various online and social media platforms such as email, WhatsApp, Facebook, Twitter, and text messaging applications. The techniques applied to analyse the data derived from the questionnaire require choosing the most appropriate analytic methods for each question on the questionnaire (For example, averages, frequencies, percentages, correlations, or content analysis). The questionnaire survey was conducted to solicit the opinions and perceptions of Nigerian household energy consumers (the general public). This is used to achieve the research objectives that can only be achieved via public opinion on the likelihood of adopting renewable energy.

Table 5. 1 Research questions and objectives answered by the survey for the research

	RESEARCH QUESTION (RQ)	RESEARCH OBJECTIVES
SELF-COMPLETED QUESTIONNAIRES	**RQ1.** What are the current household energy challenges in Nigeria? **RQ3.** What are the main drivers and barriers to household renewable energy adoption in Nigeria?	**Obj 4 -** To investigate the household energy challenges driving a shift towards integrating renewable energy technologies in Nigerian households. **Obj 6 -** To identify the factors influencing household renewable energy adoption amongst Nigerian households. **Obj 5** – To assess the public behaviour towards accepting renewable energy technologies in lieu of government subsidies on fossil fuels.

5.2. Socio-Demographic Profile of Participants for the Survey

Drawing on the complex nature of this research within the context of energy studies, socio-demographic data were collected to provide deep insight into the complexities of energy consumption and adoption within households. Socio-demographic factors in energy research are often considered significant when investigating variability in energy demand, consumption, and the likelihood of household energy adoption (Zhang, Sun and Tian, 2020; Frederiks, Stenner and Hobman, 2015). To justify the need for collating socio-demographic data, this study produced an integrative conceptual framework of the various socio-demographic variables and situational factors that are likely to influence the adoption of renewable energy in Nigerian households (as shown in Figure 5.1).

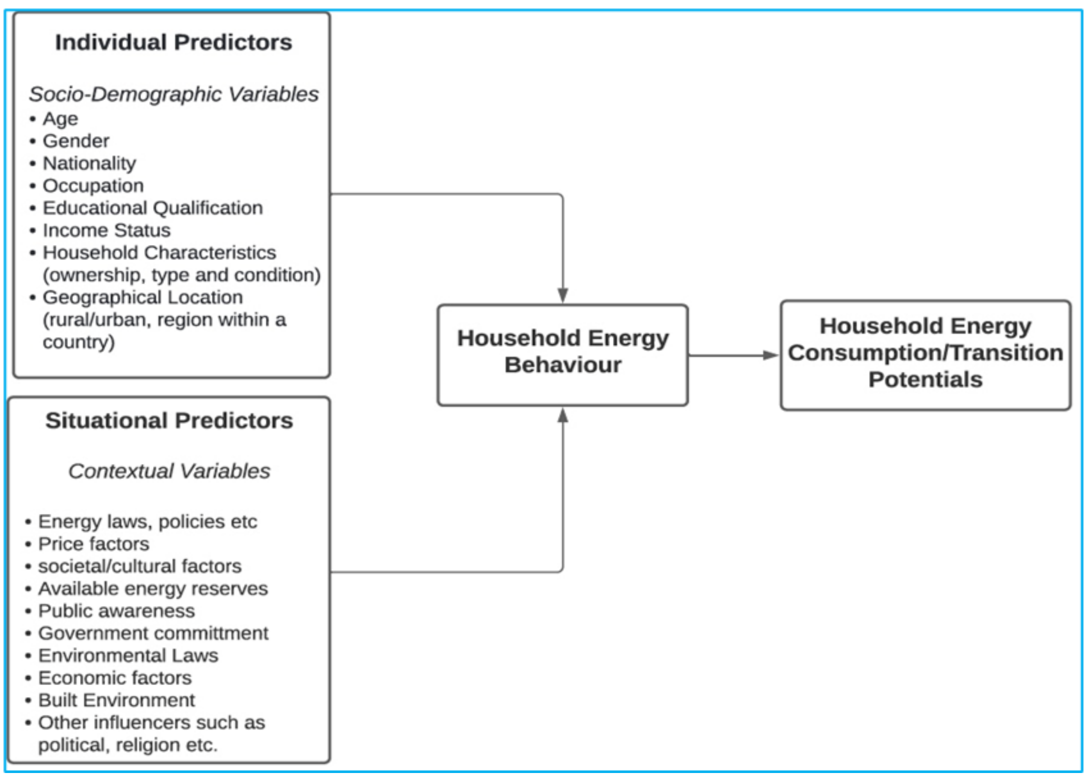

Figure 5. 1 Integrated conceptualisation of variables that influence household energy adoption

Source: Author Generated

Therefore, for this study, participants were profiled in relation to their nationality, age range, gender, occupation, level of education, area of home, housing type, and regional location of home. All participants participating in the questionnaire survey were profiled in relation to these socio-demographic variables, and the findings are discussed below.

5.2.1. Nationality

The researcher designed the first section of the questionnaire to assess the nationality of participants. Of the 746 participants, 98.7% were Nigerians, while 1.3% were non-Nigerians, as indicated in Table 5.2 and Figure 5.2. This shows conformance with the necessary sample focus, as non-Nigerians may not be fully capable of discussing issues of energy sources and energy challenges in Nigeria. This indicates that the research population reliably represents those affected by the research topic.

Table 5. 2 Nationality of participants

		Frequency	Per cent	Valid Percent	Cumulative Per cent
Valid		7	.9	.9	.9
	Nigerian	729	97.7	97.7	98.7
	Non-Nigerian	10	1.3	1.3	100.0
	Total	746	100.0	100.0	

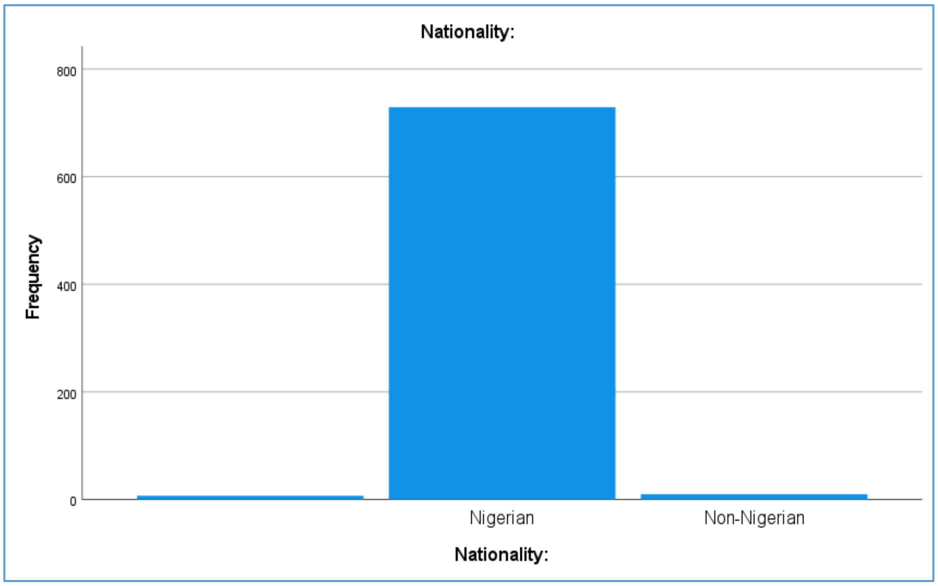

Figure 5. 2 Responses on the nationality of research participants in the survey

5.2.2. Participant's Gender

Studies over the past decade have revealed links between energy systems, gender, and socio-economic development (Fathallah and Pyakurel, 2020; Johnson, Gerber and Muhoza, 2019; Pachauri and Rao, 2013; Oparaocha and Dutta, 2011). Ryan (2013) suggested that, due to the interdisciplinary nature of energy studies, it is imperative that energy researchers and policymakers place gender at the core of energy research. This is because the impacts of energy systems affect not only economic sectors but also social systems in any national economy (IEA, 2019; Pachauri et al., 2012).

Therefore, the researchers for this study assessed the gender identity of participants, as shown in Figure 5.3 and Table 5.3. It is significant that both genders are adequately represented in this research.

Table 5. 3 Gender distribution

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		7	.9	.9	.9
	Female	323	43.3	43.3	44.2
	Male	416	55.8	55.8	100.0
	Total	746	100.0	100.0	

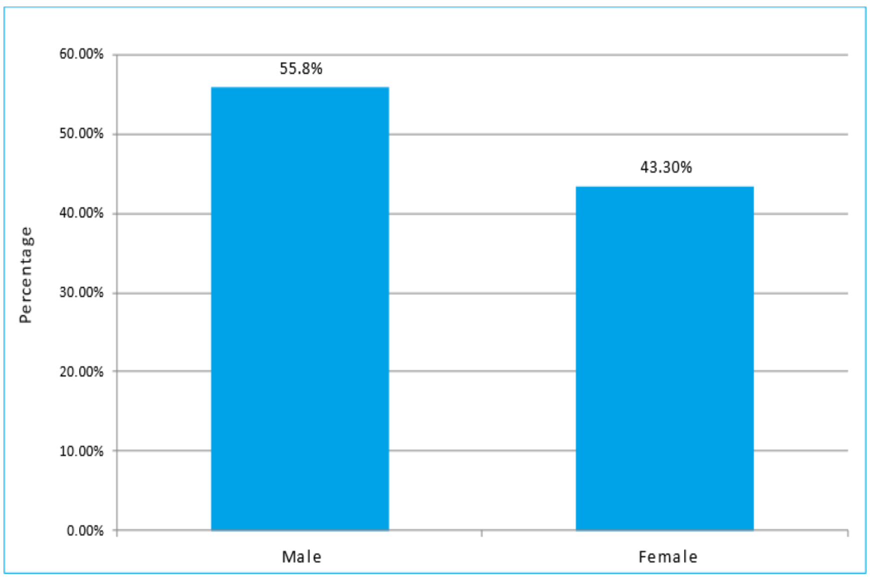

Figure 5. 3 Gender distribution of participants

While the research topic is not gender-centric, results from the survey show that more males (55.80%) than females (43.30%) are represented in the research population, thereby increasing the research credibility. Research in Nigerian homes has shown that males tend to be the head of households and a major determinant of the kind of energy being used in households (Danlami, Applanaidu, and Islam, 2018; Nwaka et al., 2020).

Additionally, males in most households in developing countries are tasked with the responsibility of catering to the family, and they often travel to urban cities to find employment and earn income for their households (Eludoyin and Lemaire, 2021). Female household members are often tasked with performing various domestic activities, such as cooking and collecting fuel in households (Dutta et al., 2018). Since both genders have different significant roles in the household, they have a certain degree of influence over the choice of fuel used in the household. However, consensus suggests that females are more susceptible to economic, social, and financial exclusion when compared with men (Nwaka, Uma and Ike, 2020; Choudhuri and Desai, 2020). As a result, the impacts of household choice of fuels mainly affect women as they are majorly responsible for performing most household activities such as cooking, cleaning, washing, and fetching fuel (firewood or charcoal) as cooking fuels (Jewitt, Atagher and Clifford, 2020; May, McGarvery and Kucera, 2018). Therefore, this research argues that household gender inequality contributes significantly to influencing household choice of fuel. As such, comparisons between the two participant groups (male versus female) for this research will be conducted in subsequent sections of this analysis.

5.2.3. Age Distribution of Participants

Most participants for this research were between 18 and 65 years old. Findings from the survey shown in Table 5.4 and Figure 5.3 reveal that 25—34-year-olds had the highest proportion of responses (51.6%), followed by 18—24-year-olds, who had the second highest proportion of responses (28.7%). Participants 65 years old and above accounted for the survey's lowest share of responses (0.27%).

Table 5. 4 The age range of participants

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		7	.9	.9	.9
	18-24	214	28.7	28.7	29.6
	25-34	385	51.6	51.6	81.2
	35-44	111	14.9	14.9	96.1
	45-64	27	3.6	3.6	99.7
	65 or over	2	.3	.3	100.0
	Total	746	100.0	100.0	

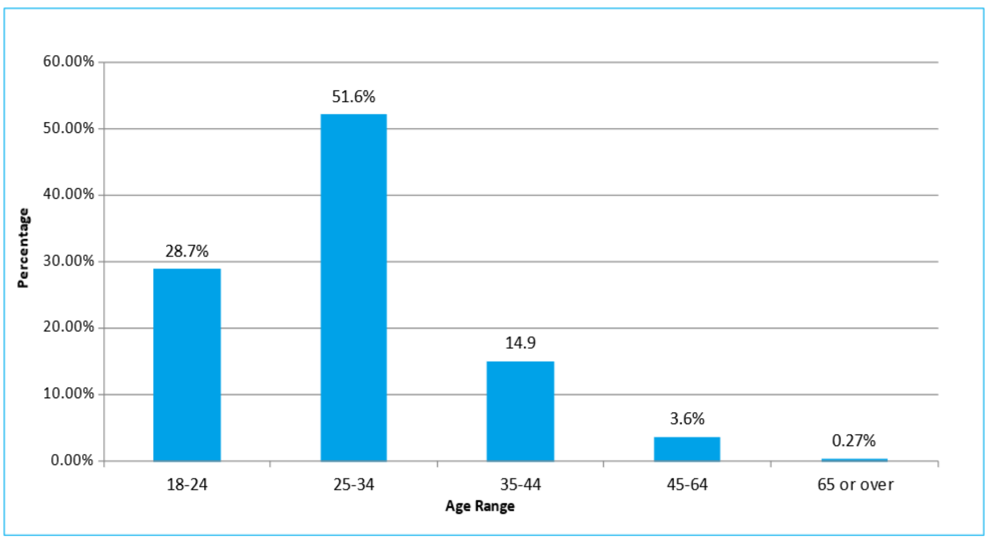

Figure 5. 4 Age range of participants

Research shows that household energy choice is sometimes influenced by socio-demographic factors like age, gender, household head, size of household, etc. (Rahut, Behera, and Ali, 2016). However, the exact relationship between some of the socio-demographic factors (such as age) and energy use is sometimes seen as complex and understudied (Estiri and Zagheni, 2019).

Nonetheless, because age is a significant proxy for many life choices, age is often seen as one of the influencers of energy choices in households (Estiri and Zagheni, 2019; Aberu, de Oliveira and Lopes, 2020; Fell and Chiu, 2014). As such, an important variable to investigate in this research is whether age can influence the public's choice of renewable energy. Although age is not a dominant factor in the determination of energy choices in Nigeria, due to the cost of energy generation and billing, a representative sample of the workforce is expected to be included. The chart shows that the majority fall within the active working age of 25-34; typically, those who work and purchase fuel for household use represent a valid research population. Therefore, it is unsurprising that the majority of the participants were within the age bracket of 25 to 34 years old. This aligns with the published census data, which reveals that Nigeria has a relatively youthful population, and such migration to urban cities is assumed to be high due to the quest for employment and better living standards (Makinwa-Adebusoye, 1992; Nigerian Bureau of Statistics, 2016).

5.2.4. Educational Qualification

According to Heltberg (2004), the level of education within a household is also regarded as an influencer of energy consumption behaviour and other energy practices in a household. Helberg (2004) highlights that households or people with higher levels of education are likely to use cleaner fuels or be aware of the impacts of their energy consumption behaviour. Therefore, for this research, participants were profiled in relation to their educational qualifications, and a summary of their academic qualifications is illustrated in Figure 5.5.

Table 5. 5 Qualification of Participants

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		47	6.3	6.3	6.3
	BA/BSc	403	54.0	54.0	60.3
	Diploma	3 4	4.6	4.6	64.9
	MA/MSc	220	29.5	29.5	94.4
	PhD	23	3.1	3.1	97.5
	Primary school	1	.1	.1	97.6
	Secondary school	18	2.4	2.4	100.0
	Total	746	100.0	100.0	

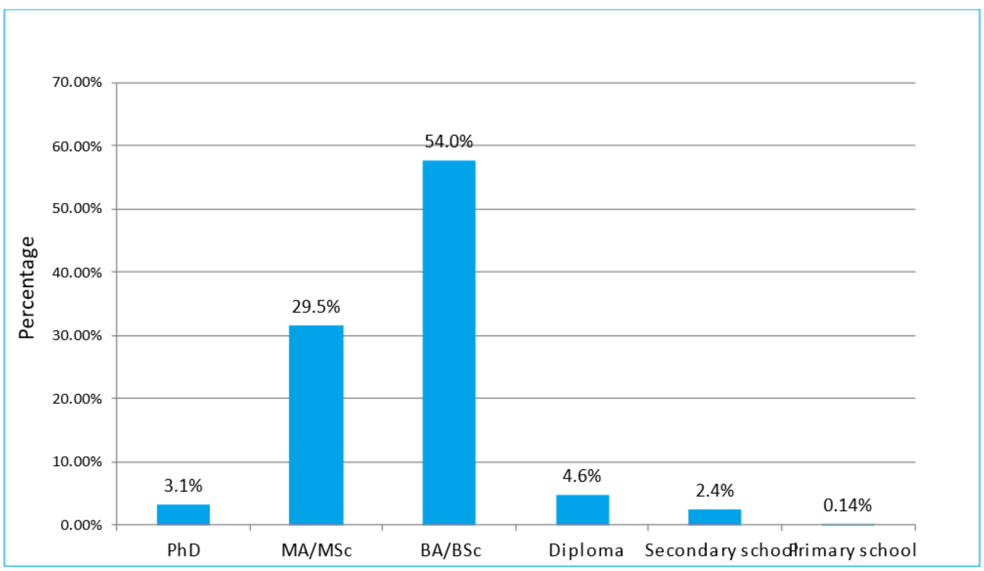

Figure 5. 5 Participant's educational level

Similarly, Walker et al. (2010) argue that household level of education is linked with improved awareness and technical knowledge of energy systems, which can act as drivers to encourage renewable energy consumption in households. Assessing household educational level is highly significant for this research. It helps the researcher to understand if households are aware of the impact of their current energy consumption patterns and the potential benefits of introducing renewable energy into their household energy consumption mix. However, from Figure 5.5, it can be observed that household access to secondary school and adult education is low. This is due to the low level of education available for most Nigerian citizens living in rural communities as compared to those in urban cities who have increased access to educational systems. Hence, a higher proportion of participants indicated that a B.Sc. and an M.Sc. were the highest levels of education.

5.2.5. Employment Status

Anderson et al. (2017) suggested that socio-economic variables such as employment status and household income are key variables that influence household energy consumption, especially in relation to affordability and accessibility of household fuel choice. Rahut, Behera and Ali (2016) added that employed household heads are likely to choose from a set of alternatives and can afford cleaner fuels for household consumption. This is because if a household head or member is in full-time/good employment, the time spent and cost of collecting non-clean fuels would impact the time and cost needed to generate family income from their job. However, the positive effect of employment on choosing clean, modern fuels would not hold true if the household size is relatively large (Heltberg, Arndt, and Sekhar, 2000). As such, even if a household head is gainfully employed, a large household size would have a negative impact on the likelihood of choosing cleaner fuels to meet household energy demand (Pandey and Chaubal, 2011).

As indicated in Table 5.5, non-governmental workers account for the highest share of participants (27.7%) regarding employment status.

Table 5. 6 Occupation of participants

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		31	4.2	4.2	4.2
	Civil servant	101	13.5	13.5	17.7
	Housewife	2	.3	.3	18.0
	Non-governmental worker (private employee)	205	27.5	27.5	45.4
	Retired	3	.4	.4	45.8
	Self-employed	136	18.2	18.2	64.1
	Student	199	26.7	26.7	90.8
	Unemployed	69	9.2	9.2	100.0
	Total	746	100.0	100.0	

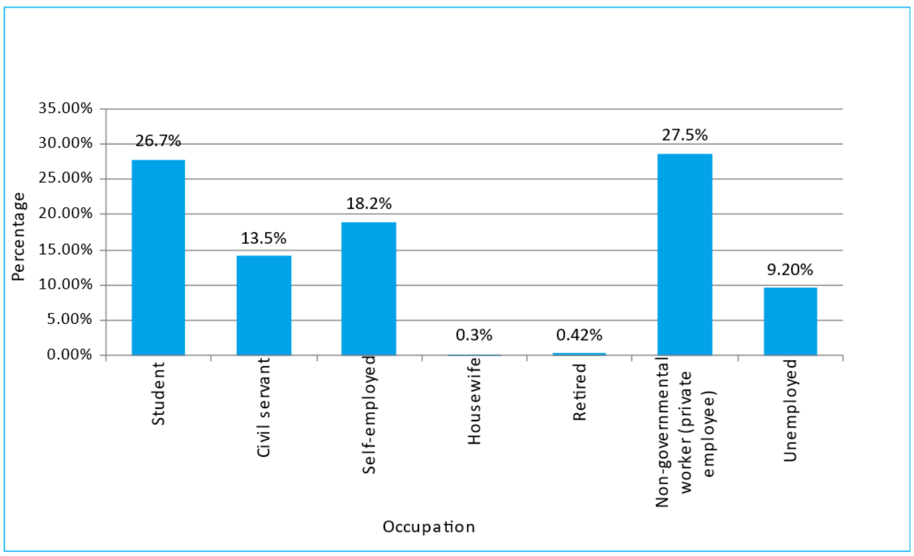

Figure 5. 6. Occupation of participants

From Table 5.6, a higher proportion of participants indicated that they are non-governmental workers (27.5%), which stresses the socio-economic vulnerabilities experienced in Nigeria, particularly high unemployment rates (Odusola and Obadan, 2018). Most workers in the country work for private organisations or are self-employed due to governmental challenges in relation to providing jobs for Nigerian citizens.

5.2.6. Regional Location and Area Location of Households

According to Zile (2019), the location of homes is related to the energy resources that are preferred. Due to the closeness of households in the southern region of Nigeria to fossil fuel reserves, households in the southern region of Nigeria may be more disposed to fuel-based energy sources and hydroelectricity. While those in the northern part of Nigeria have higher solar generation capacity. Therefore, northern households may be more interested in solar energy sources, while those in the West with access to wind and sea may prefer energy generated from such alternative sources. All regions are considered to ensure a holistic analysis, as shown in Figure 5.7.

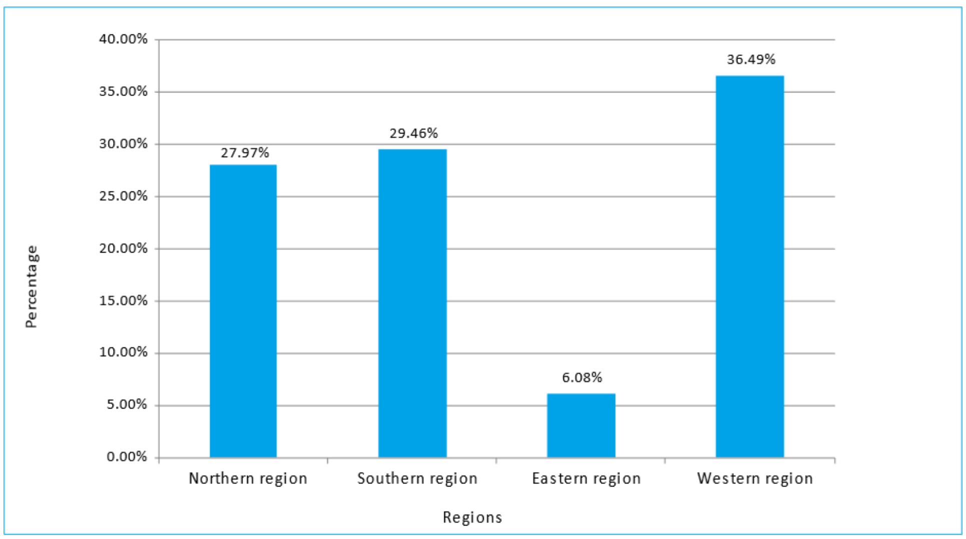

Figure 5. 7 Regional location of households in Nigeria

Similar to the significance of the regional location of households and how those influence energy choices, the area location of households also determines what type of fuel households will have at their disposal. In Nigeria, the type of primary energy consumed varies significantly between urban and rural areas (Shaaban and Petinrin, 2014; Adamu et al., 2020; Olaniyan et al., 2018). Rural dwellers have very little access to clean, modern energy sources and often rely on traditional sources of energy (Gungah, Emodi and Dioha, 2019). As such, it is crucial to examine this aspect when investigating the likelihood of Nigerian households adopting renewable energy. Based on the responses derived from the survey, 95% of participants indicated they were urban dwellers, while 4.86% of participants were rural dwellers. Figure. 5.8 shows the distribution of households between urban and rural dwellers.

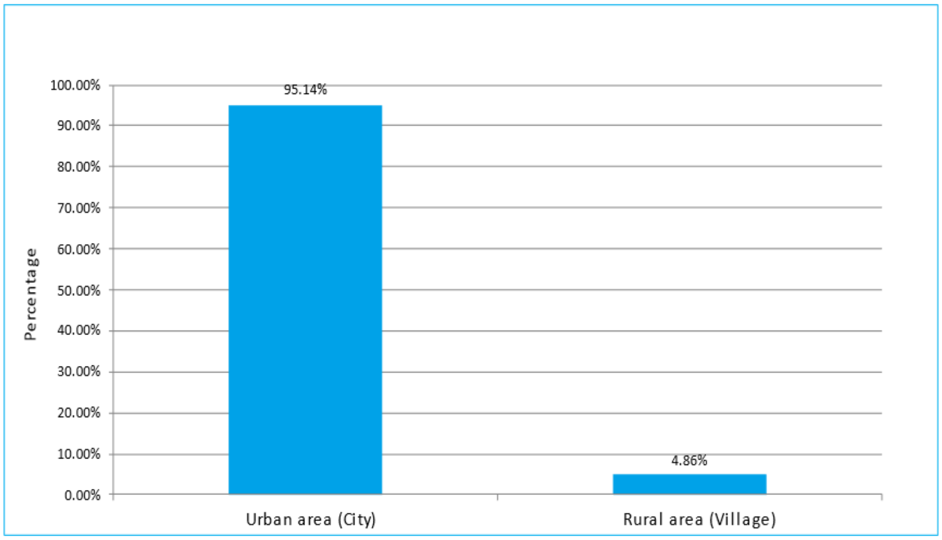

Figure 5. 8 Area location of households in the survey

The reason for the low percentage of turnout in rural responses was the lack of electricity to power mobile phone devices or computers used for filling out the survey, which resulted in the inability of participants to fill out the questionnaires. In addition, the poor road network to most rural villages also made it difficult for researchers to distribute questionnaires to some rural communities.

5.2.7. Housing Type Distribution in the Study Area

Studies show that the type of house in which people live is likely to influence their energy choices. Siksnelyte-Butkiene, Zavadska & Streimikiene (2020) suggested that people who stay in private houses tend to consider alternative energy sources more than those in rented apartments. Therefore, the researcher investigated housing type as a variable that can influence participants' preference to choose either renewable or conventional energy resources. Participants were asked to indicate what kind of houses they lived in on the questionnaire. Figure 5.9 shows the various housing distribution types attained from responses to the survey.

Table 5. 7 Types of houses lived in by participants

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		10	1.3	1.3	1.3
	Government-owned apartment	18	2.4	2.4	3.8
	Private house	343	46.0	46.0	49.7
	Rented apartment	294	39.4	39.4	89.1
	Rented house	81	10.9	10.9	100.0
	Total	746	100.0	100.0	

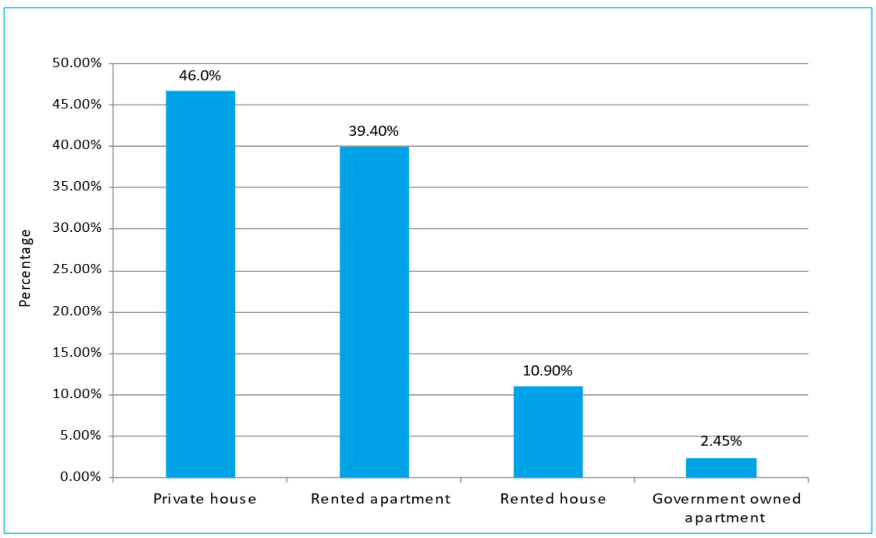

Figure 5. 9 Housing type distribution

The researcher found that 46% of participants in the survey lived in private houses owned by the household or the household head. Some indicated that they purchased their land and built their homes. 39.40% of participants stated that they lived in rented apartments obtained through private landlords. 10.90% of participants indicated living in private rented houses. A few other participants (generally young people) indicated they lived in self-contained flats or shared houses, renting just a room.

These responses, in terms of housing type, are an accurate representation of the current housing types or dwelling units in Nigeria, as demand for housing is mainly met by private housing developers (Jaiyeoba and Aklanoglu, 2012; Daniel and Hunt, 2015; Obianyo et al., 2021). The findings also reveal Nigeria's housing and residential infrastructure development challenges. Energy-efficient buildings or government-built houses are rarely available in Nigeria (Obianyo et al., 2021). Although a few government housing schemes have made some houses available, these government houses are often too expensive for most citizens. Observations made during data collection revealed that most of the houses in Nigeria are arranged in a heterogeneous pattern and are mainly family homes built by individuals (household heads) or collectively belonging to the family (Aluko, Oloruntoba, and Chukwunenye, 2018).

5.3. Energy Challenges of Nigerian Households

This section uses findings from the survey to answer research question one, which focuses on investigating the energy challenges faced by Nigerian households. The section also aims to achieve research objective one, as it is crucial to assess the impact of energy challenges on the adoption potentials of Nigerian households. A mixture of open and closed-end questions was asked, and a descriptive analysis of participants' answers was presented based on the energy challenges that they experienced. The section also demonstrated participants' views on what might be the likely challenges to utilising renewable sources as well as provide solutions to solve energy challenges and encourage the adoption to cleaner energy sources. A summary of the participant's responses is presented as follows.

5.3.1. Assessment of Current Energy Challenges in Nigerian Households

As mentioned in Chapter 1 (section 1.1), one of the major energy challenges facing Nigerian households is severe electricity shortages, as almost half of the country's population is without access to electricity (Aliyu, Dada and Adam, 2015; Oseni, 2017; Adewuyi et al., 2020). While most households in Nigeria experience recurrent electricity blackouts for 19 hours daily (Dina, 2014; Okoye and Omolola, 2019; Adelakun and Olanipekun, 2020). As such, participants were asked about the impact of these blackouts on their well-being and daily lives, as presented in Figure 5.10 and Table 5.8.

Table 5.8 The impact of electricity outages/blackouts affects households' daily operations.

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		9	25.0	25.0	25.0
	Agree	190	25.7	25.7	37.5
	Disagree	13	1.7	1.7	62.5
	Neither agree nor disagree	33	4.8	4.8	75.0
	Strongly agree	493	66.8	66.8	87.5
	Strongly disagree	8	1.0	1.0	100.0
	Total	746	100.0	100.0	

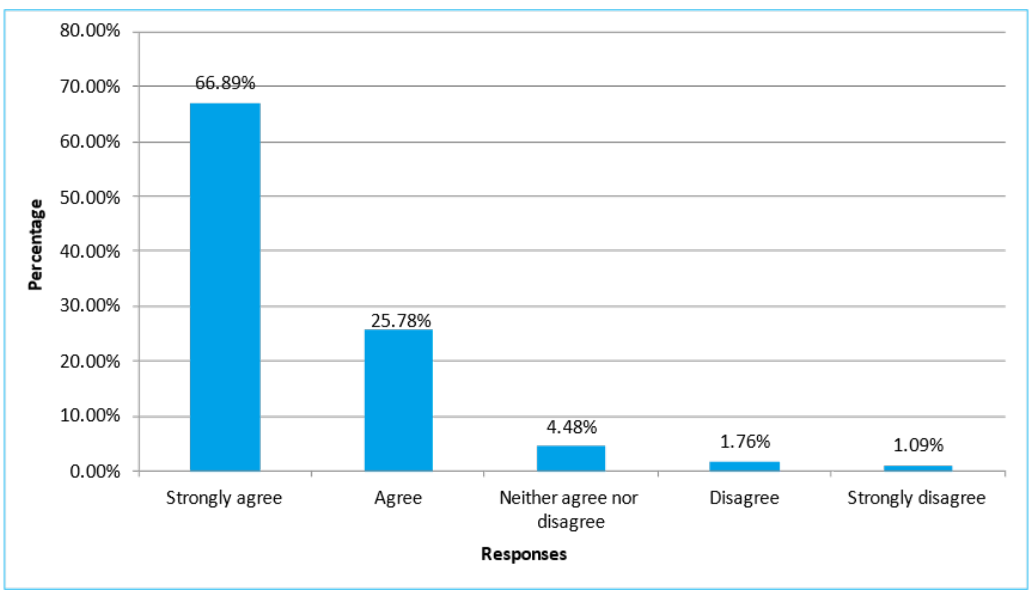

Figure 5. 10 Impact of electricity outages on household well-being

Responses from the survey show that 683 participants (92.67% of responses, i.e., 66.89% + 25.78%) strongly agree or agree that the occurrence of electricity cuts and blackouts negatively affected the daily running of their households. While 4.48% of the participants maintained a neutral opinion (neither agreed nor disagreed), only a few (1.76% disagreed and 1.09% strongly disagreed) disagreed or strongly disagreed that the recurrent blackout negatively impacts their daily lives. However, considering that most of the participants indicated that these recurrent outages affect their daily lives shows the severity of the energy challenges most Nigerian households face. Electricity abnormalities and supply shortages often adversely affect various household activities, including lighting, heating, cooling, cooking, and refrigerating (Adelakun and Olanipekun, 2020).

Responses from participants on the energy challenges they face also show that slow socio-economic growth, reduced social life, combined with high levels of criminality and insecurity, form part of the negative impacts of electricity outages on their daily lives. Participants' comments on the effects of electricity outages on their daily lives buttress the severity of the energy challenges experienced by most Nigerian households:

> "*The current electricity problem makes me feel unsafe and insecure when I am on my way home from work. Especially at night as the streets are not illuminated, the streetlights do not work.*" (RP040)

Participant RP343 also had a similar comment to RP040:

> "*We do not have steady power supply in our area… once they take the light everywhere gets dark and we feel unsafe as it is when it is dark criminals operate.*" (RP343).

To further examine the extent of the impact of electricity shortages and outages on the daily lives of households, participant RP326 stated that:

> *"At school once the lights go off, I have to use candle or a lantern to study at night which sometimes affects my eyes."* (RP326)

Some participants from the rural villages indicated reliance on traditional fuels such as charcoal and firewood as cooking fuels due to inadequate access to electricity and financial constraints. This negatively affects their health and socio-economic development as they often spend an average of two days every week gathering firewood for cooking purposes (Jewitt, Atagher and Clifford, 2020). For example, participant RP004 stated that:

> *"…some mornings, I have to go to the mangrove to collect wood for cooking before I get ready for school… or I do that after school."* (RP004)

The comment given above agrees with findings from the literature (section 2.2.2) that the lack of access to electricity and other clean fuels results in reliance on traditional fuels like firewood and charcoal in most developing countries (Acheampong, Dzator and Shabaz, 2021). Therefore, this results in stunted socioeconomic growth and opportunities, especially for women and children, as they bear the responsibility for collecting firewood for cooking activities due to inadequate access to the electricity supply (Adedayo, Oyun and Kadeba, 2010; Cicowiez et al., 2022). This shortfall in electricity supply and recurrent outages impose enormous costs on most Nigerian households as they seek alternative sources of energy to tackle the shortage in electricity supply and meet their household energy needs. For most Nigerian households, addressing the challenge of poor electricity supply and recurrent outages implies that they must invest and rely on petrol- or diesel-powered generators as backup to minimise the impact of electricity supply shortages and outages (Oseni, 2016; Heinemann et al., 2022). It is widely estimated that one in four households in Nigeria extensively uses and relies on petrol- or diesel-powered generators as backup against recurrent outages and supply shortages (Amadi, 2015; Babajide and Brito, 2021).

Reliance on petrol—or diesel-powered generators causes significant cost implications for most Nigerian households, who already live below the $1.90-a-day poverty mark, combined with health and environmental implications (Jaiyeola and Bayat, 2019; World Bank, 2017). However, this research argues that household gender inequality contributes significantly to influencing household choice of fuel. Accordingly, a comparison between male and female participants will be explored in the subsequent sections of this analysis. This will be followed by an examination of household energy use, where participants were asked to report their reliance on petrol- or diesel-powered generators, as detailed in the next section.

5.3.1.1. Gendered Impacts of Electricity Outages

The electricity outages, as seen in section 5.3.1, pose significant challenges for most Nigerian households. These electricity outages negatively impact the lives of households, resulting in wider socio-economic challenges for households (Adelakun and Olanipekun, 2020). This section explores the gendered impacts of electricity outages among households, giving an insight into how insufficient electricity supply affects female and male participants in this study.

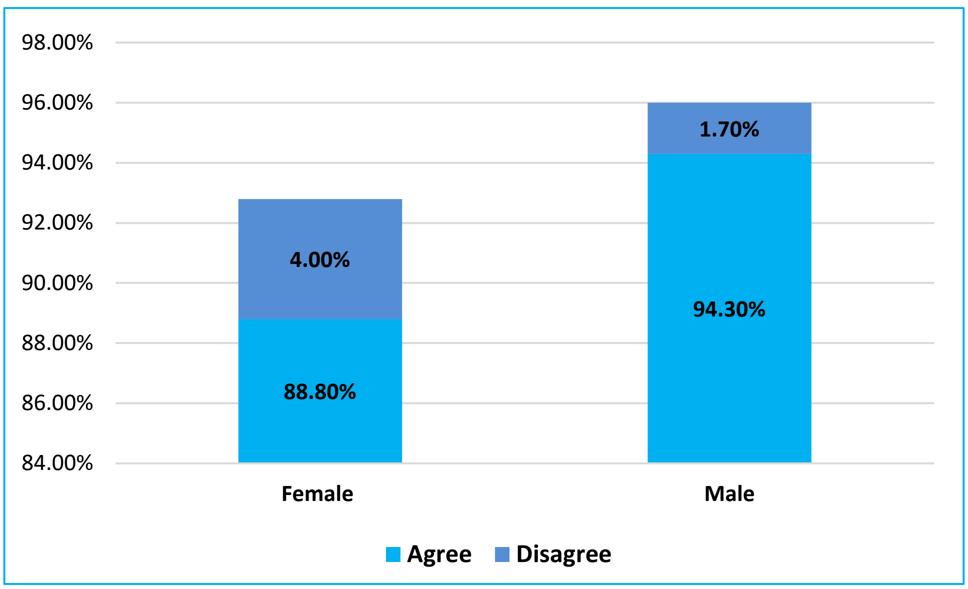

Figure 5. 11 Gender Differences in Perceptions of Electricity Outage Impacts in Nigeria

Figure 5.11 shows responses from both genders, indicating that electricity outages challenge daily household activities. However, the impact of electricity outages is perceived differently by males and females. 94.30% of males indicated that the current electricity supply shortages in Nigeria affected the daily running of their households when compared with 88.80% of females. Despite more males suggesting that electricity outages affected their lives, the general level of agreement that electricity outages negatively impacted their lives is high for both genders, showing a widespread acknowledgement of the challenges, that electricity outages pose to Nigerian households (Adelakun and Olanipekun, 2020). Additionally, qualitative feedback from participants corroborates these findings from Figure 5.9.1 and highlights specific gender concerns, as some participants suggested that:

> *"As a small business owner, the lack of reliable power means I cannot operate machinery essential for my business, which is affecting my income."* RP572 (male)

Another participant held a similar view, suggesting that the electricity outages created safety and economic concerns for them:

> "*The current electricity problem makes me feel unsafe and insecure when I am on my way home from work. Especially at night as the streets are not illuminated, the streetlights do not work.*" RP040 (female).
>
> Another participant added, *"Preserving food becomes difficult, adding to household work."* RP545 (female).
>
> Similarly, RP004 (female) added - *"…some mornings, I have to go to the mangrove to collect wood for cooking before I get ready for school… or I do that after school."*

However, the participants' comments above reveal that electricity outages affect both genders differently. While male participants reported only economic implications, suggesting severe disruption to their work and business operations, female participants highlighted severe disruptions in household management and safety concerns, including cooking activities. This indicates that the nature of the impact of electricity outages on households may differ based on gender roles and responsibilities (Ngarava et al., 2022).

Figure 5.11 shows the adverse effects of recurrent electricity outages in Nigeria on both genders. Male participants report significant vulnerability to non-household activities, particularly in relation to their employment and business operations. In contrast, female participants, while also negatively affected, experience increased burdens in managing domestic responsibilities and household tasks such as cooking with firewood and charcoal and cleaning. These tasks, although not directly linked to income generation, lead to significant socio-economic challenges for women over time (Bagdi et al., 2023; Acheampong et al., 2024). Research also indicates that in patriarchal societies, such as those prevalent in the developing world, women face unique socio-economic challenges that exacerbate their vulnerability to energy shortages, more so than male-headed households (Ogundana, 2022; Ogundana, Simba, and Dana, 2021; Ngarava et al., 2022). Therefore, it highlights the need for targeted gender initiatives to ensure just energy adoption.

5.3.2. Assessment of Household Use of Petrol- or Diesel-Generators

The findings from Section 5.3.1 above confirm that most Nigerian households experience severe energy challenges due to inadequate electricity supply and daily power outages. As a result, most Nigerian households rely on fuel-powered generators to meet their electricity demands. Participants for this research were asked to measure how often they used fuel-powered generators as a means of electricity generation. The result for this section is illustrated in Fig.5.12 and discussed as follows:

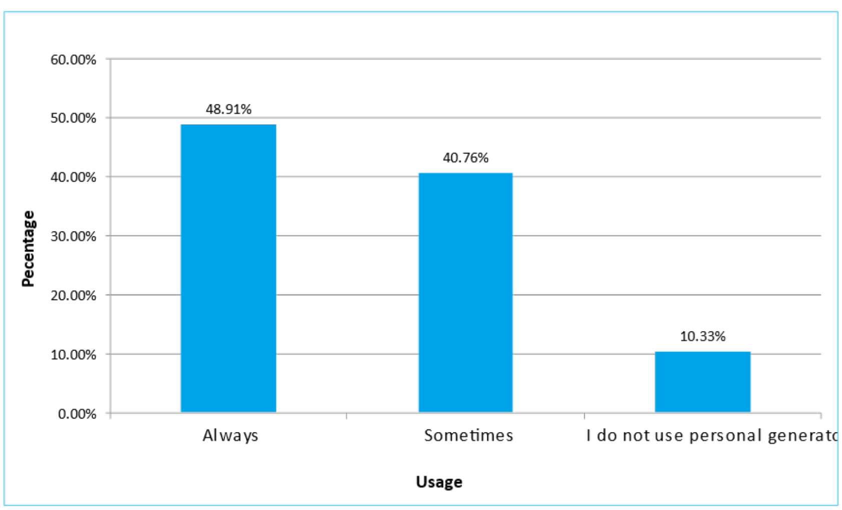

Figure 5. 12 Average use of fuel-based generators within households in Nigeria

Figure 5.12. depicts the frequency of use of fuel-based generators (petrol or diesel) amongst the participants for this research. As shown in Figure. 5.12, 48.91% of households indicated that they always use fuel-based generators as a backup against the shortage of electricity supply. In comparison, 40.76% sometimes use fuel-based generators to meet their household electricity demands. However, 10.33% of participants suggest that they should not use fuel-based generators to meet their electricity demands. The consensus from the survey shows that the majority of the participants (89.67%) rely extensively on using either petrol- or diesel-powered generators as an alternative to grid-based electricity. Findings from the survey also reveal that the frequency of use of these generators does not vary in terms of seasons, as there is no significant difference in the number of daylight-saving time hours or night hours. Nigeria only has two major seasons, the dry season from November to March and the rainy season from April to October. As such, temperature variations do not differ significantly during these seasons; thus, the frequency of use of fuel-based generators remains strong during the two seasons and all year round. As mentioned earlier, one in four Nigerian households owns or shares fuel-based generators for electricity generation (Babajide and Brito, 2021). Therefore, it is unsurprising that the use of fuel-based generators continues to rise in Nigeria. As of 2012, 60% of households used fuel-based generators, which rose to an estimated 80% use in 2014, indicating the severity of the energy crisis in Nigeria (Elinwa, Ogbeba and Agboola, 2021).

Current estimates show that approximately 84% of urban households rely extensively on petrol- or diesel-powered generators for electricity generation, while almost 98% of rural households are without electricity supply (Amadi, 2015; Elinwa, Ogbeba and Agboola, 2021). These estimates show a considerable demand for fuel-based generators in Nigeria, leading to mass importation of petrol- and diesel-powered generators. Reports in 2017 showed that approximately 70 million generators were imported into Nigeria, making the country the largest importer of generators in Africa and one of the largest importers in the world (Babatunde et al., 2020). The annual cost of importing generators into Nigeria stands at approximately $112 million (₦46.9 billion). In comparison, households spend about $3.84 billion (₦1.6 trillion) annually to maintain and operate these generators (Giwa, Nwaokocha and Samuel, 2019).

Reliance on fuel-based generators for electricity generation implies that households incur enormous financial burdens associated with using petrol- or diesel-powered generators. The cost of purchasing, operating, and maintaining these generators is significantly costlier than electricity generated from the national grid. Estimates show that the cost of using either petrol or diesel-powered generators is three times higher than the cost of electricity from the national grid in Nigeria (Elinwa, Ogbeba and Agboola, 2021). A recent report by the Rural Electrification Agency (REA) shows that Nigerians spend about $14 billion (₦5.82 trillion) annually on inefficient sources of electricity (fuel-based generators) that produce noise and environmental pollution (REA, 2020). The cost implications of using fuel-based generators also depend on the price of petrol and diesel. The price of these fuels varies across different locations in Nigeria due to the added cost of transporting the fuel from refineries to various urban and rural locations. In addition, the price of petrol or diesel in Nigeria is susceptible to fluctuations due to volatilities in global oil prices, thus making it difficult for Nigerian households to rely on petrol or diesel generators for electricity supply.

For example, the price of diesel in Nigeria as of 2019 was about $0.70 (N290.43) per litre, which the government highly subsidised. But the current price for diesel rose by 24% in 2022 from $0.98 (₦410) per litre as of January 2022 to $1.44 (₦600) in March 2022 (Adekoya, Oyebade and Gbonegun, 2022). This increase in fuel prices creates a financial burden for most households that use fuel-powered generators, coupled with the fact that most Nigerians live below the $ 1.90-a-day poverty mark. As such, this contributes to financial hardship, welfare loss and reduced energy security for most Nigerian households. Additionally, the use of fuel-based generators has become a source of concern in terms of air quality in Nigeria. These generators are fossil fuel-based, mainly run on petrol or diesel, which are known to contribute to the release of pollutants such as Carbon dioxide (CO_2), Carbon monoxide (CO), Nitrogen dioxide (NO_2), and particulate matter ($PM_{2.5}$ and PM_{10}). As such, fumes from the exhaust of these fuel-based generators constitute a major health and environmental risk if households are constantly exposed to them.

In summary, despite most participants addressing the issue of poor electricity supply and severe outages via fossil fuel-based generators. Calls for decarbonisation and regular changes in the price of fuels suggest that there are sustainability concerns associated with this mode of electricity generation. Therefore, the next section will explore key sustainability issues associated with fuel-based generators, focusing on participants' perceptions of their environmental and health impacts.

5.3.3. Household Awareness of The Sustainability Concerns of Using Fuel-Based Generators

In addition to identifying and analysing the energy challenges faced by Nigerian households, it is essential to examine the environmental, noise, and health impacts of fuel-based generators to effectively address research objective one and answer research question 1 (see Table 5.1). Therefore, this section analyses participants' awareness of the environmental, noise, and health implications of their reliance on petrol- or diesel-powered generators for electricity generation. Participants were asked if they knew that using petrol- or diesel-powered generators contributed to environmental and noise pollution.

As indicated in Fig. 5.13, the results show that 83.47% of households strongly agree that using petrol- or diesel-powered generators contributes to environmental and noise pollution, while 15.04% agreed with the above notion. This finding shows that 98.51% (83.47% + 15.04%) of participants are aware of the environmental, health, and noise implications of using fuel-based generators for electricity generation.

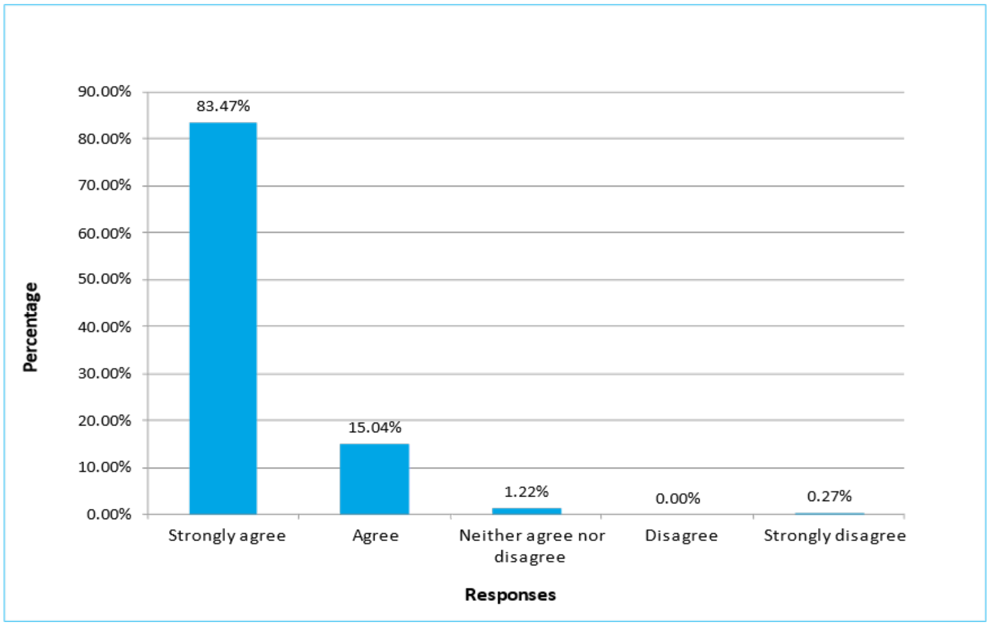

Figure 5. 13 Household awareness of the sustainability implications of using fuel-based generators

However, the extent of pollutant concentration from the environmental, noise and health implications of fuel-based generators remains under-examined in Nigeria (Giwa, Nwaokocha and Adeyemi, 2019). Therefore, a comprehensive understanding of the household's awareness of the environmental, noise and health implications of using fuel-powered generators could result from the visible fumes and noise from these generators. Nevertheless, the emissions and noise from petrol- or diesel-powered generators have been known to have adverse effects on the environment and public health of households (Mbamali, Stanley and Zubairu, 2012; Heinemann et al., 2022). The combination of air pollution from emissions and noise from either petrol or diesel-powered generators has been linked to various illnesses and diseases in Nigeria. Sadly, exposure (both long-term and short-term) to emissions from fuel-based generators (petrol or diesel) has been linked to cases of respiratory and cardiovascular diseases, dizziness, irritation of the eyes, headaches, hearing impairment, cancer and even death (Giwa, Nwaokocha and Samuel, 2019; Heinemann et al., 2022).

However, an exact quantification or literature on pollutant concentration levels and the associated health implications of using petrol- or diesel-powered generators is scarcely available in Nigeria.

This indicates a considerable knowledge gap and a lack of insight into the severity of the health risks associated with using fuel-powered generators. However, records of deaths associated with the inhalation of fumes from petrol- or diesel-powered generators inside houses or close to windows of homes have been published via various print and electronic media (THISDAY, 2019; Okeoma, 2021). This shows that the high importation and reliance on fuel-powered generators (over 70 million units) in Nigeria has a deteriorating effect on air quality, which in turn negatively impacts the health of households.

Conversely, besides air quality concerns associated with fuel-powered generators, noise pollution from fuel-powered generators is also one of the major sustainability issues. Meanwhile, noise pollution from fuel-powered generators remains under investigation compared to other forms of pollution, such as air, water, land, and light. Noise pollution counts as one of the major health hazards because of its impact on human health. Noise pollution from fuel-powered generators emanates from the interaction between generators' mechanical, combustible and engine airflow components that can be harmful if constantly exposed to the noise. Research shows that exposure (both long and short-term) to high levels of noise can have negative impacts on the physiological, psychological, auditory, and non-auditory well-being of humans (Oguntunde et al., 2019). Some of the harmful effects of noise pollution from fuel-based generators include hearing impairment, stress and anxiety, sleep deprivation, insomnia, short concentration, speech interference, and cardiovascular disorders in pregnant women (Sears et al., 2018; Selander et al., 2019; Radun, Hongisto and Suokas, 2019).

In summary, participants' views on the sustainability concerns linked with using fuel-powered generators provide compelling evidence that extensive reliance on fuel-powered generators (petrol or diesel) poses serious environmental, social, financial, and health-related concerns to households. The inhalation of fumes and noise from fuel-powered generators has been known to cause death and other illnesses in households in Nigeria. The cost of maintaining and fuelling these generators has become a financial burden on households compared to electricity from the national grid. As such, participants were asked about the financial burden of their energy bills to determine whether household energy bills form part of the energy challenges experienced by households in Nigeria.

5.3.4. Household Views on Household Energy Bills

Households were asked about their views on their energy bills, the electricity billing system employed by electricity distribution companies in Nigeria, and whether the current billing system creates a financial burden on households. Figure 5.14 illustrates some of these views.

Table 5. 9 Are your energy bills expensive or a financial pressure?

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		14	1.9	1.9	1.9
	No	106	14.48	14.48	16.1
	Sometimes (depending on household consumption)	273	37.3	37.3	52.7
	Yes	353	48.2	48.	100.0
	Total	746	100.0	100.0	

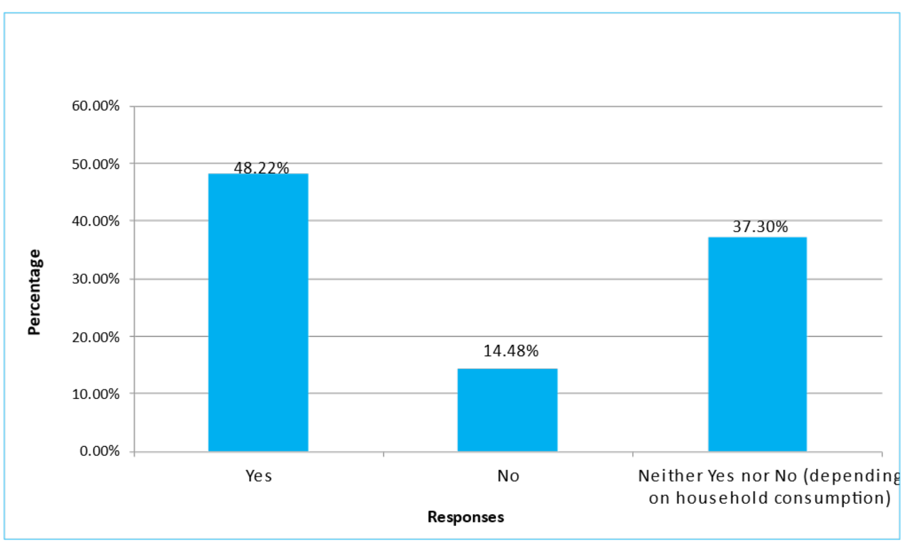

Figure 5. 14 Households' views on household energy bills

Where households knew about the billing system used to generate their monthly electricity bills, 48.2% of households reported that their energy bills are a financial burden to them due to high charges from electricity distribution companies. 14.5% indicated their energy bills do not bring them financial pressure, as they can afford to pay for their monthly energy bills. In comparison, 37.3% neither agreed nor disagreed that the current billing system had financial pressure on their energy bills. However, the high percentage of households indicating financial pressure due to high energy bills from current billing systems suggests that inefficient billing forms part of the energy challenges experienced by Nigerian households.

With Nigeria's increasing household demand for energy (mainly electricity), accurately monitoring, measuring, and billing household energy usage is crucial to ensuring efficient electricity supply and grid management. However, monitoring, measuring, and billing have been ongoing challenges in the Nigerian power sector for decades (Idowu, Ibietan and Olukotun, 2019; Arowolo and Perez, 2020). In Nigeria, electricity consumers are divided into two groups: metered customers and Unmetered customers. However, the majority of households in Nigeria are unmetered due to the inadequate and delayed supply of meters by Electricity Distribution Companies (DISCOs) in the country (Arowolo and Perez, 2020). Similarly, the heterogeneous pattern of dwellings (clusters) and the multi-tenanted nature of houses in many regions across the country make metering of households difficult as DISCOs find it hard to monitor and measure individual electricity consumption (See section 5.2.7) (Arimoro, Oyetunji and Odugboye, 2019).

Nevertheless, the inadequate and delayed supply of meters has resulted in a metering gap, as about 60% of Nigerian households are unmetered. Thus, Disco's billing system is inaccurate, unfair, and controversial. As such, Figure 5.15 illustrates households’ views on the impact of metering and the current billing system on household energy bills.

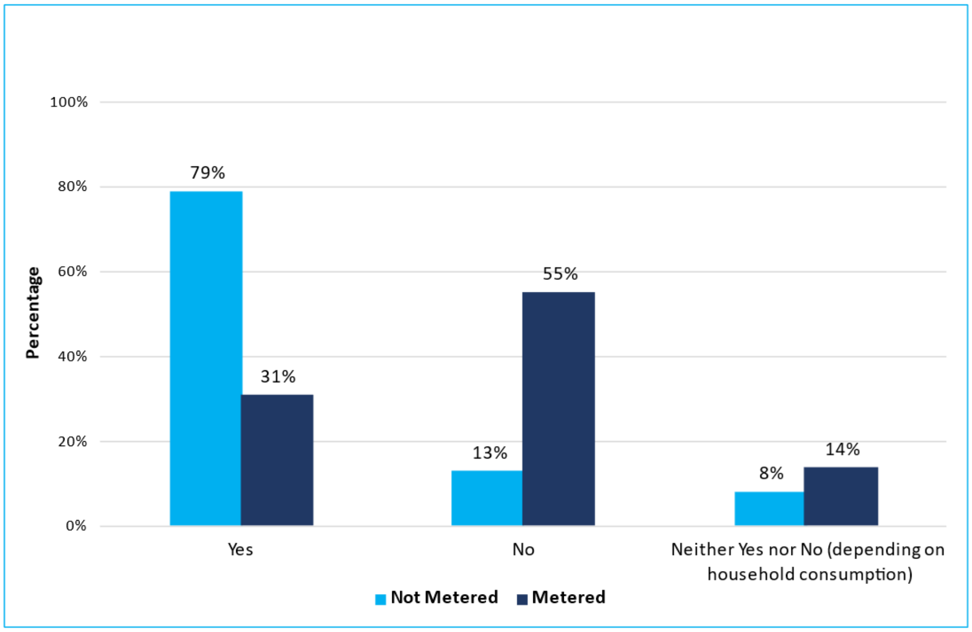

Figure 5. 15 Impact of metering on household energy bills

From Figure 5.15 above, 79% of participants reported that not having a meter impacted their household electricity bills, as they indicated that their energy bills are expensive, and only 31% of metered households indicated high electricity bills. From these findings, one could argue that the lack of meters in households creates problems of inaccurate bills, which can be a challenge when quantifying household energy consumption and allocating funds to pay energy bills. On the other hand, 13% of unmetered households revealed that their energy bills are not a financial burden to them, with 55% of metered households indicating no financial pressure with their energy bills. 55% of metered households reporting no financial pressures with their energy bills suggests the importance of accurately monitoring and measuring household electricity consumption to ensure that households only pay for what they consume. While it seems that most participants indicated that their metering status would positively or negatively impact their energy bill, there was a tendency for neutral opinions. As 8% of unmetered households and 14% of metered households were unsure if having or not having a meter affected the energy bills.

However, with 60% of Nigerian households being unmetered and 79% of participants from the study indicating that being unmetered increased their energy bills, it shows that the metering gap and the current billing system also form part of the energy challenges faced by Nigerian households. The current billing system employed by DISCOs for unmetered households in Nigeria involves the use of asymmetries known as estimated billing systems (Arowolo and Perez, 2020). This method of billing relies on estimated readings rather than accurate or real-time meter readings of customers' energy usage, where the calculation of a household's electricity consumption is usually based on a constant supply of electricity. However, due to the inadequate supply of electricity and recurrent outages in Nigeria, households view this system of billing as inaccurate, dubious, and fraudulent. Because they are forced to pay for electricity services that are not available or that were not supplied to their homes. It is noteworthy that despite the erratic electricity supply in Nigeria, electricity tariffs have been increasing over the years. Households being presented with estimated bills represent negative financial implications for households. They are forced to pay electricity charges that are obtained by multiplying an estimated consumption figure by the current energy multiplier rate plus value-added tax (VAT), which depends on the location of their homes. Therefore, in Nigeria, the monthly electric bill = (estimated consumption charge x energy multiplier) + VAT. This method of billing has resulted in controversies between DISCOs and households, as most households cite a lack of transparency, overcharging, and corrupt practices as key issues with the estimated billing system.

In summary, having considered the participants' views on their household energy bills and findings from the literature, the estimated billing system used for billing most households (unmetered) has various negative implications on household energy bills and the power sectors. Some negative impacts of estimated billing include high energy bills due to overcharging, inaccurate billings, unreliable supply, poor metering deployment.

5.4. Household Energy Use

This section presents the findings obtained from conducting the quantitative survey for this research. This section captures and analyses research participants' views on their household energy consumption patterns and behaviour. The purpose of this section is not to descriptively compare participants' views but to gain valuable insight into household energy consumption behaviours and how these behaviours can affect the likelihood of using renewable energy sources in Nigerian households.

5.4.1. Main Household Energy Source

Households perform various domestic activities that usually involve the use of energy. These activities include lighting, cooking, refrigerating, cooling, and heating. Identifying the source of energy or fuel type mainly used for these domestic activities is crucial to assessing the likelihood of households adopting other sources of energy. Analysis of the primary source of energy used in households for this study is presented below (see Figure 5.16).

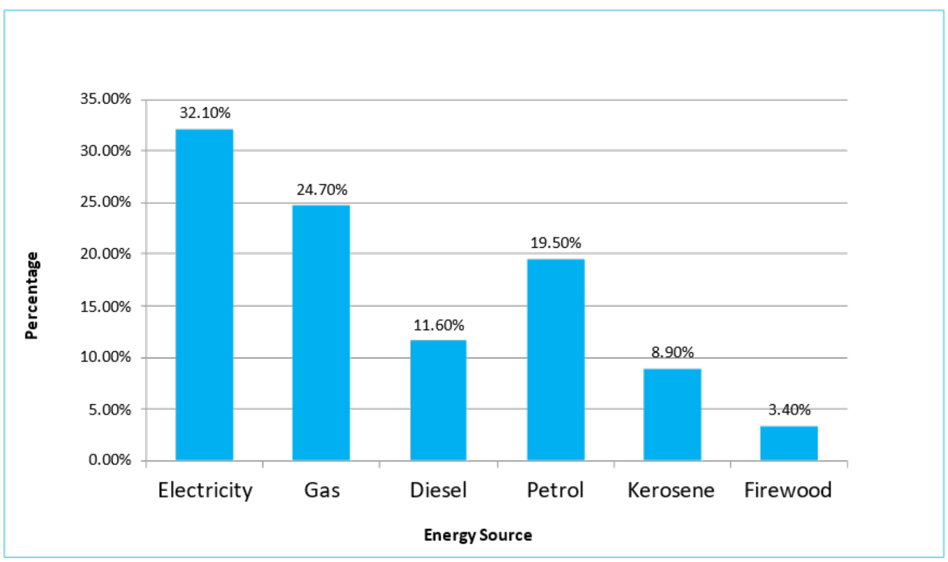

Figure 5. 16 Primary Energy Source in Households by Fuel

Results from the survey on the main source of energy in households show that electricity (32.10%) and gas (24.70%) cover the final energy consumption within surveyed households. Other forms of fossil fuel derivatives, petrol and diesel, account for 19.50% and 11.60%, respectively, followed by kerosene, which stood at 8.90%. However, a small proportion of surveyed households indicated firewood (solid fuels) (3.40%) as the main source of energy in their households. These results depict an accurate representation of primary energy consumption in Nigeria's household sector. Most households in Nigeria rely mainly on electricity to meet their energy needs. 32.10% of participants (see Figure 5.14) indicated that electricity is used for various household activities. Electricity in households is used primarily to perform various household activities such as lighting, heating, cooking, refrigerating, and leisure (Dioha and Kumar, 2020). The findings from the survey, as seen in Figure 5.16, also indicate that households rely on various sources of energy to meet various household energy needs. For example, while electricity is used for lighting, cooling, cooking, and refrigerating, gas, kerosene and firewood are used to perform cooking and heating activities. While other fossil fuel derivatives, such as diesel and petrol, are used in generators for household electricity generation and as fuels for cars (see Sections 5.3.2 and 5.3.3).

The survey results reveal that most households rely on electricity to meet their energy needs, which shows the relative importance of electricity access as an enabler of socio-economic and human development (Ayaburi et al., 2020). However, electricity access is still low in Nigeria, with only about 58% of households having access to electricity, while 42% of the population (approximately 86 million people) remain without access to electricity (Ohiare, 2015; World Bank, 2020). This indicates major electricity supply issues in Nigeria, as most households seek alternative ways of generating electricity to meet their household electricity demands. As shown in Section 5.3.1, most Nigerian households rely on various alternatives, such as fuel-based generators, to minimise the impact of inadequate electricity supply in Nigeria. Hence, the following section presents an analysis of the household's primary source of electricity.

5.4.2. Household Electricity Source

According to the International Energy Agency (IEA), most of Nigeria's electricity is generated by natural gas, hydropower, coal, crude oil, fuel-based generators, and solar PV (IEA, 2019). At present, natural gas remains the country's primary source of electricity, followed by fuel-based generators and hydropower. Although there has been a gradual shift to solar PV, the use of solar PV is only at the household level. Therefore, households will often combine multiple sources of energy to meet their household energy needs. Table 5.10 and Figure 5.17 illustrate sources of electricity for surveyed households for this study.

Table 5. 10 The main source of electricity in households

		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid		27	3.6	3.6	3.6
	Combination of sources	234	31.4	31.4	35.0
	National grid	259	34.7	34.7	69.7
	Personal generator (petrol/diesel)	213	28.6	28.6	98.3
	Renewable energy (solar energy, wind energy etc)	13	1.7	1.7	100.0
	Total	746	100.0	100.0	

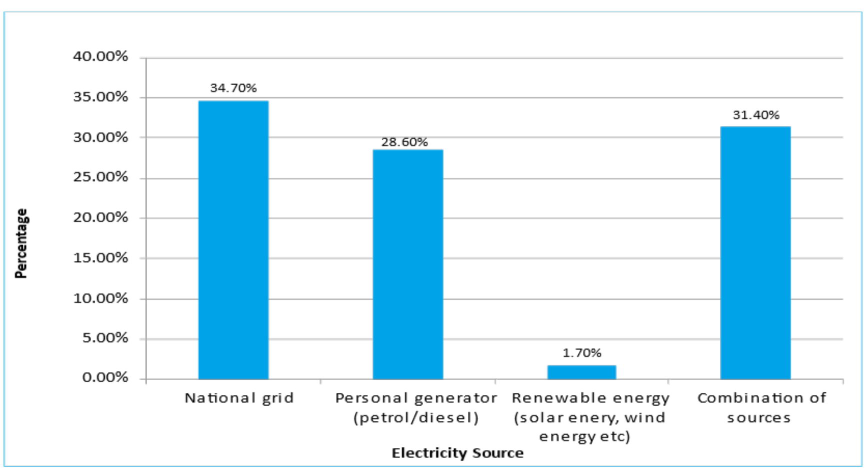

Figure 5. 17 Source of Electricity in Households

Results from section 5.4.1 indicate that the final energy consumption within the surveyed households is covered mainly by electricity (32.10%). However, due to the electricity supply shortages and recurrent blackouts in Nigeria, it is widely known that most households in the country combine different means to generate electricity. Of all the surveyed households, the results show that 34.70% of participants show that their primary source of electricity is from the national grid, which indicates governmental efforts to increase household access to electricity across all regions of Nigeria. However, out of 746 households surveyed for this research, only 259 households (34.70%) rely on the national grid for electricity supply. This shows the level of electricity access in Nigeria, as only about 58% of households have access to electricity, and 42% of households (over 86 million people) face major electricity supply issues. In turn, they rely heavily on other sources of energy (mainly fuel-powered generators) to generate electricity to meet their household demands.

Findings from the survey also show that 28.60% of participants indicated that their electricity source is from privately owned fuel-powered generators that use either petrol or diesel for electricity generation. This result aligns with findings from section 5.3.2, as most households reported that they often use their personal fuel-powered generators as backups to minimise the impact of electricity supply shortages and recurrent blackouts on daily household activities. However, as mentioned in section 5.3.2, the frequent reliance on fuel-based generators for electricity generation implies that households incur a substantial financial burden associated with the maintenance and fuel cost of using these generators. Additionally, despite the financial burden associated with using fuel-powered generators, households are also exposed to health-related concerns associated with the inhalation of fumes and noise from fuel-powered generators, which have been known to cause various illnesses and even death. From Figure 5.17 and Table 5.8 above, only 1.70% of households reported using renewable energy sources such as wind or solar to generate electricity, supporting the renewable energy potential in Nigeria. However, the use of renewable energy resources to generate electricity in Nigeria is slow and is termed expensive (Emodi and Ebele, 2016; Adewuyi, 2020). On the other hand, 31.40% of households indicated using a combination of energy sources to generate electricity for their households. This implies that some households' primary source of electricity is a mix of grid-based electricity, personal fuel-based generators, and renewable energy sources.

The findings from Figure 5.17 vary significantly when analysed within the context of urban and rural household energy consumption. Further analysis conducted by the researcher found that the electricity source for surveyed rural households was mainly from privately owned petrol- or diesel-powered generators (see Figure 5.16). This is because access to electricity is very low in most rural areas compared to urban areas in Nigeria. As such, most rural households in Nigeria are almost entirely reliant on other alternative means to generate electricity for household use. From Figure 5.16 below, 100% of surveyed rural households indicated that their primary source of electricity is from petrol- or diesel-powered generators. Urban households show that 50% of their electricity comes from the national grid, 31.58% from personal generators and 18.42% from a combination of sources. The high reliance on fuel-powered generators for rural households suggests that they are more likely to be impacted by the adverse effects of using fuel-powered generators (see sections 5.3.2 and 5.3.3). The health and financial burden of relying on fuel-powered generators will be notably worse for rural households, as they are often poor and cannot afford modern fuels, coupled with no access to the national grid.

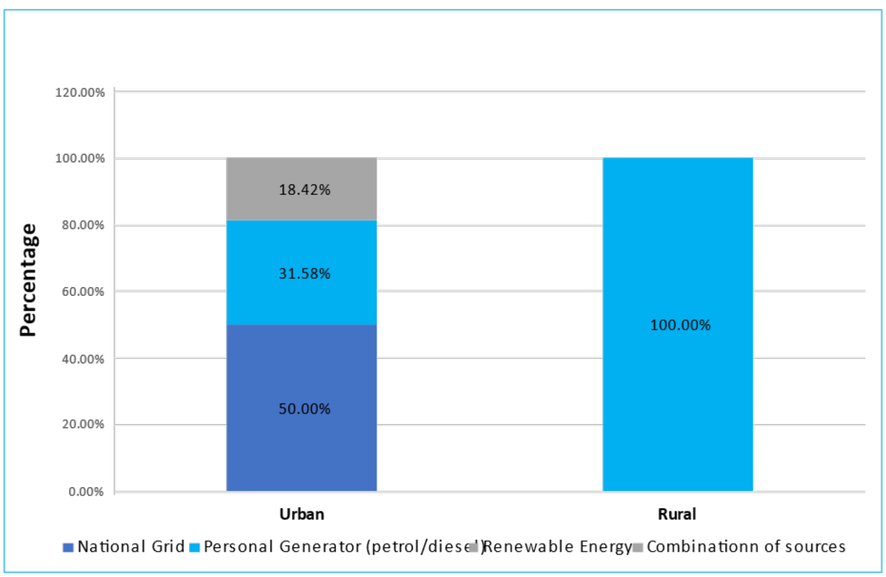

Figure 5. 18 Comparison between Urban and Rural Electricity Sources

As a result, most rural households will continue using a combination of sources for electricity generation, which is similar to urban households in Nigeria. The combination of different sources of energy to generate electricity is partially consistent with the energy stacking concept. Observations from the survey results reveal that some households use a mix of energy sources rather than switching to new energy sources to meet household energy demands. The concept of energy stacking could be seen dominating households in Nigeria, as households use both modern forms of energy, such as electricity, alongside fossil fuel-based energy, such as natural gas, diesel, petrol, and traditional fuels, like firewood (see Figure 5.16). From the findings above, it is evident that modern forms of energy, like electricity, have not yet displaced fossil fuel and traditional energy use in most Nigerian households. This incites a need for increased efforts to diversify the household energy mix by introducing renewable energy sources into the household energy mix. This could mitigate reliance on fossil fuels and ensure energy security for most Nigerian households.

5.4.3. Household Energy Use for Basic Domestic Activities

As revealed in section 5.3.2 above, the energy consumption patterns from surveyed households align closely with the "energy stacking model" characteristics. This is because energy consumption patterns in surveyed households do not show a linear movement toward cleaner modern fuels but rather the use of conventional energy sources in conjunction with modern fuels. Therefore, most Nigerian households often use a combination of energy sources to perform various domestic activities (Baiyegunhi and Hassan, 2014). This section presents an analysis of household energy use for different household activities. Results from the survey revealed that the majority of participants indicated the use of a mix of fuel types to perform most household activities, citing that cooking and lighting (freezing, powering electrical appliances and air-conditioning) account for most of the energy consumed in households. The following sections will present an analysis of surveyed household responses to their household energy use for cooking, air-conditioning, and lighting.

5.4.3.1. Household Energy (Fuel) Used for Cooking and Heating Activities

Cooking activities represent almost 91% of households' energy use in Nigeria, as food is essential for human development (Jewitt, Atagher and Clifford, 2020; Oyedepo, 2012). Analysis of the energy types used for cooking amongst surveyed households revealed that firewood, charcoal, electricity, LPG, and Kerosene are the predominant fuel types used for cooking activities (see Table 5.11). This shows that households will not necessarily move from one fuel type to another but rather alternate between different types of fuels to perform cooking activities.

Table 5. 11 Energy used for cooking in households

ENERGY SOURCE	PERCENTAGE (%)
Firewood	10.72
Charcoal	11.13
Electricity	7.76
LPG	51.12
Kerosene	19.27
Renewable Energy	0.00
TOTAL	100

The survey revealed that the predominant fuel used for cooking amongst households is LPG (51.12%), followed by kerosene (19.27%) as the second most preferred cooking fuel. Traditional fuels such as charcoal and firewood used for cooking accounted for 11.13% and 10.72%, respectively, of household responses. In contrast, only 7.76% of households indicated using electricity for cooking purposes. The positive response towards LPG as the most preferred cooking fuel is mainly due to governmental efforts in Nigeria to increase access to clean cooking fuel and reduce reliance on kerosene, charcoal, and firewood (Fraym, 2021; Alexander et al., 2018). Another reason for the high percentage of LPG use is that most of the participants in this research are urban dwellers who can easily access LPG for household use. Surprisingly, none of the surveyed households indicated using renewable energy sources for cooking. Hence, the current findings highlight that Nigeria's renewable energy development is slow.

This finding is consistent with most studies' results, as most urban households in Nigeria have much greater access to LPG and other modern cooking fuels when compared with rural areas (Ohimain, 2012). A cross-tabular analysis conducted between urban and rural areas shows that 33.82% of urban households used LPG as their primary cooking fuel, while only 5.55% of rural households used LPG. A plausible reason for this is that most rural households live in remote villages where access to LPG filling stations is usually not available, coupled with the cost of purchasing canisters to store LPG. LPG supply in Nigeria is unstable despite LPG being households' preferred cooking fuel. Some households are also categorised as “non-LPG users” due to the likelihood of fire or explosion from LPG canisters due to wear and tear, improper storage, or high temperature (Ohimain, 2012; Ozoh et al., 2018). Thus, such households would prefer to use other fuels like kerosene or solid biomass as their primary cooking fuel.

Next to LPG for cooking amongst participants is kerosene. 19.27% of households have indicated that they use kerosene as their main cooking fuel. Kerosene used for cooking in Nigeria is used primarily with unpressurised wick stoves that do not burn as efficiently as pressurised stoves (Makonese et al., 2012). Therefore, this results in indoor air pollution that will have negative health impacts on users. As with LPG, the kerosene supply is also unstable in Nigeria, as the fuel is usually imported and subsidised by the government despite Nigeria being an oil-producing country. Inadequate refining capacity, oil price changes, and supply shortages create supply shortages for kerosene. Therefore, due to scarcity, these households are failing to meet local demand and switching to a different type of cooking fuel. Charcoal and firewood account for 21.85% (163 households) of surveyed households (charcoal 11.13% + firewood 10.72%). While this result seems positive, analysing urban and rural use of solid fuels reveals otherwise. Almost 100% of rural households have indicated using either charcoal or firewood as cooking fuel in the survey (see Figure 5.17).

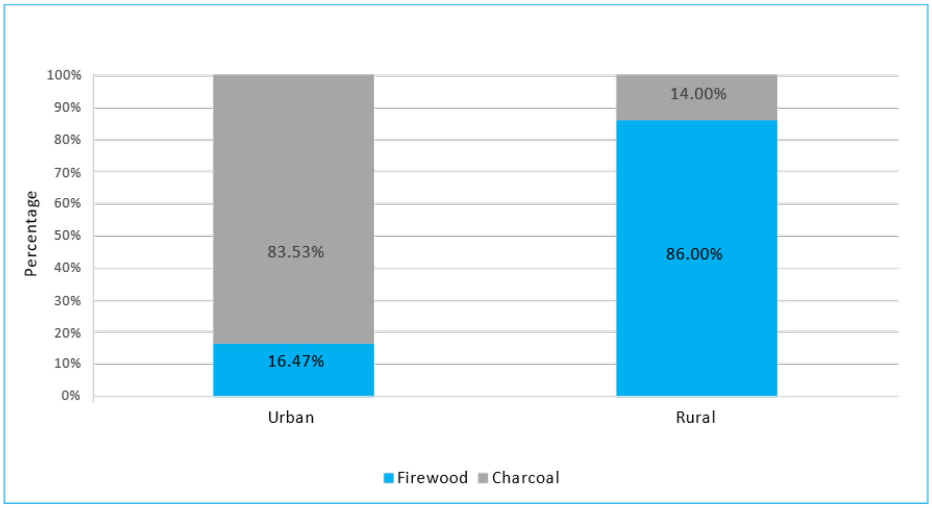

Figure 5. 19 Traditional fuel use between urban and rural households

The results from Figure 5.19 present severe health implications for most rural households. The emissions from cooking with firewood and charcoal in poorly ventilated kitchens are often associated with acute respiratory diseases that mainly affect women and children in rural areas. Additionally, the use of solid biomass as cooking fuel has also been linked with desertification due to the overexploitation of forests for firewood or charcoal production in both urban and rural areas. This practice has become unsustainable and could have severe environmental impacts in Nigeria.

5.4.3.2. Household Energy (Fuel) Used for Lighting

In this research, household energy used for lighting is considered fuel for powering household electrical appliances, freezing, air conditioning and entertainment. In Nigeria, the primary energy fuels used for domestic lighting are electricity and kerosene, with the contribution of other fuels (Maina, Kyari, and Jimme, 2020; Ibitoye, 2013). This finding from the literature is consistent with results derived from surveyed households for this research. Results from the survey showed that electricity was the dominant fuel type used for lighting amongst the surveyed households, as illustrated in Figure 5.20, but other fuels are also used for lighting purposes in households.

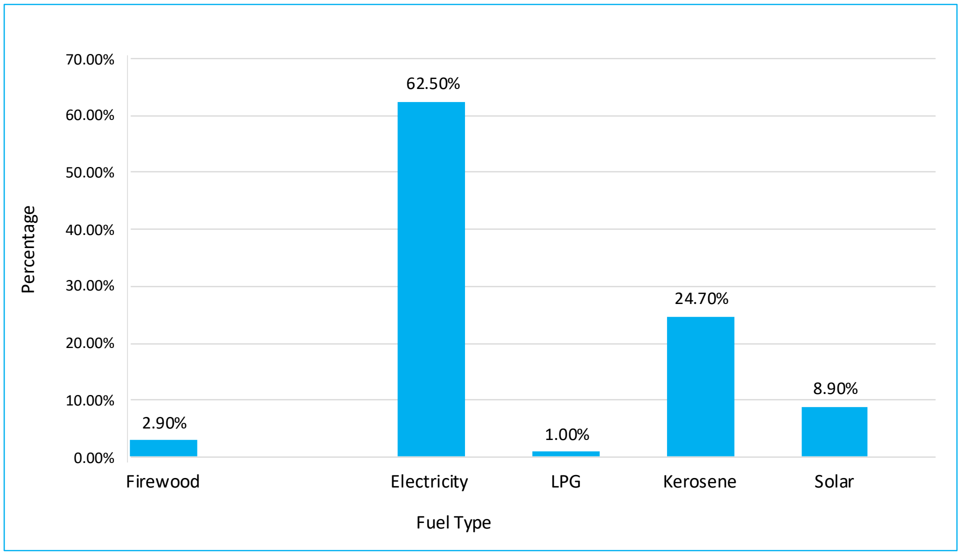

Figure 5. 20 Energy used for household lighting activities

Results from Figure 5.20 show that multiple fuels are used for lighting purposes in Nigeria. These include firewood, electricity (grid-based and fuel-powered generators), LPG, kerosene, and solar energy. However, the primary fuel source used for lighting, according to participants' responses, is electricity (62.50%), kerosene (24.70%), solar (8.90%), firewood (2.90%) and LPG (1.00%). The results show a positive aggregate for electricity and kerosene, as both fuels are the preferred fuels used for household lighting activities. This trend could be because electricity is a more efficient fuel source for lighting because of its efficiency, safety, and unit energy consumption compared with other fuels like kerosene.

However, as found in Section 5.4.2 and Figure 5.17, household electricity in this research is derived from various sources, including electricity from the national grid, personal generators (petrol- or diesel-based) and renewable energy sources. As such, electricity used for lighting purposes involves electricity from the grid and electricity from personal generators. With variations in terms of access to electricity in Nigeria (Urban access 86%, rural access 41%), it can be concluded that the use of electricity for lighting will vary disproportionately between urban and rural households. This research finds that 80% of urban households use electricity for lighting, while only 18.7% of rural households rely on electricity for lighting purposes. Thus, exacerbating the energy challenges faced by most rural households in Nigeria. This implies that most rural households will often depend on kerosene for lighting activities due to the low access to electricity. Kerosene used as fuel for lighting is solely for households with little access to electricity in Nigeria. However, recent studies have shown that urban households with access to electricity also use kerosene for lighting in the event of blackouts (Merem et al., 2018). Thus, survey-wide analysis shows that out of 24.70% of households using kerosene for lighting purposes, 75.6% of rural households and 24.4% of urban households relied on kerosene as a source of fuel for lighting. It is worth noting that the use of kerosene as fuel for lighting is based on its use in lanterns for household illumination. However, using kerosene lanterns has been associated with releasing indoor air pollutants like carbon monoxide (CO_2), nitrogen oxides (NO) and other pollutants that cause various respiratory diseases (Dioha and Emodi, 2019).

From Figure 5.20 above, it can be observed that the use of firewood (2.90%) is minimal when compared with other fuel types, which is due to the majority of the participants being in urban habitats. However, using renewable energy sources such as solar energy for various household lighting activities is also low, considering the potential benefits of solar energy in terms of efficiency and energy security. Based on the participants' responses, only 8.90% indicated using solar energy for lighting purposes. Solar energy use in Nigeria is mainly for lighting bulbs and ventilation purposes (Barau, Abubakar and Kiyawa, 2020). However, as found in literature, the adoption of solar energy for household use is slow in Nigeria due to user-related problems such as poor maintenance, lack of technical knowledge and the cost of purchasing solar panels. Trends from the survey reveal that household fuel choice for various domestic activities in Nigeria conforms to the 'Energy Stacking' energy model since most households use a combination of fuel types. The fuel-stacking model suggests that households may combine the use of different types of fuels (firewood, electricity, and solar energy) depending on certain socio-economic factors such as their household income, household size, affordability, or availability of fuels. Participant responses on household fuel choices indicate a reversal in the expected adoption towards modern fuels, regardless of household location. Instead of a steady progression towards cleaner and more efficient energy sources, many households continue to rely on multiple fuels for different domestic purposes. The following comments illustrate this trend:

> *"Generators cannot power our heavy appliances, so I only use them when we have power available from the national electricity grid, which is almost unavailable."* (RP650 - urban household)
>
> *"We mainly use gas for our cooking but sometimes use kerosene stoves due to the unavailability of gas in the market. In fact, every household, as far as I know, has a kerosene stove for backup in my neighbourhood."* (RP700 - urban household)
>
> *"Let me be honest, food cooked with firewood has this unique taste, especially our local delicacy; even though we use kerosene stoves when it is possible, I still prefer firewood, especially when we travel to the village."* (RP546)
>
> *"In our village, you must have a generator to survive because the light from the national grid is not available."* (RP150 - rural household)
>
> *"Kerosene stoves are majorly used for cooking, but sometimes when you want to cook something really fast, you can use gas, but not everyone can afford it."* (RP450 - urban household)

These findings challenge the conventional energy ladder model, which assumes a linear progression towards cleaner fuels as household income increases (Yadav, Davies, and Asumadu-Sarkodie, 2021). Instead, the responses reveal a downward shift, particularly in urban areas, where households revert to traditional biomass fuels due to inconsistent energy supply, affordability issues, and cultural preferences (Emodi et al., 2022). This highlights the complexity of household energy adoption and suggests that factors beyond income, such as availability, reliability, and cultural norms, play a critical role in shaping fuel choices. Therefore, the following section examines the factors that influence household choice of fuel.

5.4.4. Drivers of Household Energy Choice

This section examines the key drivers of household energy choice for households surveyed in this research. The primary energy types identified in Table 5.9 (firewood, charcoal, LPG, electricity, kerosene, and solar energy are modelled against key variables that are likely to influence household energy choice. The variables chosen to investigate the likelihood of their influence on household fuel choice are mutually exclusive and include cost, availability, accessibility, environment, culture, affordability, and household size. Table 5.12 presents an account of household responses to the drivers of their energy choice.

Table 5. 12 Drivers of household energy choice

DRIVERS	HOUSEHOLD RESPONSES (%)
Price	50.21
Efficiency	12.66
Affordability	41.03
Accessibility	41.45
Availability	60.50
Culture	5.84
Household Size	9.60

Observations made during the collation of data revealed that households chose multiple reasons why they adopted a particular energy type for household use. From Table 5.10 above, 60.50% of surveyed households (451.33 households) suggested that the availability of any fuel type will determine whether they use that fuel or not. Meanwhile, 50.21% of households responded positively to price as a factor influencing their household fuel choice. These results are an accurate representation of the energy situation and drivers of household energy choices in Nigeria. Fuel availability and price of fuels are considered key factors that significantly influence the type of fuel used by most households (Danlami, Applanaidu and Islam, 2018). This implies that households will often adopt fuels that are considered cheap and readily available for household energy use. This finding aligns with the general opinion and is consistent with findings from other studies conducted on the drivers of household energy choice to perform various domestic activities (Mensah and Adu, 2013; Danlami, Applanaidu and Islam, 2018). Further analysis of the survey also shows that households indicated that the affordability (41.03%) and accessibility (41.45%) of any fuel type would also influence their choice of using that fuel. An example of this is the accessibility and affordability of kerosene to most households surveyed in this research. 24.70% of surveyed households indicated that they use kerosene as their primary cooking fuel. However, the accessibility of a particular fuel type does not translate to the availability or affordability of the fuel. For example, in Figure 5.15, where 63.30% of participants indicated electricity as the primary energy used in their household, only 34.70% of households have electricity available from the national grid. 28.60% of households indicated they generated electricity from fuel-based generators due to the unavailability of electricity in Nigeria. Similarly, the affordability of electricity from personal generators could be negative for households due to the high cost associated with operating and maintaining these generators.

The results also show that household size influences the choice of fuel used for various household activities. 9.60% of households indicated that the likelihood of using more than one fuel type increases when household size increases. This is because when the number of household members that depend on the household head (family member with constant income) increases, the household head could experience difficulties affording cleaner modern fuels like LPG and electricity that are more expensive than traditional fuels like firewood and charcoal. Further analysis also reveals that cultural factors influence household energy choice. A small proportion of households (5.84%) have indicated that their culture and way of living influence their energy choice. This finding is factual, especially for households that strongly prefer food cooked using firewood or charcoal. The smoke from burning firewood or charcoal for cooking is deemed valuable to such households and a way of life. This agrees with findings from studies conducted on household cooking fuel preference, as some households indicate that their cultural beliefs override empirical and health knowledge about using firewood, charcoal, and their associated household air pollution (Akintan, Jewitt and Clifford, 2018).

In this study, qualitative comments from free-text responses offer valuable insights into context-specific factors influencing household energy stacking behaviour in Nigerian households. Cultural preferences, such as the taste of local food prepared using traditional methods, emerged as a significant consideration. For instance, one participant suggested that:

> *"Let me be honest, food cooked with firewood has this unique taste, especially our local delicacy; even though we use kerosene stoves when it is possible, I still prefer firewood, especially when we travel to the village"* (RP546 - urban household).

This highlights the enduring cultural attachment to firewood, even in urban settings where alternative fuels are available.

5.5. Household Perception of Renewable Energy Use in Nigeria

This section presents findings derived from a quantitative survey conducted for this study, focusing mainly on household perception of renewable energy. The section analyses how participants in this study view the feasibility of integrating renewable energy into their household energy mix. The aim of this section is not only to compare these perceptions but also to extract valuable insights into how the views and acceptance of renewable energy among Nigerian households can influence its utilisation in the country. These perceptions are crucial for investigating the willingness and feasibility of households to utilise renewable energy and to understand the factors that influence or hinder renewable adoption in Nigeria.

5.5.1. Reducing Nigeria's Fossil Fuel Dependence through Renewable Energy Generation

Drawing on the findings from Section 5.4, which revealed the prevalent reliance on personal fossil-fuelled generators among households for daily electricity needs. Participants were asked about their perceptions of renewable energy as an alternative to reducing their fossil fuel dependency. This question was asked in response to earlier findings in the survey that households were concerned about the high cost and sustainability of their current household fuel.

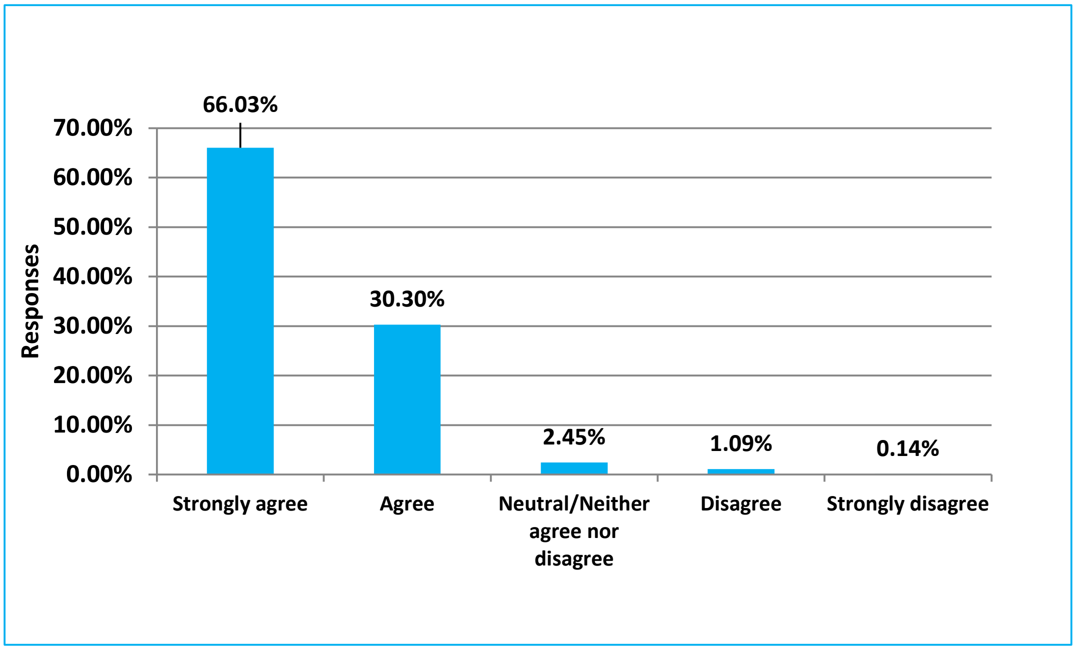

Figure 5. 21 Participants' views on renewable energy's role in reducing fossil fuel use

Figure 5.21 shows that the majority of the participants support the idea that renewable energy can reduce household dependence on fossil fuels, especially the use of petrol or diesel-powered generators. 66.03% of participants strongly agreed, while 30.30% agreed that the generation of electricity from renewable energy resources could significantly reduce Nigeria's dependence on fossil fuels, respectively. This strong acknowledgement of renewable energy's role in reducing fossil fuel dependence reflects a positive public perception towards renewable energy technologies, indicating a potential for broad adoption across Nigeria (Chen et al., 2024). Despite the overwhelming support for renewable energy, with 96.33% of participants supporting renewable energy as an alternative to fossil fuel use, a minority of participants disagreed with this view. Specifically, 2.45% of participants were neutral, 1.09% disagreed, and 0.14% strongly disagreed with the prevailing view. This indicates potential barriers to the adoption of renewable energy, primarily due to limited technical knowledge, a lack of awareness about renewable options, and economic concerns in Nigeria (Abdullahi et al., 2022). Sadly, these potential barriers to renewable energy adoption are likely to worsen gender vulnerabilities, particularly among women in developing countries (Partey et al., 2020; Johnson et al., 2020; Bryan et al., 2024). Therefore, the researcher sought to explore participants' views on renewable energy's role in reducing fossil fuel use based on gender.

5.5.2. Gender Perspectives on Renewable Energy in Reducing Nigeria's Fossil Fuel Dependence

Findings from Section 5.5.1 and Figure 5.21 show strong household support for renewable energy as an alternative to fossil fuel dependence. Yet some of the participants disagree with the consensus that renewable energy adoption could reduce fossil fuel dependence (see Figure 5.21), indicating barriers to renewable energy adoption that could have varying impacts on male-led or female-led households. These barriers to renewable energy adoption (see Table 5.12), such as cost, lack of awareness, and low-level technical knowledge, are likely to worsen gender vulnerability, especially among women in developing countries like Nigeria (Abdullahi et al., 2022; Partey et al., 2020). Women and young girls are disproportionately impacted due to their household responsibilities involving energy-related tasks such as cooking, cleaning, and fetching fuel for household use (Ngarava et al., 2022). Therefore, this study sought to examine the gender views on renewable energy's role (solar energy) in reducing household dependence on fossil fuels in Nigeria.

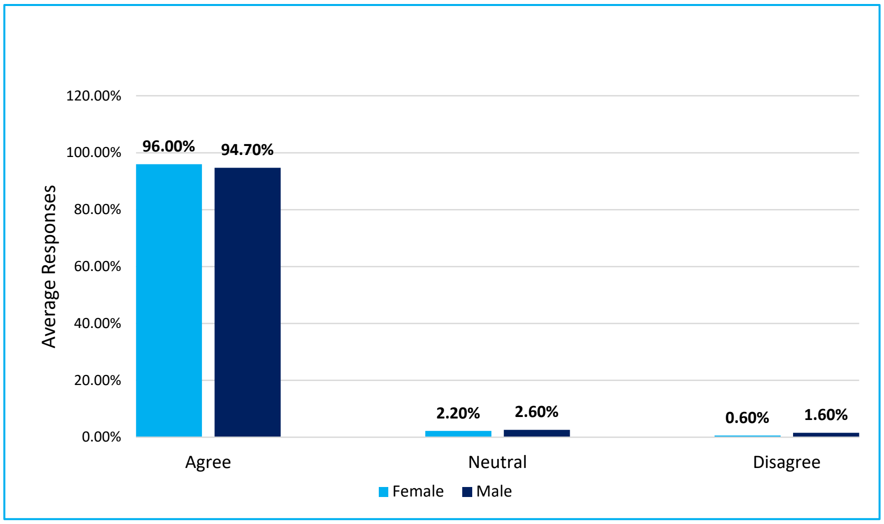

Figure 5. 22 Gender Views on Solar Energy's Role in Mitigating Traditional Fuel Use

Both male and female participants demonstrate significant support for renewable energy as a viable alternative to reducing dependence on traditional household fuels. Although both genders share this view, the data in Figure 5.22 shows that a slightly higher proportion of females (96%) support renewable energy compared to males (94.7%). This indicates that women's involvement in the energy adoption process could play a crucial role in boosting the adoption of renewable energy solutions, as their participation may enhance the overall effectiveness of these efforts (Tornel-Vázquez, Iglesias, and Loureiro, 2024).

The high level of female support for renewable energy, as shown in Figure 5.20, can also be explained by gendered patterns of energy use in households. In many developing countries, including Nigeria, women are the primary energy users, responsible for activities such as cooking, cleaning, and heating (Acheampong et al., 2024). As the main users of household energy, women are disproportionately affected by the challenges associated with traditional fuels like charcoal and firewood, which are still commonly used in Nigeria (Oyeniran and Isola, 2023; Emodi et al., 2022). These fuels are not only inefficient but also contribute to serious health risks, particularly respiratory diseases caused by exposure to particulate matter (PM2.5), which primarily affects women and children (Bede-Ojimadu and Orisakwe, 2020; Carrión et al., 2019). In addition, women are often responsible for gathering firewood and managing kerosene stoves, further limiting their economic and social opportunities (Abdullahi et al., 2022; Ogundana, 2022). Therefore, the health and economic vulnerabilities faced by women due to their reliance on traditional fuels are likely to drive their support for renewable energy alternatives, such as solar energy, which are cleaner, more sustainable, and abundant in Nigeria. Qualitative feedback from participants corroborates these findings shown in Table 5.13 below:

Table 5. 13 Summary of Female Participants' Energy Vulnerabilities

Vulnerability Category	Female Participant's Comments
Health Vulnerabilities – These vulnerabilities relate to health risks associated with the use of traditional fuels such as firewood and charcoal.	• *"At school once the lights go off, I have to use candle or a lantern to study at night which sometimes affects my eyes."* (RP326) • *"Preserving food becomes difficult, adding to household work."* (RP545) • *"Let me be honest, food cooked with firewood has this unique taste, especially our local delicacy; even though we use kerosene stoves when it is possible, I still prefer firewood, especially when we travel to the village"* (RP546)
Economic Vulnerabilities—These vulnerabilities relate to the availability and financial burden of conventional fuels like LPG, kerosene, and firewood, which are mostly unavailable or expensive for households and require time to purchase or gather.	• *"Kerosene stoves are majorly used for cooking, but sometimes when you want to cook something really fast, you can use gas, but not everyone can afford it".* (RP450) • *"We mainly use gas for our cooking but sometimes use kerosene stoves due to the unavailability of gas in the market. In fact, every household, as far as I know, has a kerosene stove for backup in my neighbourhood."* (RP700) • *"…some mornings, I have to go to the mangrove to collect wood for cooking before I get ready for school… or I do that after school."* (RP004)
Safety and Insecurity – these vulnerabilities relate to those associated with crime and the well-being of households.	• *"The current electricity problem makes me feel unsafe and insecure when I am on my way home from work. Especially at night as the streets are not illuminated, the streetlights do not work."* (RP040)

Table 5.13 summarises the vulnerabilities experienced by female participants in this study. It highlights vulnerabilities related to health, economic, and safety risks linked to the use of traditional fuels like firewood, charcoal, and kerosene. These vulnerabilities occur due to varying household responsibilities, where women are mainly responsible for domestic activities and rely on traditional fuels to perform household chores. In view of the vulnerabilities experienced by female participants above, the researcher sought to explore what type of renewable energy sources participants viewed as beneficial to mitigate their household energy challenges and female vulnerabilities.

5.5.3. Preferred Renewable Energy Source

This section analyses and evaluates data derived from the participants regarding their perspectives on which types of renewable energy sources would be most beneficial in reducing their reliance on traditional fuels. Understanding their preferred renewable energy source is crucial, as it would help to identify the most viable and acceptable solutions suited to their household energy needs. By assessing participants' preferences, the study can determine which renewable energy sources are likely to be adopted, considering factors such as local availability, cost-effectiveness, and ease of implementation. Therefore, the participants were asked about their preferred type of renewable energy source in the table below.

Table 5. 14 Preferred Renewable Energy Sources for Nigerian Households

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		19	2.5	2.5	2.5
	Biomass energy	34	4.6	4.6	7.1
	Geothermal energy	5	.7	.7	7.8
	I don't know	84	11.3	11.3	19.0
	Solar energy	581	77.9	77.9	96.9
	Tidal wave energy	1	.1	.1	97.1
	Wind energy	22	2.9	2.9	100.0
	Total	746	100.0	100.0	

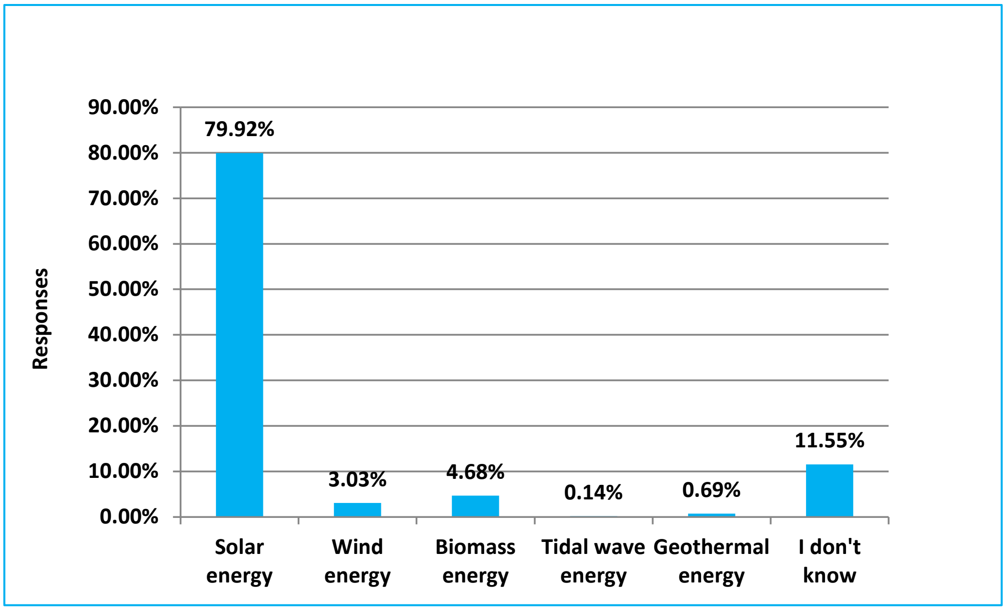

Figure 5. 23 Household Renewable Energy Choice

Findings from Figure 5.23 show that 79.92% of households identified solar energy as their preferred renewable energy source. The high preference for solar energy can be linked to factors such as an abundance of solar energy and high solar radiation in Nigeria. Nigeria receives about 4.0 kWh/m^2/day - 7.0 kWh/m^2/day solar radiation in most parts of the country, and it is often viewed as a renewable energy resource to address the country's household energy challenges (Ogunmodimu and Okoroigwe, 2019). This view makes solar a viable alternative to the traditional energy sources used in most households. Other reasons for the overwhelming preference for solar energy could be due to its affordability and the likelihood of solving energy challenges for households in rural areas (Nduka, 2021; Obada et al., 2024). From Figure 5.23 above, 4.68% of households preferred biomass energy, followed by 3.03% who preferred wind energy. Tidal wave and geothermal energy were the least preferred renewable energy sources for households with 0.14 % and 0.69%, respectively. These sources have lower preferences, which could be due to low awareness, lack of technical knowledge and infrastructural challenges in their discovery and development in Nigeria (Osuizugbo et al., 2024; Ayodele, Ogunjuyigbe et al., 2021). Therefore, making solar energy a viable solution to Nigeria's household energy challenges.

5.5.4. Renewable Energy Use in Households

Findings from Section 5.5.3 show solar energy as the most preferred renewable energy source for surveyed households. Due to solar energy's potential to serve as a viable alternative to mitigate household energy challenges in Nigeria, this section investigates solar energy use amongst study participants.

Table 5. 15 Solar Energy Use in Households

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		17	2.3	2.3	2.3
	I don't know	24	3.2	3.2	5.5
	No	565	75.7	75.7	81.2
	I plan to install solar energy in the future	45	6.0	6.0	87.3
	Yes	95	12.7	12.7	100.0
	Total	746	100.0	100.0	

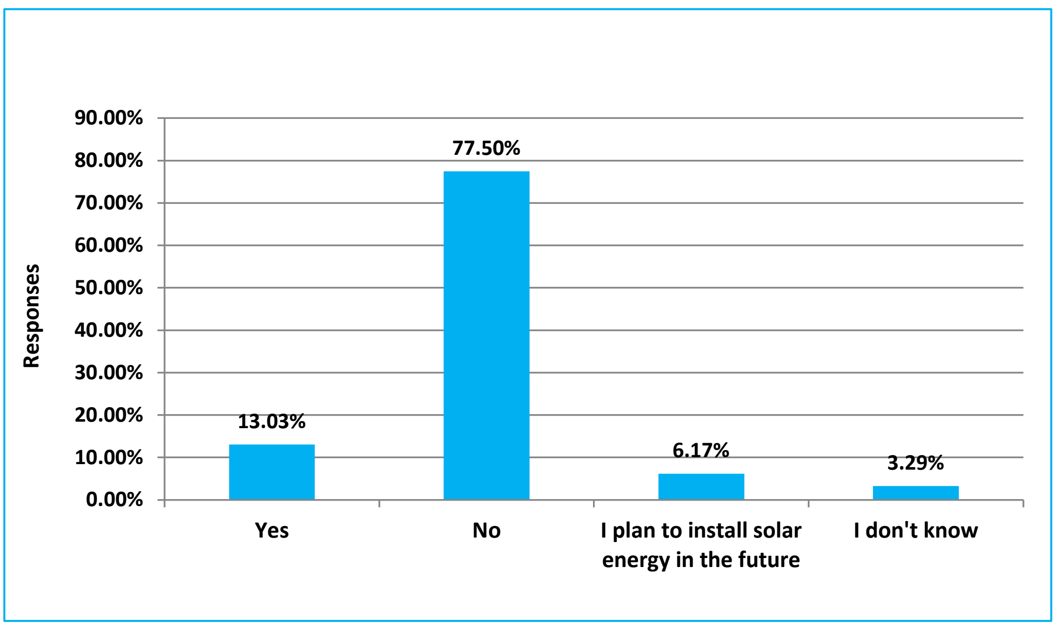

Figure 5. 24 Household Solar Energy Use

Table 5.15 and Figure 5.24 show that only 13.03% of surveyed households use solar energy in their homes, compared to a higher proportion of 77.50% of households that do not use solar energy. Additionally, 6.17% of households showed a willingness to install solar energy in the future, while 3.29% of households are undecided about using solar energy. These findings highlight solar energy as a viable solution to Nigeria's household energy challenges. However, its adoption is accompanied by challenges. Despite solar energy being abundant in Nigeria, its high initial cost, poverty rates, and limited access to financial incentives make solar energy unaffordable for most Nigerian households (Olayungbo, Faiyetole and Olayungbo, 2024). Therefore, limiting its use among surveyed households, as seen in Figure 5.24. Nevertheless, a large proportion of households indicated they would consider using solar energy if barriers to its utilisation could be removed.

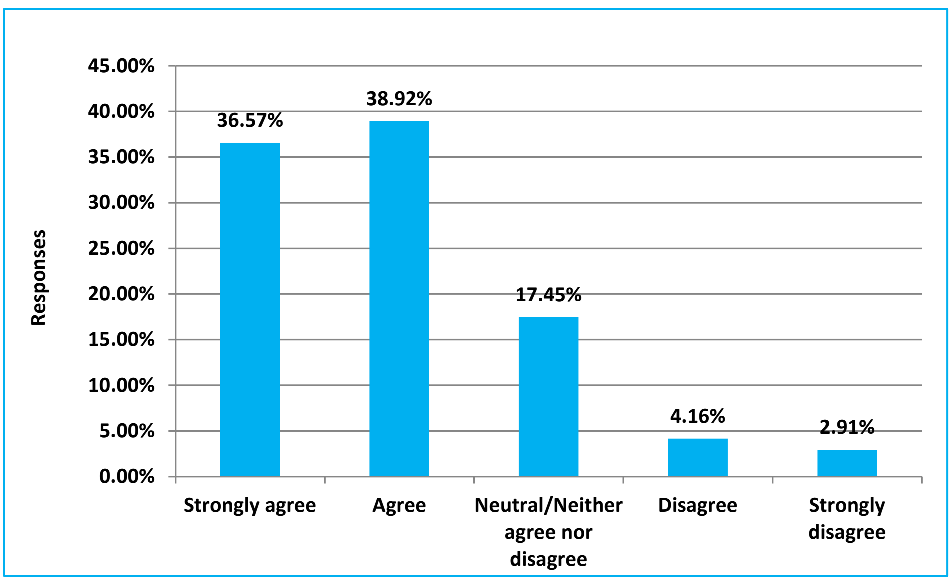

Figure 5. 25 Household Views on Government Subsidies and Incentives for Solar Adoption

Following household challenges in adopting solar energy, a combined 75.49% of participants indicated that they would be willing to adopt solar energy if government subsidies and incentives were available. 36.57% of participants strongly agree, and 38.92% agree that government subsidies would encourage them to use solar energy. This shows an interest in solar energy if financial support were available due to the high installation cost of solar panels, which is unaffordable for many

Nigerian households (Olayungbo, Faiyetole and Olayungbo, 2024). However, 17.45% of participants were neutral regardless of government support, suggesting uncertainties about the availability of government subsidies. Only 4.16% disagreed, and 2.91% of participants strongly disagreed that government subsidies would encourage them to adopt solar energy. The findings from Figure 5.25 highlight the significance of government subsidies and incentives in addressing the barriers to solar energy adoption and renewable energy adoption.

5.6. Feasibility Indicators of Household Adoption of Renewable Energy in Nigeria

This section examines the factors that influence the feasibility of adopting renewable energy in Nigerian households. The analysis of survey data from the previous chapters reveals several key determinants that affect household energy choices (see Table 5.12). According to Table 5.12, the most significant drivers of household energy choices are fuel availability (60.50%), price (50.21%), and affordability (41.03%). This section focuses on these factors to assess whether they act as feasibility indicators that influence the likelihood of households adopting renewable energy in Nigeria. Understanding and analysing these factors is essential for identifying the barriers to renewable energy adoption in Nigeria.

Analysing the impact of these feasibility indicators revealed a significant relationship between fuel availability, fuel cost and household income on the likelihood of utilising solar energy as the most preferred renewable energy source. The results show a positive correlation, indicating that these factors could influence household decisions to adopt renewable energy.

5.6.1. Impact of Fuel Availability on the Feasibility of Utilising Renewable Energy

The results from Table 5.16 show a χ^2 value of 447.636 and a probability value of 0.000, which is lower than the 0.01 threshold. This suggests that fuel availability, relating to the lack of electricity discussed in Section 5.3.1, significantly influences the feasibility of households adopting renewable energy.

Table 5. 16 Impact of Fuel Availability on the Feasibility of Utilising Renewable Energy

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	447.636[a]	25	.000
Likelihood Ratio	99.976	25	.000
N of Valid Cases	746		

a. 24 cells (66.7%) have an expected count of less than 5. The minimum expected count is .01.

This implies that households that experience energy shortages are more willing to adopt renewable energy, such as solar, as an alternative to traditional energy sources, including electricity from the national grid. Indicative comments from participants support these findings and are presented below.

> *"The current electricity problem makes me feel unsafe and insecure when I am on my way home from work. Especially at night as the streets are not illuminated, the streetlights do not work" (*RP040*).*

> *"We do not have a steady power supply in our area… once they take the light, everywhere gets dark, and we feel unsafe as it is when it is dark. Criminals operate."* (RP004)

> *"…The electricity from NEPA (national grid) is out almost every day, and it can be off for hours and sometimes all day. This is frustrating and makes it hard to get anything done in the house and at work."* (RP200)

> *"I run a small business selling cold drinks, and the constant electricity outages are killing my productivity and increasing my costs because I have to use the generator to power my fridge, and the cost of petrol is unaffordable for me."* (RP683)

The findings from Table 5.16 and qualitative responses from participants reveal the significant energy challenges faced by Nigerian households in relation to insufficient electricity supply. Participants 040 and 004 express safety and security concerns due to poorly illuminated streets at night, thus suggesting a security risk from an unreliable power supply. Similarly, participants 200 and 683 emphasise the broader implications of this unreliable power supply, negatively affecting their business activities. This persistent instability in power supply increases their reliance on costly, fossil fuel-powered generators, further elevating the need for more affordable and sustainable energy alternatives, such as renewable energy.

5.6.2. Impact of Fuel Cost on the Feasibility of Utilising Renewable Energy

The analysis of the correlation between fuel cost and the feasibility of utilising renewable energy among surveyed households shows fuel prices as an important feasibility indicator. This relationship suggests that the price of fuel will influence household energy decisions to adopt renewable energy, as seen in Table 5.17.

Table 5. 17 Impact of Fuel Cost on the Feasibility of Utilising Renewable Energy

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	329.201[a]	15	.000
Likelihood Ratio	63.103	15	.000
N of Valid Cases	746		

a. 11 cells (45.8%) have an expected count of less than 5. The minimum expected count is .04.

Table 5.17 shows a positive relationship between fuel cost and the likelihood of households adopting renewable energy. This suggests that as conventional fuel prices increase, households will be more likely to explore affordable alternatives that will reduce their energy bills (see Figure 5.12). Therefore, fuel price is a key feasibility indicator and driver in household energy decisions towards adopting renewable energy. This highlights the need for government subsidies and incentives on renewable energy technologies to drive their adoption among households in Nigeria. To support this view, some research participants added that:

“Electricity bills are going up and up, and yet we don't get enough power supply to justify these costs." (RP400)

“Most times NEPA gives us estimated electricity bills, that shows what we have not used and if I don’t pay they will cut off my light” (RP315)

“We spend so much on petrol for generators because the electricity from NEPA (national grid) is so unreliable. It is becoming difficult running the generator for my business and at home." (RP733)

Collectively, the qualitative responses provided by participants show that rising fuel costs, including household energy challenges, could significantly influence household decisions to adopt renewable energy. Therefore, it implies that as fuel prices increase, the likelihood of households exploring renewable energy alternatives increases.

5.6.3. Impact of Household Income on the Feasibility of Utilising Renewable Energy

Table 5.18 below analyses the relationship between household income and the feasibility of adopting renewable energy. The findings show that an increase in household income could increase the likelihood of households perceiving renewable energy as more viable than traditional fossil fuels.

Table 5. 18 Impact of Household Income on the Feasibility of Utilising Renewable Energy

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	432.181[a]	20	.000
Likelihood Ratio	133.275	20	.000
N of Valid Cases	746		

a. 8 cells (26.7%) have an expected count of less than 5. The minimum expected count is .42.

This high feasibility can be attributed to households' increased financial capacity to afford the high initial investment cost of renewable energy. The significant relationship between household income and the feasibility of utilising renewable energy shows that household income plays a significant role in driving household adoption of renewable energy.

5.7. Correlation Analysis

To correlate the responses of the participants at a 95% confidence interval, data cleaning was done such that a relative scale was introduced for all response ranges in similarity to the Likert scale as applied by Arslan et al. (2021). Any response with Yes, Sometimes, Agree and Strongly Agree is ranked as 2, while responses with No, Disagree, and Strongly Disagree were ranked 1. All other responses, such as Neutral, I don’t know, and all undefined responses, are ranked 0. Then, a bivariate correlation is carried out on the participants’ responses to the following questions.

a) The occurrence of electricity outages/cuts affects the daily running of your household.
b) How often do you use a personal generator (petrol/diesel) to generate electricity in your house?
c) The use of personal generators results in environmental and noise pollution.
d) Generation of electricity from renewable energy resources (solar energy) might reduce Nigeria's dependence on fossil fuel (petrol, diesel, coal etc.)
e) Renewable energy such as solar energy is the future source of energy in Nigeria?
f) Are your energy bills expensive or a financial pressure?
g) Do you have an electric meter installed in your house?
h) Do you switch OFF the lights when leaving a room in house?
i) Do you switch OFF lights during the daytime?
j) Do you turn OFF all household appliances (TV, computer etc.) when not in use?
k) Is your home thermally insulated?
l) Do you use LED (energy saving) bulbs at home?
m) Do you leave the air condition ON when you leave the house?
n) Do you use automatic sensors that switch OFF lights automatically in your house?

o) Do you think using energy from renewable energy resources is a way to conserve the environment?
p) Will you consider using electric cars?
q) Renewable energy will serve as an alternative to solve Nigeria's energy challenges, ensure energy security and improve the economy.
r) Do you use renewable energy in your home?
s) If solar energy is more expensive than fossil fuel (petrol), will you still use solar energy?
t) Governmental agencies have made considerable efforts to promote renewable energy in Nigeria.
u) Governmental subsidies and other financial incentives on renewable energy will encourage you to use renewable energy.
v) If you use solar panels in your house, will you be worried about damage or theft?
w) I have a proficient knowledge about renewable energy (wind, solar, hydro, thermal, etc.) through personal study.
x) The price of renewable energy technology in Nigeria is higher due to a lack of government incentives.
y) The growth of the renewable energy sector still experiences a slow pace in Nigeria.
z) More governmental effort needs to be targeted towards developing renewable energy technologies in Nigeria, especially for rural communities. Government and environmental agencies need to do more to increase the awareness and benefits of renewable energy

Table 5. 19 Correlational Analysis of Household Energy Challenges and Support for Renewable Energy Adoption

		The occurrence of electricity outage/cuts affects the daily running of your household.	How often do you use a personal generator (petrol/diesel) for electricity generation in your house?	Renewable energy such as solar energy is the future source of energy in Nigeria?	Renewable energy will serve as an alternative to solve Nigeria's energy challenges, ensure energy security and improve the economy.
The occurrence of electricity outage/cuts affects the daily running of your household.	Pearson Correlation	1	.257**	.094*	.084*
	Sig. (2-tailed)		.000	.010	.021
	N	746	746	746	746
How often do you use a personal generator (petrol/diesel) for electricity generation in your house?	Pearson Correlation	.257**	1	.119**	.158**
	Sig. (2-tailed)	.000		.001	.000
	N	746	746	746	746
Renewable energy such as solar energy is the future source of energy in Nigeria?	Pearson Correlation	.094*	.119**	1	.333**
	Sig. (2-tailed)	.010	.001		.000
	N	746	746	746	746
Renewable energy will serve as an alternative to solve Nigeria's energy challenges, ensure energy security and improve the economy.	Pearson Correlation	.084*	.158**	.333**	1
	Sig. (2-tailed)	.021	.000	.000	
	N	746	746	746	746

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

On testing, if electricity outages compelled participants to use generators as an alternative energy source, the correlation test shows there is a weakly significant relationship (0.257), implying that if electricity is not supplied, at least 25% of the people will consider generators as an alternative power source. On if the participants interested in using generators for power supply will be motivated to consider renewable energy such as solar power, the correlation is still weakly significant at 0.119. There is, however, a rather higher significant relationship (0.333) between those interested in solar energy and those who believe that renewable energy is the future of energy sources in Nigeria. This implies that the power challenge of the country has increased people’s willingness to consider alternative energy sources, with people believing that renewable energy is the way forward for the country.

Table 5. 20 Correlational Analysis Between Generator Use, Environmental Impact, and Perceptions of Renewable Energy

		The use of personal generator results in environmental and noise pollution?	Renewable energy such as solar energy is the future source of energy in Nigeria?	Do you think using energy from renewable energy resources is a way to conserve the environment?
The use of personal generator results in environmental and noise pollution?	Pearson Correlation	1	.213**	.194**
	Sig. (2-tailed)		.000	.000
	N	746	746	746
Renewable energy such as solar energy is the future source of energy in Nigeria?	Pearson Correlation	.213**	1	.169**
	Sig. (2-tailed)	.000		.000
	N	746	746	746
Do you think using energy from renewable energy resources is a way to conserve the environment?	Pearson Correlation	.194**	.169**	1
	Sig. (2-tailed)	.000	.000	
	N	746	746	746

**. Correlation is significant at the 0.01 level (2-tailed).

On testing if there is any relationship between those who are of the opinion that renewable energy is required in Nigeria and those with disaffection for pollution from generator usage, the significant correlation of 0.213 shows that at least 21% of the people feel solar energy is an alternative power source in order to better manage environmental pollution while the energy conservationists equally believe solar energy is a better option with a correlation of 0.169. This implies that a number of people who use generators are not comfortable with them and will readily opt for other environmentally friendly renewable energy sources, such as solar energy.

Table 5. 21 Correlational Analysis Between Energy Costs, Metering, and Household Energy Conservation Practice

		Are your energy bills expensive or a financial pressure?	Do you have an electric meter installed in your house?	Do you switch OFF the lights when leaving a room in house?	Do you switch OFF lights during daytime?	Do you turn OFF all household appliances (TV, computer etc.) when not in use?
Are your energy bills expensive or a financial pressure?	Pearson Correlation	1	-.005	.093*	.020	.086*
	Sig. (2-tailed)		.884	.011	.594	.019
	N	746	746	746	746	746
Do you have an electric meter installed in your house?	Pearson Correlation	-.005	1	.279**	.200**	.180**
	Sig. (2-tailed)	.884		.000	.000	.000
	N	746	746	746	746	746
Do you switch OFF the lights when leaving a room in house?	Pearson Correlation	.093*	.279**	1	.512**	.528**
	Sig. (2-tailed)	.011	.000		.000	.000
	N	746	746	746	746	746
Do you switch OFF lights during daytime?	Pearson Correlation	.020	.200**	.512**	1	.520**
	Sig. (2-tailed)	.594	.000	.000		.000
	N	746	746	746	746	746
Do you turn OFF all household appliances (TV, computer etc.) when not in use?	Pearson Correlation	.086*	.180**	.528**	.520**	1
	Sig. (2-tailed)	.019	.000	.000	.000	
	N	746	746	746	746	746

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

On whether the financial demands of energy usage could influence the desire for renewable energy sources, which may be higher than conventional electricity, there was no significant relationship between those who felt that expensive power supply could influence them to start putting off appliances in the house. The correlation between those using meters and those who switch off their light is weakly significant, implying that the notion of being able to read and control energy usage is more important to people than expensive power generation. There is, however, a high correlation between those who switch off the light when leaving the room and those who switch off the light during the day (0.512) and those who prefer turning off all appliances when not in use (0.520). This implicitly means that people may be willing to pay a higher price for other alternative sources, provided they can better control their consumption.

Table 5. 22 Correlational Analysis Between Household Energy Efficiency Features and Energy Use Behaviour

		Is your home thermally insulated?	Do you use LED (energy saving) bulbs at home?	Do you leave the air condition ON when you leave the house?	Do you use automatic sensors that switch OFF lights automatically in your house?
Is your home thermally insulated?	Pearson Correlation	1	.196**	.082*	.165**
	Sig. (2-tailed)		.000	.025	.000
	N	746	746	746	746
Do you use LED (energy saving) bulbs at home?	Pearson Correlation	.196**	1	.121**	.293**
	Sig. (2-tailed)	.000		.001	.000
	N	746	746	746	746
Do you leave the air condition ON when you leave the house?	Pearson Correlation	.082*	.121**	1	.187**
	Sig. (2-tailed)	.025	.001		.000
	N	746	746	746	746
Do you use automatic sensors that switch OFF lights automatically in your house?	Pearson Correlation	.165**	.293**	.187**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	746	746	746	746

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

On people's personal effort to conserve energy usage, those who use energy-saving bulbs at home had a significant correlation (0.293) with those who use automatic sensors to manage consumption in their homes. Those who have thermally insulated homes equally have tendencies to prefer energy-saving bulbs, as the correlation of 0.196 is significant, while those who habitually leave the air conditioner on prefer having an automatic sensor switch it off for them, with a significant correlation of 0.187. The implication is that people are more disposed to conserving energy if such conservation can be automatic, which renewable energy sources can offer.

Table 5. 23 Correlational Analysis Between Public Perception of Government Efforts for Renewable Energy Development

		Governmental agencies have made considerable efforts to promote renewable energy in Nigeria.	Governmental subsidies and other financial incentives on renewable energy will encourage you to use renewable energy.	More governmental effort needs to be targeted towards developing renewable energy technologies in Nigeria especially for rural communities	Government and environmental agencies need to do more to increase the awareness and benefits of renewable energy
Governmental agencies have made considerable efforts to promote renewable energy in Nigeria.	Pearson Correlation	1	.163**	.127**	.124**
	Sig. (2-tailed)		.000	.000	.001
	N	746	746	746	746
Governmental subsidies and other financial incentives on renewable energy will encourage you to use renewable energy.	Pearson Correlation	.163**	1	.216**	.214**
	Sig. (2-tailed)	.000		.000	.000
	N	746	746	746	746
More governmental effort needs to be targeted towards developing renewable energy technologies in Nigeria especially for rural communities	Pearson Correlation	.127**	.216**	1	.567**
	Sig. (2-tailed)	.000	.000		.000
	N	746	746	746	746
Government and environmental agencies need to do more to increase the awareness and benefits of renewable energy	Pearson Correlation	.124**	.214**	.567**	1
	Sig. (2-tailed)	.001	.000	.000	
	N	746	746	746	746

**. Correlation is significant at the 0.01 level (2-tailed).

On if governmental supports could motivate users to consider renewable energy as an alternative, there is significant correlation (0.163) between those who feel that promoting renewable energy and offering incentives will encourage them to use renewable energy, those who feel more effort needs to be made in encouraging renewable energy (0.216) and those who posit that the government pointing out to its benefits will encourage people to consider the renewable energy sources. This implies that the government has a significant job to do in encouraging people to consider renewable energy.

Table 5. 24 Correlational Analysis Between Renewable Energy Use, Cost Sensitivity, and Willingness to Adopt Electric Vehicles

		Will you consider using electric cars?	Do you use renewable energy in your home?	If solar energy is more expensive than fossil fuel (petrol), will you still use solar energy?
Will you consider using electric cars?	Pearson Correlation	1	.082*	.100**
	Sig. (2-tailed)		.025	.006
	N	746	746	746
Do you use renewable energy in your home?	Pearson Correlation	.082*	1	.093*
	Sig. (2-tailed)	.025		.011
	N	746	746	746
If solar energy is more expensive than fossil fuel (petrol), will you still use solar energy?	Pearson Correlation	.100**	.093*	1
	Sig. (2-tailed)	.006	.011	
	N	746	746	746

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

While exploring the correlation between those who are considering energy conservation, such as that offered in electric cars, and those who are open to renewable energy, there is no significant relationship, as the potential for seeing renewable energy as a replacement for electricity may be perceived in terms of cars using renewable energy. The significant correlation between those with a preference for electric vehicles and those who still wish to use solar energy irrespective of cost shows that this assumption may be based on their knowledge of cars being run by solar panels. This indicates that the kind of renewable energy being offered as an alternative is equally dependent on what the generated energy is going to be used to power household appliances.

Table 5. 25 Correlational Analysis Between Public Awareness, Perceived Costs, and Barriers to Renewable Energy Development in Nigeria

		I have a proficient knowledge about renewable energy (wind, solar, hydro, thermal, etc.) through personal study.	The price of renewable energy technology in Nigeria is higher due to lack of government incentives.	The growth of the renewable energy sector still experiences a slow pace in Nigeria.
I have a proficient knowledge about renewable energy (wind, solar, hydro, thermal, etc.) through personal study.	Pearson Correlation	1	.228**	.108**
	Sig. (2-tailed)		.000	.003
	N	746	746	746
The price of renewable energy technology in Nigeria is higher due to lack of government incentives.	Pearson Correlation	.228**	1	.377**
	Sig. (2-tailed)	.000		.000
	N	746	746	746
The growth of the renewable energy sector still experiences a slow pace in Nigeria.	Pearson Correlation	.108**	.377**	1
	Sig. (2-tailed)	.003	.000	
	N	746	746	746

**. Correlation is significant at the 0.01 level (2-tailed).

On how the knowledge of renewable energy influence pricing and growth of renewable energy, the correlation between knowledge of renewable energy and willingness to still pay the high cost of renewable energy in Nigeria is significant (0.228), while the growth of the renewable energy sector is correlated with the price of the renewable energy (0.377). This implies that there is potential for greater growth in the renewable energy sector of Nigeria if prices are made consumer friendly.

5.8. Summary

The data presented in this chapter revealed critical issues surrounding Nigeria's energy situation and the potential for households to adoption to renewable energy sources. A recurring theme that emerged from the analysis is the prevalence of frequent power outages, which significantly disrupts the daily lives of most Nigerians. This finding underscores the inadequacy of the current national grid system in meeting the energy demands of the population, highlighting the urgent need for reliable and sustainable alternatives.

Another key theme is the growing public awareness of the environmental and health impacts associated with the energy sources commonly used in Nigeria. This increased awareness could play a pivotal role in driving the adoption of renewable energy, as informed households are more likely to consider cleaner energy options when they become accessible and affordable.

Additionally, the data highlighted the persistent reliance on traditional and fuel-based energy sources due to affordability and availability issues, which further complicates the adoption process. Socioeconomic factors such as income levels, fuel availability, and cultural preferences continue to influence household energy choices, creating a complex landscape for energy adoption efforts. The findings from this chapter form a foundation for further analysis in the next chapter, where they are critically compared with key insights from the literature. This comparative analysis provides a deeper understanding of Nigeria's energy dynamics and informs potential strategies for promoting the adoption of renewable energy at the household level.

Chapter 6. Analysis of Results from Interviews with Key Policymakers

6.1. Introduction

This chapter presents the key findings from semi-structured interviews. The interviews provided deep insights into renewable energy integration within Nigerian households. The results discussion is focused on five key themes: inadequate energy supply, untapped renewable energy sources, gaps in renewable energy policy implementation, cost and market barriers to renewable energy adoption and lack of awareness and public support. Verbatim quotations are integrated into the main text to enrich the analysis with detailed viewpoints. To maintain confidentiality and adhere to the ethical standards required in research, pseudonyms and codes are used; 'researcher' (R) denotes the researcher, and 'INT01' represents the first interviewee and so on, ensuring the anonymity of participants while allowing for a clear and structured presentation of the findings (Audette, Hammond and Rochester, 2020). These themes emerged during the thematic analysis of the data from semi-structured interviews (see Figure 6.1)

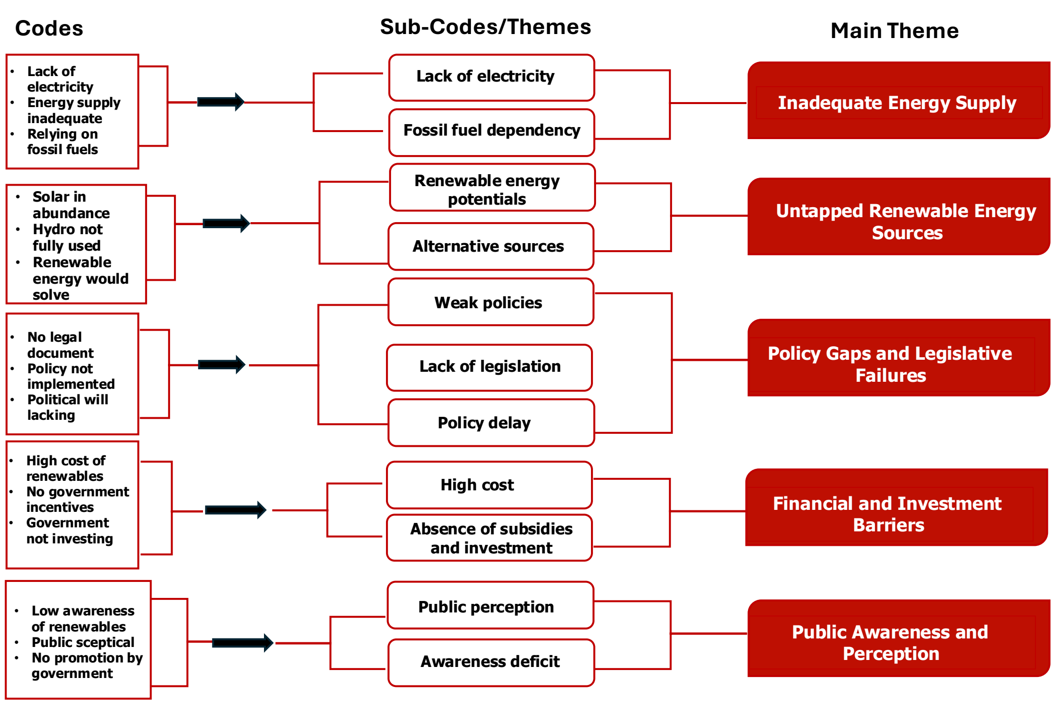

Figure 6. 1 Diagram of Code from Thematic Analysis

6.2. Inadequate Energy Supply

In the researcher's quest to understand Nigeria's energy landscape, it was essential to assess the energy challenges faced by households in the country first. This assessment provides a comprehensive understanding of Nigeria's energy situation and infrastructure and is crucial for developing tailored solutions that ensure renewable energy integration into the Nigerian household energy mix. When asked about the primary energy challenges faced by Nigerian households, interviewees highlighted that these challenges significantly influence the adoption to renewable energy in households.

Inadequate energy supply in Nigeria was one of the most prominent themes identified during the thematic analysis of the interview data. Most interviewees indicated the severity of inadequate energy supply and how this constitutes a major energy challenge for most Nigerian households. Therefore, it acts as a driver for households who want to switch to renewable energy alternatives as a solution to the energy crisis in Nigeria. It is interesting to note that almost all interviewees indicated that inadequate energy supply is a major energy challenge in Nigeria. Indicative comments from interviewees showing this are presented below.

> *"Supply of energy in whatever form is roughly inadequate in Nigeria. The technology, even though the capacity, that is the manpower, it is not adequate".* (INV01)

> *"First of all, we all know Nigeria has the main challenge, which is lack of constant energy."* (INV02)

> *"Our problem in this country is gross inadequate energy supply. Because if we have adequate energy supply, we create jobs for people, activity, industries will come up. There are many people who don't even want to work for government. But the major constraint now is that the power is not there. Even if you have the fund and you want to set up an outfit for production, you have problem, because the energy is not there."* (INV03)

"*Because they will tell you inadequate generation, inadequate -- yes, it's one of them. But inadequate transmission capacity is number one. Number two is inadequate generation. Number three is weak infrastructure—weak distribution infrastructure. Distribution is the weakest link. I'm answering some of your questions*." (INV04)

"Unfortunately, for now, we have less than 50% energy access. And especially in the rural areas, we have less than 30% of energy access, that is modern energy." (INV07)

Interviewees also indicated that the unreliable supply of electricity and constant grid collapse are fundamental energy challenges for Nigerian households but also barriers to renewable energy adoption that severely affect rural households. It is interesting to note that almost all participants poor supply issues and weak energy infrastructure as a challenge. The participant's indicative comments are presented below.

"*Basically, lack of electricity, lack of constant gas for heating or cooling, and then for cooking. But the main challenge is the lack of electricity throughout the whole year. It will be very difficult to see that, so far, Nigeria has not generated a lot of electricity that will be sufficient for the whole environment. So that is the main challenge, to be honest. And from that, we are relying on what? Fossil fuels. We are not relying on any renewable source of energy, which I think is one of the problems, because we can use these sources of energies. We have hydro, we have water in Nigeria. We can use solar – I am not sure of wind, but I think we can use solar also to help us generate the electricity*". (INV08)

"*Yeah. The energy challenges we have in Nigeria is enormous. You know, statistics has it that only 30% of Nigerians are exposed to inconsistent supply of power because of the national grid. So the chunk of Nigerians are of that energy in terms of power. So it's a big challenge. And as it is now, the main -- the utility, which is the national grid, is generating just about 4 megawatts for a population of about 180 million*." (INV01)

"Starting from electricity, there's no constant electricity. Everyone knows that." (INV06)

While participants identified inadequate energy supply, unreliable electricity, and frequent grid collapses as the primary energy challenges, interviewee INV09 offered an alternative perspective, highlighting the lack of professional expertise and effective leadership in the Nigerian energy sector as a significant contributor to household energy challenges. Comments by the interviewee suggested that

> *"……that the government has failed in trying to find the right person for the job, they failed the country by putting a square peg in a round hole. What I mean by that is that there are some areas you need to put professionals to be in charge. Technocrats that are professional in those areas should be put in charge of such agencies and ministries. You cannot put a lawyer to be in charge of the health sector or the engineering sector, and you expect it to work. And that is a problem we're having. The same thing, you cannot put an accounting officer to head a utility -- a power utility company. It will not work."* (INV09)

From the interviewee's comments above, a summary of the primary energy challenges for Nigerian households includes

Table 6. 1 Summary of the Main Energy Challenges

Household Energy Challenges	Interviewee's Comments
Inadequate Energy Supply	• *"Supply of energy in whatever form is roughly inadequate in Nigeria" (INV01).* • *"First of all, we all know Nigeria has the main challenge, which is lack of constant energy" (INV02).* • *".... Our problem in this country is gross inadequate energy supply" (INV03).*
Unreliable Electricity Supply and Grid Collapse	• *"The main challenge is the lack of electricity throughout the whole year" (INV08).* • *"Statistics has it that only 30% of Nigerians are exposed to inconsistent supply of power because of the national grid" (INV01).* • *"There's no constant electricity. Everyone knows that" (INV06).* • *Frequent grid collapses were identified as a significant issue affecting energy reliability (General participant consensus).*
Weak Electricity Transmission and Distribution Infrastructure	• *"… Inadequate transmission capacity is number one. Number two is inadequate generation. Number three is weak infrastructure—weak distribution infrastructure. Distribution is the weakest link" (INV04).*
Lack of Energy Access in Rural Areas	• *We have less than 50% energy access. And especially in the rural areas, we have less than 30% of energy access, that is modern energy" (INV07).*
Reliance of Fossil Fuels	• *"We are relying on what? Fossil fuels. We are not relying on any renewable source of energy, which I think is one of the problems" (INV08).*
Lack of Professional Expertise and Leadership	• *"The government has failed in trying to find the right person for the job... Technocrats that are professional in those areas should be put in charge of such agencies and ministries" (INV09).*

These comments highlight that energy poverty is a significant challenge for households in Nigeria. Households have little access to a reliable electricity supply, leading to an over-reliance on expensive and environmentally harmful alternatives such as petrol and diesel generators (Babajide and Brito, 2021; Ayodele et al., 2019). The weak energy infrastructure not only limits the deployment of renewable energy but also impedes economic development. The inadequate energy supply and infrastructure present a significant barrier to the adoption of renewable energy technologies (Sovacool, 2010). Even though renewable energy, particularly solar, could bypass some of the grid-related issues, the lack of investment in grid expansion and maintenance hampers its integration (Nyarko, Whale and Urmee, 2023). Addressing this challenge is crucial to enable households to benefit from clean energy solutions.

The interviewees' responses align with findings from previous studies, highlighting Nigeria's significant energy challenges. As the most populous country in Africa, a substantial portion of its population lacks access to reliable electricity and energy supply. Despite Nigeria's vast renewable energy potential—estimated at 427,000 MW for solar, 11,000 MW for wind, and 14,750 MW for hydropower (Adelaja, 2020), the energy sector remains predominantly dependent on fossil fuels. Oil and gas account for over 80% of the national energy mix, while 96% of households continue to rely on traditional energy sources such as firewood and kerosene (Okoh and Okpanachi, 2023; Oyeniran and Isola, 2023). This complicates efforts to shift towards renewable energy adoption (Nalule, Anaman and Acheampong, 2022).

In recent years, the Nigerian government has taken steps to diversify its energy sources and promote renewable energy through various policies and legislative measures. The Renewable Energy Master Plan (REMP), developed by the Energy Commission of Nigeria, aims to increase the contribution of renewable energy to the national energy mix from 13% in 2015 to 23% by 2025 and 36% by 2030 (Energy Commission of Nigeria, 2022). Additionally, the National Renewable Energy and Energy Efficiency Policy (NREEEP), introduced in 2015, provides a framework for developing, utilising, and efficiently managing renewable energy resources in Nigeria. However, these policies are yet to be implemented into law, and they act as barriers to household renewable energy adoption (Adeyanju et al., 2020). Energy is a vital input for powering transportation, agriculture, industry, healthcare, and education globally (Sambo, 2010). For any nation to achieve rapid and sustained socioeconomic growth, access to reliable infrastructure, particularly electricity, is essential (Sovacool, Hess, and Cantoni, 2021). However, in Nigeria, the national energy infrastructure has deteriorated significantly, resulting in over 200 power outages in the past nine years (Emodi and Boo, 2015; Owebor et al., 2021).

The adoption of renewable energy is imperative for Nigeria to meet its international climate change commitments. As a signatory to the Paris Agreement, Nigeria has pledged to limit global temperature increases to below 2°C above pre-industrial levels (Dioha and Kumar, 2020). Achieving this target requires a substantial increase in the share of renewable energy in the household energy mix, incorporating sources such as solar, wind, and hydropower into electricity generation. Despite this ambition, several barriers hinder Nigeria's effective implementation of renewable energy policies (see Table 6.2). These include weak legal and regulatory frameworks, inadequate funding and investment, and limited technological and infrastructural capacity. Overcoming these challenges is essential for Nigeria to exploit its renewable energy potential and achieve sustainable development.

6.3. Untapped Renewable Energy Sources

In addition to understanding Nigeria's energy landscape, it was essential to assess the country's renewable energy potential. This assessment is critical for evaluating the feasibility of integrating renewable energy sources into the household energy mix. Renewable energy potentials were a central theme of the analysis of interview data. Interviewees highlighted that Nigeria has vast amounts of renewable energy resources, particularly solar energy, biomass, small hydro, geothermal, and wind power. These resources present an enormous opportunity for Nigeria to diversify its energy mix and provide sustainable energy solutions for households. Participants indicated the following statement.

"We have sun in abundance …. and we have wind. Though our wind regime is not very strong. But we have wind source …. we have biomass resources and the geothermal is weak. And we have not done any work in geothermal. We have not done any work in geothermal, because our potential for geothermal is very weak. The hydrogen is still at the experimental level". (INV01)

"Yes. I think I have mentioned the hydro and solar. I'm not sure about wind, to be honest …... we can generate a lot, I think, from hydro. Yes, we can generate a lot from hydro. And I think we will generate more, as we see in the Kainji Dam effect". (INV02)

"We have hydro and biomass resources in abundance… small-scale hydro projects could help off-grid communities" (INV07)

"For the solar, we are just using the sun's energy, at least, to generate electricity. Having a solar farm, I think, is a worthwhile investment". (INV03)

Other interviewees highlighted the renewable energy potential in Nigeria based on regional availability:

"…… And again, in the South -- even in the North, we do have dams that we are using to generate electricity, but most of them are not being looked after. I know for the hydro part of electricity, we rely on Kainji Dam." (INV03)

"In the North, we have farmlands that can be used for solar farms… In the South, we can use dams to generate electricity." (INV04)

These comments from interviewees highlight the availability of renewable energy sources in various parts of Nigeria. From the comments above, solar energy is seen to be widespread across most parts of Nigeria and could play a significant role in bridging the energy supply gap identified in theme 1, reduce dependence on fossil fuel and increase electricity access to rural areas (Mohammed et al., 2017; Adelaja, 2020). However, while most interviewees indicated Nigeria's vast renewable energy potential, some noted that these renewable energy resources remain untapped. For example:

> INV01 suggested – *"We have sun in abundance …. and we have wind. Though our wind regime is not very strong. But we have wind source …. we have biomass resources and the geothermal is weak. And we have not done any work in geothermal. We have not done any work in geothermal because our potential for geothermal energy is very weak. The hydrogen is still at the experimental level".*
>
> While INV02 stated that - *"We are not relying on any renewable source of energy, which I think is one of the problems because we can use these sources of energy*".

Despite these renewable sources being underutilised in Nigeria, several interviewees view renewable energy as a viable solution to the country's energy crisis. Most pointed out that solar energy, if adequately explored, could meet household energy demands in Nigeria (see Table 6.3).

Table 6. 2 Comments on renewable energy as a viable solution to Nigeria's energy crisis

Interviewee	Interviewee's Comments
INV01	*"We have sun in abundance... Solar energy has other applications, including electricity, cooking, and pasteurisation. If fully utilised, it could help address our energy needs"*
INV02	*"From an energy perspective, the amount of hydro water we have in the South and the solar potential in the North can significantly reduce our reliance on crude oil and fossil fuels. Solar farms would be a worthwhile investment"*
INV03	*"Renewable energy, especially solar, is a win-win for us. It is the least-cost option for increasing energy access in rural areas, and mini-grids using solar have been successful in some states"*
INV04	*"The amount of sunlight in Nigeria should be enough to give us substantial electricity. Solar panels could address our energy challenges if properly utilised"*

The following comments from interviewees INV01, INV02, INV03, and INV04 further support the perspectives outlined in Table 6.3, particularly in response to the researcher's question about which renewable energy source would be the most economically feasible for wide-scale adoption in Nigerian households. The interviewees added the following:

> *"Solar energy is one of the most widely economically usable energy resources in Nigeria. Its applications, including electricity generation, cooking, and drying, make it highly versatile and suitable for widespread adoption"* (INV01)
>
> *"Renewable energy, particularly solar, is the most feasible option for increasing energy access in rural areas. Mini-grids and off-grid systems powered by solar are cost-effective and can complement the existing grid"* (INV03)
>
> *"The amount of sunlight in Nigeria makes solar energy highly promising. While hydropower has potential, solar seems more feasible for wide-scale implementation due to its abundance and accessibility"* (INV04)
>
> *"From what I see, hydro energy has significant potential. Investments in dams like Kainji, Tiga, and Bagauda could generate substantial electricity. However, solar farms in the North would also be a worthwhile investment to address energy challenges"* (INV02)

The comments above reflect a strong preference for solar energy as Nigeria's most viable renewable energy resource. This is due to the abundance of solar radiation in parts of the country and its flexibility in addressing the country's household energy challenges (Ogunmodimu and Okoroigwe, 2019). Hydropower was also acknowledged as an essential renewable energy resource, but interviewees recognised solar energy as more feasible for widespread household adoption in Nigeria.

Nigeria’s renewable energy potential is approximately 1.5 times greater than its fossil fuel resources (Aliyu, Dada, and Adam, 2015). Renewable energy sources such as hydro, solar, biomass, and wind have the potential to significantly improve Nigeria’s limited access to electricity (Shaaban and Petinrin, 2014). These sources have also been proposed as viable options for decentralised energy generation in remote areas with challenging terrains (Shaaban and Petinrin, 2014; Yamusa II and Ansari, 2015). Currently, Nigeria’s generating capacity falls short of meeting its energy demand, resulting in a persistent energy crisis. Although the country possesses a wealth of both fossil and renewable energy resources, only about 60% of the population has access to the national grid (Dioha and Kumar, 2020). A more balanced energy mix could help mitigate this crisis. Nigeria could augment its power generation capacity and partially address household energy challenges by utilising renewable energy resources such as solar, small hydro, biofuels, wind, and biomass.

6.4. Policy Gaps and Legislative Failures

Based on the interviewee's comments on Nigeria's renewable energy potential, the researcher sought to determine whether any renewable energy policies or general energy policies exist in Nigeria. Examining renewable energy policies was deemed essential, as such policies play a pivotal role in establishing frameworks that guide the development and adoption of renewable energy (Hoicka et al., 2021; Ahmad et al., 2024). They also help address barriers to implementation and create a favourable environment for investment opportunities (Hoicka et al., 2021). Interviewees stated that there are several renewable energy policies and regulatory frameworks in place in Nigeria, in collaboration with efforts to implement these policies through various projects. Interviewee’s comments are presented below:

> *"The Energy Commission of Nigeria has produced a National Energy Policy in 2003. It was approved by the Federal Executive Council. Since then, it has been revised. And the last revised form of it was done in 2014. It was revised in 2007 and 2014 last. The revision was necessary to take care of the changes in the energy sector, because the 2003 that was*

approved by the Federal Executive Council, since then, a lot of changes have taken place in the energy sector. So because of that, it has to be revised". (INV01)

Interviewee INV03 also suggests that

"We have a policy on renewable energy and energy efficiency, which was passed by the Federal Executive Council in 2015. Additionally, there is a National Action Plan on Renewable Energy and a Sustainable Energy for All Action Agenda". (INV03)

To further support the views expressed above, interviewee INV01 noted that Nigeria's energy and renewable energy policies are developed in line with international best practices. Demonstrating the government's commitment to supporting the adoption of renewable energy. Interviewee INV01 stated that:

"…. We have developed it. And we use international best practices to come up with a policy. Our policy, wherever it goes, is adjudged to be very, very good. Because we involve all stakeholders relevant ministries, academia, International organisations that have something to do with energy: World Bank, UNDP, UNIDO, JICA. All of them came on board in the policy. So we have it, the policy document. If you go to the website, you'll see it." (INV01)

Some participants further emphasised efforts made by the Nigerian government to implement some of these policies through various renewable energy projects and initiatives across the country. They both suggested that:

"We have developed relevant documents guiding state governments and individuals on implementing renewable energy facilities. There is also an understanding with the National Assembly for solar streetlights, solar boreholes, and mini-grids in remote areas" (INV01)

The mini-grid regulations were passed in 2016 to promote renewable energy projects for rural areas. These regulations have supported projects in several states, such as Plateau, Niger, Sokoto, Ogun, and Cross River." (INV03)

Both comments confirm the presence of renewable energy policies and other regulatory frameworks in Nigeria to promote household renewable energy adoption and attract investment into the sector. Table 6.4 shows examples of such policies and regulatory frameworks designed to implement some of these policies through renewable energy projects and initiatives.

Table 6. 3 Renewable Energy Policies and Implementation Frameworks

POLICIES/REGULATORY FRAMEWORKS	KEY FEATURES	OBJECTIVES/OUTCOMES
National Energy Policy (Nep), 2003	• Developed by the Energy Commission of Nigeria (ECN) • Led to the creation of the Rural Electrification Funds under Policy 5 guideline • Led to the establishment of the Rural Electrification Agency (REA)	Provided a framework for financing renewable energy projects through the Renewable Electricity Trust Fund, funded by private and governmental contributions.
Economic Sustainability Plan (ESP)	• Launched by the Nigerian government in collaboration with the REA • To expand energy access in off-grid communities and mitigate the impact of COVID-19.	Aims to provide five million new solar connections, reaching 25 million people through Solar Home Systems (SHS) and mini-grid solutions, while creating 250,000 jobs.
5 million Solar Homes Scheme	• A key programme under the ESP, designed to provide affordable and sustainable electricity to rural and underserved areas.	Enhances energy reliability, reduces dependence on fossil fuels, promotes renewable energy adoption, and stimulates economic growth in remote communities.

On the contrary, despite the existence of renewable energy policies in Nigeria, their impact on household adoption remains limited (Osunmuyiwa and Kalfagianni, 2017; Adelaja, 2020). Several interviewees highlighted persistent gaps between policy formation and implementation, pointing to weak frameworks and legislative deficiencies as major barriers to the adoption of renewable energy. The following statements illustrate this:

"the policies are in place. There is no constraints. We have the policy. We have developed it. The problem is the implementation" (INV01)

Interviewees INV05 and INV04 held a similar view to INV01, adding that:

"We have all the necessary policies on renewable energy and energy efficiency, but the main challenge is in implementation. Signing agreements is delayed due to stringent conditions and lack of funding to support private sector participation" (INV05)

"Even if we have renewable-energy policies, I don't think they are properly implemented. There is no information or clear circulation of these policies" (INV04)

The comments above show that the lack of a robust legislative framework significantly hinders household renewable energy adoption in Nigeria (Emodi and Boo, 2015; Adewuyi et al., 2020). While the Energy Commission has developed comprehensive policy documents, the absence of legislative approval and enforcement mechanisms undermines their effectiveness. Participants emphasised that the lack of political will and the absence of legislative backing hinder the inflow of local and foreign investments into renewable energy technologies in Nigeria. The statement below illustrates this effectively:

"The government has put the policy in place, but the political will to implement it is lacking. Even with good policies, inadequate funding makes them ineffective" (INV01)

INV01 further added that –

"The costs of procurement of renewable energy facilities is also very expensive for the beneficiaries. No adequate government incentives to encourage the beneficiaries. The market awareness is also very, very low. The political will on the side of the government is also very poor. No legal document in terms of energy law, though they draft policies exist. But there is no legal document. They have not yet passed into law. And this is a very big constraint to investors into the renewable energy, you see it, of Nigeria". (INV01)

Similarly, INV05 added - *"...... Signing agreements is delayed due to stringent conditions and lack of funding to support private sector participation"*

INV08 also stated that *"…… Then the second is that the politicians are greedy set of people who are only interested in their own pocket. They're not thinking of how they will benefit the constituency they're representing"*

The study also observed that a lack of coordination between various agencies regarding policy formation and implementation hinders household renewable energy adoption. Comments by interviewee INV01 indicate overlapping mandates from multiple institutions in the Nigerian energy sector. Interviewee INV01 suggested that

"The ministry of power is looking at renewable energy, electricity... They derive it from the energy policy... They only talk of renewable energy with respect to the electricity... The Energy Commission of Nigeria is there to guide them to look at the area that come to electricity... NNPC... they have biofuel policy... Ministry of Agriculture, they have, because when you are talking of biofuel... you are going to use seed... Ministry of Agriculture have their own policy." (INV01)

Interview INV01 further recognises the Energy Commission of Nigeria's role in coordinating policy formation but also highlights fragmentation in this process.

"Energy Commission is the umbrella under which these other ones derive their own... It's policy for that particular sector, operational policy for that sector... So we don't disturb them." (INV01).

The comments from interviewee INV01 demonstrate how various governmental agencies are simultaneously involved in renewable energy policy formation but focusing on different aspects which could lead to coordination challenges.

In summary, the interviewees' comments highlight a disconnect between policy formation and implementation in Nigeria, compounded by a lack of political will. These policy gaps and political barriers hinder the household adoption of renewable energy. Therefore, a strong political commitment and legislative backing are essential to create a favourable environment for renewable energy investments (Burke and Stephens 2018). Passing the National Energy Policy into law and ensuring its effective implementation would be a critical step forward.

6.5. Financial and Investment Barriers

The researcher sought to explore whether financial and economic incentives exist to support household adoption to renewable energy in Nigeria. Although there is a willingness among households to adopt renewable energy, feedback from interviewees indicates that financial constraints remain a significant barrier to adoption. The following section highlights key interviewee perspectives on the role of finance and economic incentives in facilitating household renewable energy adoption. Interviewee INV05 suggested that:

> *"But when the cost is on the high side and when you want government or as Nigeria's sovereign wealth to underwrite private investment, these are critical decisions for government. So I would say if the cost of renewable energy or the funds, that is really the major issue".* (INV05)

> INV05 again stressed the statement above by adding that *"I would say the major barriers as I said earlier again, is funding."*

The researcher reminded interviewees of the Economic Sustainability Plan (ESP) and the 5 million Solar Homes Scheme, which aim to deliver solar connections to 25 million people, create 250,000 jobs, enhance energy reliability, reduce fossil fuel dependence, and boost renewable energy adoption in remote communities. However, some interviewees noted that these schemes were still in the planning stages and are yet to be implemented. They also highlighted that poverty and the high cost of renewable energy technologies made them unaffordable for most households (see Table 6.5).

Table 6. 4 Comments showing financial barriers to household renewable energy adoption

Interviewee	Interviewee's Comments
INV01	*"The costs of procurement of renewable energy facilities are very expensive for the beneficiaries. There are no adequate incentives to encourage them"* *"When people look at the affordability of oil and gas compared to renewable energy, where the initial cost of procurement is very high, they opt for fossil fuels. The purchasing power is very weak"*
INV05	*"For now, the private sector's cost of generation from renewable energy is much higher compared to conventional energy sources. The average mix cost is about 7.50 cents, whereas renewable power purchase agreements were signed at 11 cents, making it challenging for broader adoption"*
INV03	*"There is no incentive for Nigerians to use renewable energy. The government is not investing, which discourages individuals from participating or investing"*
INV02	*"I think it's lack of investment and incentive from the government. If the government incentivize the use of renewable energy, at least more people would get into that, by investing more or participating in the use of renewable energy. So there is no incentive for Nigerians to use renewable energy. So I would say government is not doing anything on that. And I am not sure if the government is even investing, talk less of individuals to invest."*
INV09	*"So for the solar type, I don't think individuals are generating that much to be able to feed back into the grid. Now, in the house, say, you want a solar generator where you can use inductive loads like ACs and fridges, the cost of installing such in your house will be enormous, to provide that power for yourself and be able to have excess to be able to push to the grid again. The cost is very, very high".*

The comments from Table 6.4 indicate a lack of household capacity to afford to install renewable energy sources. Interviewee INV01 suggested that the current subsidy on fossil fuels (petrol and diesel) creates an additional barrier to household renewable energy adoption. Interviewee INV01 stated that:

> *"People will tend to go where they spend less money… subsidies on fossil fuels make renewable energy less attractive."* (INV01)

This statement is consistent with findings in the literature, which highlight that subsidies on fossil fuels, particularly petrol, diesel and kerosene, are more financially appealing to households than renewable alternatives (Aliyu, Modul, and Tan, 2018; Adeyanju et al., 2020; Ozoegwu and Akpan, 2021; Adelaja, 2020). These subsidies undermine household adoption efforts by reducing the competitiveness of renewable energy in Nigeria's energy market, thereby discouraging investment in cleaner options (Matallah et al., 2023).

INV02 highlighted that more initiatives are focused on promoting fossil fuel use due to its lower cost. He further explained that.

> *"In fact, there are more advertising in generators than renewable energy*" (INV02)

To address the issue of financial barriers, interviewee INV01 suggested that incentivising households to adopt renewable energy technologies could encourage widespread adoption by households in Nigeria. As interviewee INV01 stated:

> "*And in order to alleviate the problem, this is where subsidy comes in. Government should take a very big position in providing the subsidy for them. Like in countries where you have renewable energy making impact. In India, in Nepal, China, government has always taken greater funding part in the projects. They provide subsidy up to 70%, 80%. And that will also help in promoting the technology. When people see that it is working, they will start to key into it on their own."* (INV01)

The comment expressed above is corroborated by interview INV06, stating that:

> *"That is why there needs to be incentives to promote the spread of renewable energy. And this has come in various form. Either in form of policy incentives or what we call a kind of rebates for renewable energy all over the world".* (INV06)

Nevertheless, interviewees expressed mixed opinions regarding the availability of government incentives to support household renewable energy adoption. While some interviewees suggested that incentives were lacking, others believed they were present. For instance, interviewees INV02 and INV03 shared the view that no government incentives existed to promote household renewable energy adoption (See comments below).

> *"…… I think it is a lack of investment and incentive from the government. If the government incentivize the use of renewable energy, at least more people would get into that, by investing more or participating in the use of renewable energy. So there is no incentive for Nigerians to use renewable energy. So I would say government is not doing anything on that. And I am not sure if the government is even investing, talk less of individuals to invest."* (INV02)

> *"There is no incentive for Nigerians to use renewable energy. The government is not investing, which discourages individuals from participating or investing"* (INV03)

On the contrary, the views of other interviewees (INV05 and INV07) showed the availability of government incentives to promote renewable energy adoption in Nigeria. A selection of some of the comments illustrating this is presented below:

> *"Yes we have such incentives. Like as I said, we have tax holidays. Apart from tax holidays, we also have waivers. But these waivers needs an approval process. At times is a big cumbersome. Then for the feed in tariff, yes, we also have -- because our renewable energies are in three categories. For less than five megawatts -- okay. Let me start from the smallest. That is less than a 100 kilowatt, you have what we call the mini grid regulation where the consumers and the developer negotiate a price. Then we have for five megawatts to 10*

megawatts where we talk of feed-in tariff. We have feed-in tariff for solar, wind, biomas and hydro, which have been stated published by the regulator. That is the Nigerian Electricity Regulatory Commission, which is also reviewed from time to time. Then we have for more than 30 megawatts, which we either do unsolicited or we do competitive. For the 14 we did that we signed PPA, they were unsolicited bids. So we're trying to move away from that to competitive tender so that it'll be more transparent. And we also have a very competitive tariff. So all those are there" (INV05)

INV07 also had a similar view and stated that: *"A lot in the policy. The biofuel policy -- the renewable energy policy is there to encourage people. For example, if you are going into renewable energy, you are going to generate power from solar, for example. Or you are going to build a refinery that will produce biofuel, blend it with the PMS, you have tax holidays of up to 10 years. You have reduced import duties on your equipment. So I think those things are good incentives for people to come in. Those ones are well-spelt out."*

Despite the statement above, the analysis of interview data revealed that incentives intended to promote household renewable energy adoption in Nigeria were either ineffective or primarily directed at power-producing companies rather than households. As interviewee INV05 stated that

"Yeah, we have such incentives. Like as I said, we have tax holidays. Apart from tax holidays, we also have waivers. But these waivers need an approval process. At times is a big cumbersome process …... But as I said earlier during the interview, we've not been able to exhaustively test the policies ……. so, we are hoping maybe in not too long future we can get at least maybe a hundred to 200 megawatts on the grid and also one or two companies within this bracket of 5 to 10 megawatts coming up and making use of the feed in tariff system." (INV05)

In summary, interviewees' comments indicate that despite households’ willingness to adopt renewable energy into their household energy mix, financial barriers constrain adoption efforts. Interviewees highlighted that the high cost of renewable energy technologies, coupled with a lack of government subsidies and incentives, makes renewable energy unaffordable for most Nigerian households. Interviewees expressed mixed views on the availability of government incentives to promote renewable energy adoption in Nigeria, but the findings reveal that existing incentives were either ineffective or targeted towards power-generating companies rather than households, further limiting the adoption of renewable energy.

6.6. Public Awareness and Perception

Alongside financial constraints, interviewees identified a lack of public awareness and negative perceptions as key obstacles to the adoption of renewable energy technologies in Nigerian households. These factors undermine the feasibility of integrating renewable energy into everyday energy use despite its potential benefits (Giwa et al., 2017; Zebra et al., 2021). Table 6.5 provides a summary of some of the views of interviewees on awareness of renewable energy technology in Nigeria.

Table 6. 5 Summary of comments on renewable energy awareness and public perceptions

Interviewee	Interviewee's Comments
INV01	*"In the case of renewable energy, the awareness is very, very poor. Not many people really understand the benefit of renewable energy."* *"No adequate incentives to encourage the beneficiaries. The market awareness is also very, very low. The political will on the side of the government is also very poor. No legal document in terms of energy law, though they draft policies exist. But there is no legal document. They have not yet passed into law. And this is a very big constraint to investors into the renewable energy, you see it, of Nigeria."*
INV02	*"I do not think there are any measures. Basically, if you are watching Channels or NTA, there is nothing that has to do with raising awareness of renewable energy …. I haven't seen anything that has to do with renewable energy in the system or encouraging people to go into renewable energy".* *"In fact, there are more advertising in generators than renewable energy. … So awareness is one of the barriers that we are facing."*
INV04	*"None that I know of… No awareness"*

The interviewee's comments in Table 6.6 reveal that public awareness of renewable energy remains low in Nigeria despite its availability and potential benefit to households. The views of interviewees show that households lack adequate information from the government on the benefits of renewable energy and how it can be integrated into household daily energy use (Oyedepo, 2014; Aliyu, Modu and Tan, 2018; Ibrahim et al., 2021).

Additionally, analysis from the interview revealed that the lack of information on renewable energy options, combined with public misconception about their affordability and effectiveness, has resulted in scepticism about the reliability of renewable energy technologies in Nigeria. One interviewee held this view and stated that:

"Nigerians are sceptical about solar because they do not trust its reliability… they prefer familiar sources like kerosene and firewood, it still comes back to the government. They have to market it. They have to get the people to accept it. So you don't just expect people to go out of their way to look for the renewable energy when they have a government. So, I think it still boils down to government. They have to encourage people to accept it". (INV04)

Conversely, some interviewees expressed a different perspective, suggesting that awareness of the benefits of renewable energy in Nigeria is increasing. Their comments are provided below:

"*the Commission at our own level, we have tried to help in the capacity building by training the personnels that will drive the technology. And we have a scheme with the National Youth Service Corps whereby we trained youth corpers, at least about 60 of them every year in two of the states of the Federation. Initially, we started by covering geopolitical zone, by training not less than hundreds per state. But due to lack of funds, we are not able to carry such population. We restricted it to two states every year. And we have been able to train over 1000 youth corpers since 2004 this scheme started, training them on various aspects of renewable energy and energy efficiency. So in terms of awareness, we have been carrying out conferences, workshops to make people know where the Commission is"*. (INV01)

INV07 also added that: *"There's a lot of awareness. Sometimes we use it as -- in our computers, you open your computer in the morning, that's the first thing you see to tell you -- to give you -- to keep you aware. And particularly, energy efficiency. If at the end of the day, if you are leaving office and you leave your lights on, you leave some gadgets on overnight, you'll be queried. You'll be queried. And as it is, the renewable energy division of NNPC has written national and got approval to start in phases of changing all our incandescent bulbs to LED, Light Emitting Diodes, that 5 watts, 8 watts can light what hitherto requires 100 watts to do. And when we do that, we free excess energy to other users. And just this year, before the year runs out, the whole of this floor, Block B, all these bulbs will be changed to Light Emitting Diodes. We started with this floor because we, the -- we start at home. Charity begins at home. Phillips is doing it. We have secured that contract. So* *it's just implementation that we're waiting for it to go. Once we do it, and we see the success story, then we will do for the whole of this Block B and then spread it to other blocks. So energy efficiency is very key, because if 5 watts can light a bulb and you get the light intensity that you require from 5 watts, it means you can light 12 bulbs with a 60 watt bulb that you are used to right now. So you see the excess, you release it to other people -- for other people. And if you release the access to other people, it means you are burning less and less fossil oil to generate the power from the source, thereby, you're still sending less greenhouse gases to the atmosphere."* (INV07)

The comments from interviewees INV01 and INV07 reflect an awareness of renewable energy in Nigeria; however, this awareness appears to be largely confined to organisational and institutional contexts rather than being widespread among households. Therefore, the broader impact on household-level awareness remains low in Nigeria, hindering widespread adoption of renewable energy technologies (Oyeniran, Omojolaibo and Alasinrin, 2025). To address the limited awareness and public misconceptions surrounding renewable energy technologies, it is essential to implement public sensitisation and awareness campaigns to promote their adoption among households in Nigeria (Ibrahim et al., 2021; Oyeniran, Omojolaibo and Alasinrin, 2025). In this context, one interviewee suggested:

"But the first thing before all this is to sensitize the people, create awareness. You must tell the local government, the state government, and the federal government, this is what we intend doing". (INV08)

6.7. Summary

This chapter examines the challenges and opportunities for integrating renewable energy into Nigerian households, offering insights into five key themes: inadequate energy supply, untapped renewable energy potential, policy gaps, financial barriers, and low public awareness. The findings highlight Nigeria's severe energy deficit, characterised by limited grid access, frequent power outages, and an overreliance on fossil fuels. Although the country has substantial renewable energy resources, particularly solar and small hydro, these remain underutilised due to weak infrastructure, insufficient investment, and high initial costs. The analysis also reveals significant policy and legislative gaps. While several renewable energy policies and frameworks exist, such as the Renewable Energy Master Plan, their implementation is hindered by weak legislative backing and inadequate political will. This lack of enforcement and regulatory clarity discourages both local and foreign investment, thereby further delaying the adoption of renewable energy. Additionally, the absence of financial incentives, coupled with high costs, makes renewable energy inaccessible to most households.

Public awareness of renewable energy remains low, mainly due to widespread misconceptions about its affordability and reliability. Awareness efforts are primarily confined to organisational and institutional levels, leaving households insufficiently informed about the benefits of renewable technologies. To address these challenges, the chapter recommends improved policy enforcement, legislative reform, financial incentives, public awareness campaigns, and stronger stakeholder engagement and capacity building to promote adoption. The chapter concludes by emphasising the need for a more collaborative and well-coordinated approach to renewable energy implementation. These findings lay the groundwork for Chapter 7, which presents a comprehensive analysis of the feasibility of integrating renewable energy into Nigeria's household energy mix, drawing on both qualitative and quantitative data.

Chapter 7. Discussion of Key Quantitative and Qualitative Findings

7.1. Introduction

Chapters 5 and 6 present key findings from the quantitative survey and semi-structured interviews for this research. By rigorously analysing these datasets, the study uncovers significant insights into the energy challenges faced by households, energy use patterns, barriers to renewable energy adoption and the potential of renewable energy as a viable alternative to fossil fuels. Building upon these results, Chapter 7 presents a discussion on the main findings from the previous data analysis chapters. The discussions will be aligned with the research questions and objectives, as identified in Chapter 1. The chapter will evaluate the major findings and themes from data analysis against existing literature to address the identified knowledge gaps for this research. This chapter will highlight the study’s contributions to understanding the feasibility of renewable energy utilisation within Nigerian households by examining the implications and relationships among the key findings.

7.2. Discussion of Quantitative Findings

The primary objective of conducting household surveys in this study was to examine energy dynamics at the household level. Analysis of the survey data provided valuable insights across four central themes: household energy challenges, factors influencing energy choices, perceptions towards renewable energy, and gender dynamics in energy use. The following sections discuss each of these themes in detail, aligning them with the research objectives and illustrating how they address the study's research questions (see Table 7.1).

Table 7. 1 Alignment of Research Questions with Quantitative Findings

Research Questions (RQ)	Research Objectives (Obj)	Quantitative Findings
RQ1. What are the current household energy challenges in Nigeria?	Obj 1. To critically evaluate the West African energy landscape within the context of energy dynamics in West Africa and Nigeria. Obj 4. To investigate the household energy challenges driving a shift towards integrating renewable energy technologies in Nigerian households.	• Section 5.3.1 – Assessment of Current Energy Challenges • Section 5.3.2 – Use of Petrol/Diesel Generators • Section 5.3.4 – Views on Household Energy Bills • Section 5.4.1 and 5.4.2 – Household Energy and Electricity Sources • Section 5.4.3 – Energy For Cooking and Lighting
RQ3. What are the main drivers and barriers of household renewable energy adoption in Nigeria?	Obj 5. To assess the public's behaviour towards accepting renewable energy technologies in lieu of government subsidies on fossil fuels. Obj 6. To identify the factors influencing household renewable energy adoption amongst Nigerian households.	• Sections 5.4.4 - Drivers of Household Energy Choice – Cost, Availability, Affordability, Culture. • Section 5.5 – Household Perception of Renewable Energy • Section 5.5.2 - Gender Perspective on Renewable Energy in Reducing Nigeria's Fossil Fuel Dependence • Section 5.5.3 - Preferred Renewable Energy Source • Section 5.5.4 - Renewable Energy Use in Households • Section 5.6 – Feasibility Indicators for Household Renewable Energy Adoption in Nigeria

7.2.1. Household Energy Challenges

Given that Nigeria's centralised electricity infrastructure fails to meet the country's population's energy demands, more than 50% of Nigerians live without access to a reliable electricity supply (Eludoyin and Lemaire, 2021; Ibrahim and Ayomoh, 2022). As a result, many households experience daily power outages lasting up to 19 hours, which disrupt daily routines and contribute to socioeconomic vulnerabilities (Adelakun and Olanipekun, 2020). The findings presented in Section 5.3.1. on household energy challenges align with and reinforce extant literature on energy insecurity, energy poverty and weak energy infrastructure in Nigeria.

Consistent with findings from Eludoyin and Lemaire (2021), Adewuyi et al. (2020) and Ibrahim and Ayomoh (2022), the quantitative survey results show widespread dissatisfaction with the inadequate electricity supply and its negative impact on households' livelihood. Results from Section 5.3.1. showed that 92.7% of surveyed households indicated that the recurrent electricity outages affected the daily running of households, leading to various vulnerabilities. Qualitative responses further highlight the effects of unreliable electricity supply on household wellbeing (see Table 5.13). For instance, participants RP040 and RP343 noted that frequent power outages contribute to feelings of insecurity, particularly among women (see Section 5.3.1). The responses from participants RP040 and RP34 reveal that household energy challenges in Nigeria have clear gender dimensions. Women and girls are disproportionately affected, largely due to their primary roles in performing household tasks such as cooking and sourcing fuel (Ngarava et al., 2022). Showing gender inequalities and placing additional burdens on women and girls compared to their male counterparts (Acheampong et al., 2024; Ogundana, 2022).

The findings presented in Section 5.3.1.1 show gender differences in perceptions of the household energy challenges in Nigeria. The study found that 94.3% of men reported that electricity outages affect their daily activities, and 88.8% of women held similar views, although with an emphasis on domestic and caregiving activities. This aligns with studies by Ngarava et al. (2022) and Acheampong et al. (2024), who suggest that energy poverty shows gendered dimensions, often intensifying the labour burden and health risks faced by women. Qualitative responses from participants in this study show how electricity outages increase the time women spend on domestic tasks such as cooking and collecting fuel, with negative consequences on their education, health, and economic opportunities. For example, RP004 described gathering firewood before school, while RP545 noted that the lack of electricity for refrigeration made food preservation difficult, adding to daily household responsibilities. These findings align with findings from Jayasinghe et al. (2025) and Cicowiez et al. (2022), who associate fuel scarcity with lower educational attainment among girls in developing countries, as time spent on energy-related household tasks often comes at the expense of schooling and personal development.

Similarly, comments from RP326 and RP545 pointed to health risks linked to the reliance on traditional fuels such as firewood and charcoal, which many households are forced to use due to inadequate electricity supply. Additionally, qualitative feedback from female participants (see Table 5.13) highlights the distinct vulnerabilities women experience as a result of reliance on traditional fuels. This study finds that Nigerian women face a combination of health, economic, and personal security risks linked to their roles as primary energy users in the household. Graham (2016) argues that prolonged power outages do not just disrupt daily household activities and convenience but also reverse or de-modernise household life and economic progress. Implying that when electricity is unavailable for extended periods, the technologies and services that define modern living, such as lighting and refrigeration, become inaccessible, taking a step backwards in modernisation. The effect of these power outages also has severe impacts on household income, particularly for households that rely on electricity to run businesses. These frequent outages reduce business productivity, disrupt service delivery and limit economic opportunities, not only affecting household livelihood but worsening living standards (Avordeh et al., 2024; Heinemann et al., 2022).

This persistent, unreliable electricity supply in Nigeria has resulted in most households relying on petrol or diesel-powered generators to meet their household energy demands (Heinemann et al., 2022; Oseni, 2016). The findings from Section 5.3.2 show that the unreliable electricity supply has led to almost 90% of surveyed households relying on petrol or diesel-powered generators as their primary or backup electricity source. These findings are similar to findings from Babajide and Brito (2021) and Elinwa, Ogbeba and Agboola (2021), who identify Nigeria as one of the largest importers and users of generators for household electricity generation globally. However, the reliance on petrol- or diesel-powered generators as backup for household electricity generation creates a substantial financial burden for households. Nigerians spend approximately $10 billion annually on fuel and generator maintenance (The Guardian, 2021). This financial burden is compounded by an increase in fuel prices as the cost of petrol and diesel now exceeds ₦1200 and ₦1300 per litre, respectively, making generator use unaffordable for most households (BBC News Pidgin, 2024; Dangote Industries, 2024). Some participants for this study acknowledged that generators are essential to meet their households' electricity demands due to an undersupply of electricity from the national grid, yet these generators are expensive to run and maintain.

> For example, RP150 highlighted that *"In our village, you must have a generator to survive because the light from the national grid is not available."*

Therefore, the use of personal generators as backup for electricity shortages in most Nigerian households highlights a paradox where access to basic electricity is reliant on expensive and environmentally harmful alternatives. This reliance on petrol or diesel-powered generators contributes to increased carbon emissions, severe health risks and economic losses estimated at $12 billion annually from the importation, fuelling and maintenance of petrol or diesel-powered generators (Okedere et al., 2021). Despite the significant financial costs of using petrol- or diesel-powered generators, research indicates they also have profound environmental and health implications (Okedere et al., 2021). These include air pollution from particulate emissions, noise pollution, increased fire hazards, and deaths, therefore raising sustainability concerns associated with fossil fuel-powered generator use (Giwa and Taziwa, 2024; Giwa, Nwaokocha and Samuel, 2019; Kumar et al., 2023).

While participants recognised generators as essential to meeting their household electricity needs, 99.51% of participants showed an awareness of the environmental and health implications of using fossil fuel-based generators. However, participants mainly expressed particular concern over the financial burdens involved. Participants indicated additional financial pressures arising not only from the high cost of operating generators but also from high estimated electricity bills from distribution companies. 48.22% of participants indicated that their electricity bills are a financial burden to them in spite of the unreliable electricity supply. Adding that not having an electricity meter negatively impacted their household electricity bills, as 79% of participants reported that not having electricity meters to regulate their daily electricity consumption resulted in inflated electricity charges from distribution companies. This experience is similar to the views of most Nigerians, as most Nigerian households remain unmetered and express frustration with this estimated billing system, referring to it as unfair and overpriced without the presence of household electricity meters (Idoko et al., 2021). The widespread absence of electricity meters in Nigerian households is mainly due to their limited availability and delayed distribution by Electricity Distribution Companies (DISCOs) (Arowolo and Perez, 2020). This issue is further complicated by the varied housing patterns and prevalence of multi-tenanted dwellings across the country, which makes household-level metering challenging (Arimoro, Oyetunji and Odugboye, 2019). According to the National Electricity Regulation Commission, only about 19% of Nigerian households are officially registered electricity customers, and among these registered customers, 55% remain without meters (Roy et al., 2023). Consequently, this metering shortage has resulted in approximately 60% of Nigerian households receiving estimated electricity bills (Jeremiah, 2022). This billing method, based on assumed rather than actual energy consumption, is frequently perceived as inaccurate and unfair (Ikwuagwu and Ajah, 2023). The approach assumes a constant electricity supply, which often does not reflect reality, leading to widespread dissatisfaction and controversy (Arowolo and Perez, 2020).

The energy challenges discussed above, such as a centralised energy system, unreliable electricity supply, fluctuating fuel prices and inadequate metering system reflect systemic failures and bottlenecks in Nigeria’s energy infrastructure. These issues represent significant barriers to achieving energy security and economic development, driving most households to explore renewable energy alternatives (Bappah et al., 2024). The findings of this study, presented in Section 5.6, support this trend, indicating that energy-related difficulties significantly influence household decisions to adopt renewable energy technologies. The surveyed households for this study indicated that they are increasingly seeking sustainable solutions that are affordable, accessible, and reliable. This finding is consistent with results from Adedokun et al. (2025), who found that the inadequacy of existing energy systems in Nigeria encourages the adoption of renewable alternatives. Therefore, transitioning towards a decentralised system based on renewable energy sources may offer a viable and sustainable solution to Nigeria's current household energy challenges.

7.2.2. Household Energy Use Patterns

Another objective of this study was to explore household energy use patterns, considering the energy challenges discussed above. Exploring these patterns is crucial as it provides insights into household energy behaviours and the factors that must be addressed to achieve a smooth adoption towards renewable energy in Nigerian households. The study analysed household energy consumption data and found that households use multiple fuel types to meet their various household energy demand (see Section 5.4.1). The results from this study show that electricity accounts for 32.1% of final energy consumption among households, followed by gas at 24.7%. Petrol and diesel contribute 19.5% and 11.6%, respectively, while Kerosene represents 8.9% of household energy use. Only a small proportion of participants (3.4%) reported firewood as their primary energy source. This finding aligns with findings from Yunusa et al. (2024) and Dioha and Emodi. (2019), which shows that households in Nigeria use multiple fuel types, mainly consisting of conventional and traditional fuels, for various household activities.

This finding reflects the current patterns of primary energy consumption within Nigeria's household sector, where electricity is the primary energy source for activities such as lighting, entertainment, and refrigeration (Dioha and Kumar, 2020). However, due to unreliable grid-based electricity supply, many households rely on multiple sources to generate electricity (Pokubo and Pepple, 2024; Ayodele et al., 2021). Among participants, 34.7% use grid electricity as their main source of electricity, 28.6% rely on fuel-powered generators, and only 1.7% use renewable energy like solar energy. Surprisingly, 31.4% of participants reported using a combination of energy sources to generate electricity for their homes. This pattern suggests that the household electricity supply in Nigeria is highly fragmented, with many families depending on a mix of grid electricity, fuel-based generators, and, to a much lesser extent, renewable energy. Such diversification reflects not only coping strategies in response to unreliable grid infrastructure but also highlights the need for more stable and sustainable energy systems (Adedokun et al., 2025). This fragmented pattern of electricity generation is consistent with the findings of Zebra et al. (2021), who highlight that in many developing countries, including Nigeria, unreliable grid infrastructure and the high cost of fossil fuel-based generators have prompted households to adopt hybrid energy systems. These systems typically combine grid electricity, solar photovoltaic, and fuel-powered generators to create a more reliable and cost-effective energy supply for various household activities (Zebra et al., 2021).

In Nigeria, households primarily use energy for cooking and lighting (Jewitt, Atagher and Clifford, 2020). The following sections examine the patterns of energy use across these activities, revealing how factors such as access, affordability, and cultural practices shape fuel choices and contribute to a fragmented and unequal energy landscape.

7.2.2.1. Patterns of Household Energy Use for Cooking and Heating

The patterns of cooking and heating in Nigerian households also show a fragmented and unequal energy landscape influenced by income, location, and cultural norms. The findings presented in Section 5.4.3.1 reveal that 51.12% of households rely on liquefied petroleum gas (LPG) for cooking, while a significant proportion still use kerosene (19.27%), charcoal (11.13%), and firewood (10.72%). This diversity of fuel use reflects the energy stacking model, where households combine multiple energy sources rather than transitioning linearly from traditional to modern fuels (Van der Kroon, Brouwer and van Beukering, 2013). This finding aligns with the results of Oyeniran, Omojolaibi and Alasinrin. (2025) and Emodi et al. (2022), who highlighted that some Nigerian households have experienced a reverse adoption, returning to the use of conventional and traditional biomass fuels. This pattern of energy use challenges the linear progression assumed by the energy ladder model, highlighting that a range of factors beyond income alone influence household energy adoption. The findings from this study reveal that energy security in Nigeria is achieved not through substitution but through diversification. For instance, RP700 stated that most households have kerosene stoves as a backup, even when LPG is available. Implying that the energy use pattern in Nigeria is often influenced by intermittent electricity supply, fluctuating prices, and cultural preferences (see Section 5.3.1 and 5.6). This multi-fuel behaviour suggests that future energy interventions must accommodate the complex realities of energy use in Nigeria rather than assume uniform scenarios. Notably, cultural preferences emerged as a significant driver of household energy choices, underscoring the need to consider social and cultural contexts when analysing energy use behaviours in Nigerian households. For example, the continued use of firewood, especially in rural areas, often for cultural reasons, was noted by participant RP546, who stated that

> *"Let me be honest, food cooked with firewood has this unique taste, especially our local delicacy; even though we use kerosene stoves when it is possible, I still prefer firewood, especially when we travel to the village."* (RP546)

These findings confirm Abubakar et al.'s (2024) and Akintan, Jewitt and Clifford's (2018) assertion that cultural factors play a crucial role in household energy use in developing countries like Nigeria. However, this reliance on traditional biomass (firewood and charcoal) in rural settings contributes significantly to environmental and social costs, including deforestation, desertification, and indoor air pollution (Yunusa et al., 2023). It also imposes a time burden on women and girls, who are primarily responsible for collecting firewood, limiting their opportunities for education and economic participation (Jayasinghe et al., 2025). These patterns reflect not only a stalled progression along the energy ladder but also show a reverse adoption, where households revert to traditional fuels due to the high cost or unreliability of modern alternatives (Pokubo, Pepple and Al-Habaibeh, 2024).

7.2.2.2. Patterns of Household Energy Use for Lighting and Domestic Appliances

The study found that multiple fuels are used for lighting purposes and powering domestic appliances in Nigeria. As shown in Section 5.4.3.2, electricity was the most commonly used energy source for lighting (62.5%), followed by kerosene (24.7%) and solar energy (8.9%). These findings are consistent with those of Olaniyan, Caux, and Maussion. (2024) and Ogunro and Afolabi. (2022), who highlight that multiple fuel types are used for lighting purposes in Nigeria, particularly in rural areas where access to reliable grid electricity is limited. This pattern reflects broader energy access inequalities and highlights the continued reliance on both modern and traditional energy sources in most Nigerian households.

The results from this study reveal that lighting choices in Nigeria show an unequal distribution of electricity access. While 62.5% of participants identified electricity as their main source of energy for lighting and powering domestic appliances, this figure drops to 18.7% among rural households, who continue to rely heavily on kerosene lanterns (24.7%). This finding aligns with Olaniyan, Caux and Maussion. (2024), who reported that due to the unreliable electricity supply, most rural households often rely on kerosene lamps, candles, and even open fires for lighting. Consequently, rural households in Nigeria are significantly disadvantaged, with limited access to electricity compared to urban households (Ogunro and Afolabi, 2022). This highlights disparities in electricity access between rural and urban areas in Nigeria, causing rural residents to rely on self-generated power sources, such as petrol or diesel generators, which are often costly and detrimental to the environment and their health (Pelz et al., 2023). Such disparities reflect the structural inequalities in electricity infrastructure and affordability of energy, with rural populations experiencing less access to reliable power (Dioha and Emodi, 2019). Although Nigeria has vast solar potential, only 8.9% of participants reported using solar energy for lighting, pointing to barriers such as high upfront costs, limited maintenance knowledge, and lack of financing, factors also identified by Ugwoke et al. (2021) as hindering solar adoption in low-income and rural settings.

Overall, the findings from this study reaffirm the understanding that Nigeria's household energy use is characterised by energy stacking and unequal access. It highlights the limitations of the traditional energy ladder model in explaining household energy behaviour in Nigeria. This supports Emodi et al.'s (2022) argument that household energy consumption patterns in Nigeria follow the energy stacking model, where households revert to inefficient fuels due to economic and socioeconomic barriers. Therefore, inclusive energy policies and targeted interventions are essential for successful renewable energy adoption. As such, strategies must consider key factors, including affordability, reliability, cultural relevance, and infrastructure access, to ensure that the adoption is both equitable and sustainable.

7.2.3. Drivers to Renewable Energy Adoption in Nigeria

One key objective of this study is to identify the factors influencing household energy choices in Nigerian households and household perceptions of renewable energy adoption in Nigeria. The findings highlight that fuel availability (60.5%), fuel cost (50.21%), affordability (41.03%), and accessibility (41.45%) are the dominant factors influencing household energy choices to adopt renewable energy. These results are consistent with those of Oyeniran and Isola. (2023) and Roche et al. (2024) who argue that high fuel cost, limited availability and poor accessibility remain as major drivers of household energy decisions. Adding that households prioritise fuels that are both affordable and readily accessible, often neglecting the health risks associated with traditional fuel use. This pattern is mainly practised in rural areas, where income levels are generally lower and infrastructure for the distribution of cleaner fuels and their accessibility remains weak. A similar trend is observed by Emodi and Dioha (2019), where rural households in Nigeria face structural disadvantages in accessing modern energy services due to poor infrastructure and geographical constraints, which reinforces the importance of these factors as drivers of household energy choices.

The identified factors contrast with earlier studies by Foxon et al. (2013) and more recent research by Walk and Stognief (2022), which identified government commitments and international emissions reduction targets as the primary drivers of renewable energy adoption. However, these studies focused mainly on developed countries, where energy poverty is comparatively low, and energy security is not a pressing concern. In contrast, the context in developing countries such as Nigeria presents a different set of priorities. In Nigeria, high levels of fuel poverty and persistent energy insecurity significantly influence energy choices. While Nigeria's commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol reflect its intention to reduce carbon emissions, these commitments are not the main drivers of renewable energy adoption at the household level. Instead, the adoption to renewable energy is influenced by a complex mix of factors, including the need for reliable, affordable, and accessible energy services (Okoh and Okpanachi, 2023; Atedhor, 2023). This perspective aligns with the arguments of Bosman et al. (2014) and Jim et al. (2025), who emphasise that energy security challenges are central to the global push towards renewable energy. Furthermore, Sovacool and Brown (2010) contend that energy security should not be viewed in isolation but understood in relation to the availability, reliability, and affordability of energy supply. Therefore, addressing energy security via the lens of fuel availability, accessibility, and price remains a critical driver of renewable energy adoption for households in developing countries like Nigeria.

This study also found that household size plays a role in household energy choice, with only 9.6% of participants indicating that larger household sizes increase the likelihood of using multiple fuel types. However, the study finds that larger households were more inclined to adopt conventional and traditional fuels, as a negative correlation between household size and the exclusive use of modern energy sources was observed among surveyed households. This finding corroborates with Oyeniran and Isola. (2023), who found that in larger or extended family structures, the economic burden of relying solely on modern fuels like LPG or electricity often leads households to adopt fuel stacking practices, combining both modern and traditional fuels to balance cost and availability. However, while these drivers (availability, accessibility, fuel price and household size) are well-researched, this study contributes new insights by highlighting cultural factors as an emerging but crucial factor influencing household energy choices. Cultural factors as a theme are largely overlooked in previous studies (Danlami, Applanaidu and Islam, 2018; Mensah and Adu, 2013; Gungah, Emodi and Dioha, 2019). The analysis of data from Section 5.4.4 (see Table 5.12) shows some participants explicitly identifying culture as a factor. Qualitative responses from participants revealed a much more profound cultural influence on household energy decisions. For example, several participants expressed a strong preference for food prepared with firewood due to its distinct taste. Participant RP546 reflected this cultural sentiment, stating that:

> *"Let me be honest, food cooked with firewood has this unique taste, especially our local delicacy; even though we use kerosene stoves when it is possible, I still prefer firewood, especially when we travel to the village".* (RP546)

This comment, from Participant RP546, an urban household, illustrates how cultural preferences influence household energy use patterns even when modern alternatives are available. This finding challenges the assumption of a linear progression along the energy ladder, which states that households naturally move from traditional to modern fuels as income rises (van der Kroon, Brouwer and van Beukering, 2013). Instead, these results support the growing recognition of energy stacking and reverse adoption, where households either combine fuel sources or revert to traditional fuels due to affordability, accessibility, or cultural preferences (Oyeniran and Isola, 2023).

Unlike extant studies, the recognition of culture as a key driver also highlights gaps in existing renewable energy policies, which tend to focus primarily on economic incentives and infrastructure development while neglecting the social and cultural contexts that influence household energy choices (Ugwoke et al., 2021; Emodi et al., 2022). Therefore, this study contributes to the current literature by arguing that inclusive energy adoption processes must account not only for affordability, accessibility, availability and fuel price but also for cultural factors. This is because, without considering cultural factors, renewable energy adoption interventions risk limited adoption or failure to achieve long-term behavioural change, particularly in rural and low-income households.

7.2.4. Barriers to Renewable Energy Adoption

Sections 5.3, 5.4, and 7.2.3 outlined several household energy challenges and the drivers of household energy choices, respectively. The study analysed quantitative data from these sections and identified several barriers to renewable energy adoption at the household level. From the data, high fuel cost emerged as the main barrier to renewable energy adoption, with participants consistently citing cost or fuel price as the primary reasons influencing their household energy decisions (see Sections 5.3.4 and 5.4.4). This aligns with Oyeniran and Isola. (2023) and Roche et al. (2024) who report that high cost is a barrier to renewable energy adoption in Nigeria. Similarly, affordability (see Section 5.4.4 and Table 5.12) was also identified as a significant barrier, suggesting further financial constraints that households face when considering adopting cleaner or renewable energy alternatives.

The quantitative data also revealed that fuel availability and accessibility are barriers to renewable energy adoption. Participants indicated in Section 5.4.4 and Table 5.12 that the availability and ease of accessing energy resources influence their energy choices. This supports findings from Emodi and Dioha (2019), who argue that infrastructural limitations, poor distribution networks and lack of government-backed community renewable energy systems limit household access to cleaner energy options, especially for rural households. Additionally, beyond these barriers, the study also identified cultural preferences as a significant barrier, as qualitative comments suggest that local cooking preferences favour firewood and charcoal despite the awareness of cleaner alternatives. Collectively, these findings indicate that without addressing these barriers, the feasibility of utilising renewable energy in Nigerian households and the pace of adoption will remain slow.

7.2.5. Household Perception of Renewable Energy Use in Nigeria

Given the continued reliance on fossil and traditional fuels in the Nigerian household energy mix (see Section 5.4), this study explored household perceptions of renewable energy as a potential alternative. As shown in Section 5.5.1, the findings indicate a generally positive attitude towards acknowledging renewable energy as a viable substitute for fossil fuels. Notably, 96% of female participants support renewable energy, slightly higher than the 94.7% of male participants (see Section 5.5.2 and Figure 5.20). This reveals gender-based differences in renewable energy perception as female-led households expressed greater support for renewable energy adoption compared to male-led households. This finding addresses a knowledge gap identified in the literature review, which emphasises the need to explore the gendered implications of renewable energy adoption in Nigeria. Gender disparities in energy adoption remain an underexplored area in Nigerian energy research, making this study particularly significant (Alda-Vidal et al., 2023).

In most Nigerian households, women are responsible for cooking, cleaning, and managing household fuel use (Acheampong et al., 2024). As a result, they experience the direct consequences of unreliable energy supply more acutely than men. This leads women to favour cleaner, more sustainable alternatives that could alleviate the challenges of reliance on conventional energy sources. These findings align with Tornel-Vázquez, Iglesias, and Loureiro (2024), who observed that women as primary energy users in households are directly affected by the health and labour burdens associated with traditional fuel use.

Qualitative responses from female participants in this study, such as those who emphasise health risk of using conventional fuels (for example "At school once the lights go off, I have to use candle or a lantern to study at night which sometimes affects my eyes" - RP326), provide deeper insights into the challenges women face. These insights are crucial when exploring the feasibility of utilising renewable energy, as they reveal how renewable energy alternatives like solar could alleviate these challenges by offering cleaner, safer alternatives (Obada et al., 2024). These findings align with contemporary energy adoption studies that emphasise the important role of women as key influencers in the adoption of renewable energy at the household level and suggest that gender-inclusive policies may enhance the effectiveness of clean energy initiatives in Nigeria (Alda-Vidal et al., 2023). Therefore, implying that female participation in renewable energy agenda could increase the likelihood of renewable energy adoption in Nigeria

7.2.6. Preferred Renewable Energy Sources in Nigerian Households

Building on the widespread support for renewable energy outlined in Section 7.3, this study further explored which renewable energy sources Nigerian households would prefer. The findings presented in Section 5.5.3 reveal a strong preference for solar energy, with 77.9% of participants identifying it as their preferred renewable option (see Figure 5.21). This preference is consistent with Nigeria's abundant solar resource, where most regions receive between 4.0 kWh/m²/day and 7.0 kWh/m²/day of solar radiation (Ogunmodimu and Okoroigwe, 2019). The results also align with Nduka (2021), who argues that solar energy offers a viable solution to Nigeria's household energy challenges, particularly in rural areas with limited access to the national grid. Despite this strong preference, actual usage of solar energy remains low. Only 13.03% of participants reported using solar energy, compared to 75.50% who indicated they do not (see Figure 5.22). This discrepancy highlights a significant barrier to renewable energy adoption in Nigeria, particularly the high initial cost of solar technology. These findings are consistent with those of Okoh and Okpanachi (2023), who note that although solar energy is an abundant and viable resource in Nigeria, financial constraints significantly limit its adoption, especially among low-income households.

Further supporting this, Akuru et al. (2017) argue that residential solar energy remains unaffordable for the majority of Nigerians, with the average cost of installing a rooftop solar photovoltaic system estimated at approximately $2,200. This cost is prohibitive, especially considering that 56% of Nigerians live below the $1.90-a-day international poverty line (National Bureau of Statistics, 2022; World Bank, 2024). These findings contribute to the growing literature on barriers to renewable energy adoption in Nigeria, highlighting that the high upfront costs of solar systems, coupled with limited government incentives, impede household adoption to clean energy (Adeniyi and Isah, 2023). However, the data presented in Figure 5.23 offers a more positive outlook on household solar energy use. A significant 75.49% of participants indicated a willingness to adopt solar energy if financial support or government incentives were available. This suggests that while affordability remains a major obstacle, interest in solar energy adoption could increase substantially with targeted financial interventions. This observation is supported by Olayungbo, Faiyetole and Olayungbo (2024), who emphasise that the high cost of solar installation remains a key barrier but can be mitigated through government-backed subsidies and support programmes.

7.2.7. Household-Level Indicators for Renewable Energy Adoption in Nigeria

The primary aim of this study was to assess the feasibility of households adopting renewable energy in Nigeria. The findings presented in Section 5.4.4 identify fuel availability, fuel cost, and household income as key factors influencing household energy choices (see Table 5.12). These factors were analysed to determine their role as feasibility indicators for renewable energy adoption in Nigerian households. The analysis of the survey data revealed that fuel availability, fuel cost, and household income significantly impact the feasibility of adopting renewable energy, with a positive correlation between these factors and the likelihood of adopting renewable energy. The following sections present the feasibility indicators as determined by the research participants.

7.2.7.1. Effect of Fuel Availability on the Likelihood of Renewable Energy Adoption

The findings presented in Table 5.12 indicate that 60.5% of participants believe fuel availability plays a crucial role in their energy decisions. The relationship between fuel availability and renewable energy adoption was tested, particularly in relation to electricity shortages discussed in Section 5.3.1. The results showed that households experiencing electricity shortages were more likely to seek sustainable alternatives, such as solar energy, highlighting the significance of fuel availability in the adoption of renewable energy. This finding addresses a key knowledge gap in the literature, which primarily focuses on economic, political, and environmental factors, but neglects the direct influence of fuel availability on the likelihood of renewable energy adoption in Nigerian households (Nwaka et al., 2020).

Qualitative feedback from participants further supports these findings. Many participants expressed frustrations with the frequent electricity outages in Nigeria. For instance, one participant stated,

> *"The electricity from NEPA (national grid) is out almost every day, and it can be off for hours and sometimes all day. This is frustrating and makes it hard to get anything done in the house and at work".* (RP200)
>
> Another participant mentioned, *"I run a small business selling cold drinks, and the constant electricity outages are killing my productivity and increasing my costs because I have to use the generator to power my fridge, and the cost of petrol is unaffordable for me".* (RP683)

These statements highlight the socio-economic challenges posed by unreliable electricity supply, driving the need for alternative energy solutions. Additionally, these comments support Ukoba et al. (2024), who argue that households reliant on fossil-fuel-powered generators are increasingly motivated to explore more affordable and stable energy alternatives, such as solar energy, in response to energy shortages.

7.2.7.2. Effect of Fuel Cost on the Likelihood of Renewable Energy Adoption

Another key feasibility indicator identified in this study is fuel cost, with 50.21% of participants indicating that fuel prices significantly influence their household energy decisions (see Table 5.12). Correlation analysis between fuel costs and the feasibility of utilising renewable energy reveals a positive relationship, suggesting that as fossil fuel prices rise, households are increasingly inclined to explore more affordable and sustainable alternatives. This finding aligns with Liñeiro and Müsgens (2025), who argue that globally, the rising cost of conventional energy and the declining cost of renewable technologies are driving demand for cleaner, more affordable energy options. Similarly, Adewuyi (2020) supports this observation, noting that increasing fuel prices are prompting a greater interest in cheaper renewable energy sources in developing countries, such as Nigeria.

Qualitative feedback from participants further illustrates this trend. Many households reported that the financial burden associated with purchasing petrol and diesel for generator use motivates their interest in renewable alternatives such as solar energy. For example, one participant emphasised that,

> *"We spend so much on petrol for generators because the electricity from NEPA (national grid) is so unreliable. It is becoming difficult running the generator for my business and at home."* (RP733)
>
> Another participant expressed concern over rising electricity prices, stating, *"Electricity bills are going up and up, and yet we don't get enough power supply to justify these costs."* (RP400)

These comments underscore the substantial financial burdens that unreliable and expensive energy sources impose on Nigerian households. Consequently, they create a strong preference for solar energy as a viable alternative (see Section 5.5.3). Although the correlation between fuel costs and the likelihood of households using renewable energy is positive, it also indicates that fuel costs represent a significant barrier to the adoption of renewable energy. This highlights the need for targeted government incentives and subsidies to make renewable energy technologies more accessible to households (Qadir et al., 2021). This finding is consistent with Olujobi et al. (2023), who argue that Nigeria's inconsistent electricity supply and the high cost of fossil fuels (petrol-diesel powered generators) have contributed to widespread economic hardship. They further suggest that the unreliable electricity supply and the high cost of fossil fuels can act as significant driving factors encouraging households to consider renewable energy adoption (Olujobi et al., 2023).

7.2.7.3. Effect of Household Income on the Likelihood of Renewable Energy Adoption

Household income is another crucial factor influencing the feasibility of renewable energy adoption in this research. As presented in Section 5.6.3, a significant relationship exists between household income and the likelihood of adopting renewable energy (see Table 5.18). The results show that high-income households are more likely to adopt renewable energy as a viable alternative to conventional and traditional fuels, largely due to their ability to afford the high initial investment costs associated with renewable technologies (see Figure 5.23). This finding aligns with Twumasi et al. (2022), who identified household income and renewable energy costs as the most critical factors shaping renewable energy adoption in developing countries. This finding suggests that while higher income can drive the adoption of renewable energy, lower income can act as a significant barrier to its adoption for low-income households. This supports Akuru et al.'s (2017) assertion that due to the financial capacity of high-income households, they are more likely to adopt renewable energy when compared to low-income households, who are prohibited by the high upfront cost of renewable energy technologies. Survey responses support this, with several participants indicating a willingness to adopt solar energy if government subsidies or incentives were available. These findings are consistent with extant literature advocating for financial inclusion measures such as green subsidies, feed-in-tariffs and revolving low-interest loans as strategies to enhance renewable energy adoption, particularly among low-income and rural households (Burke and Stephens, 2017; Tamasiga et al., 2024).

Examining these indicators is essential for identifying the drivers and barriers to renewable energy adoption in Nigerian households. The three indicators discussed, fuel availability, fuel cost, and household income, align with previous studies, which highlight their importance in encouraging the adoption of renewable energy. This study extends beyond identifying these drivers; it tests the impact of these three factors on the feasibility of renewable energy adoption in Nigerian households (see Figure 7.1). By doing so, it provides a practical framework to promote the adoption of renewable energy technologies within Nigerian households.

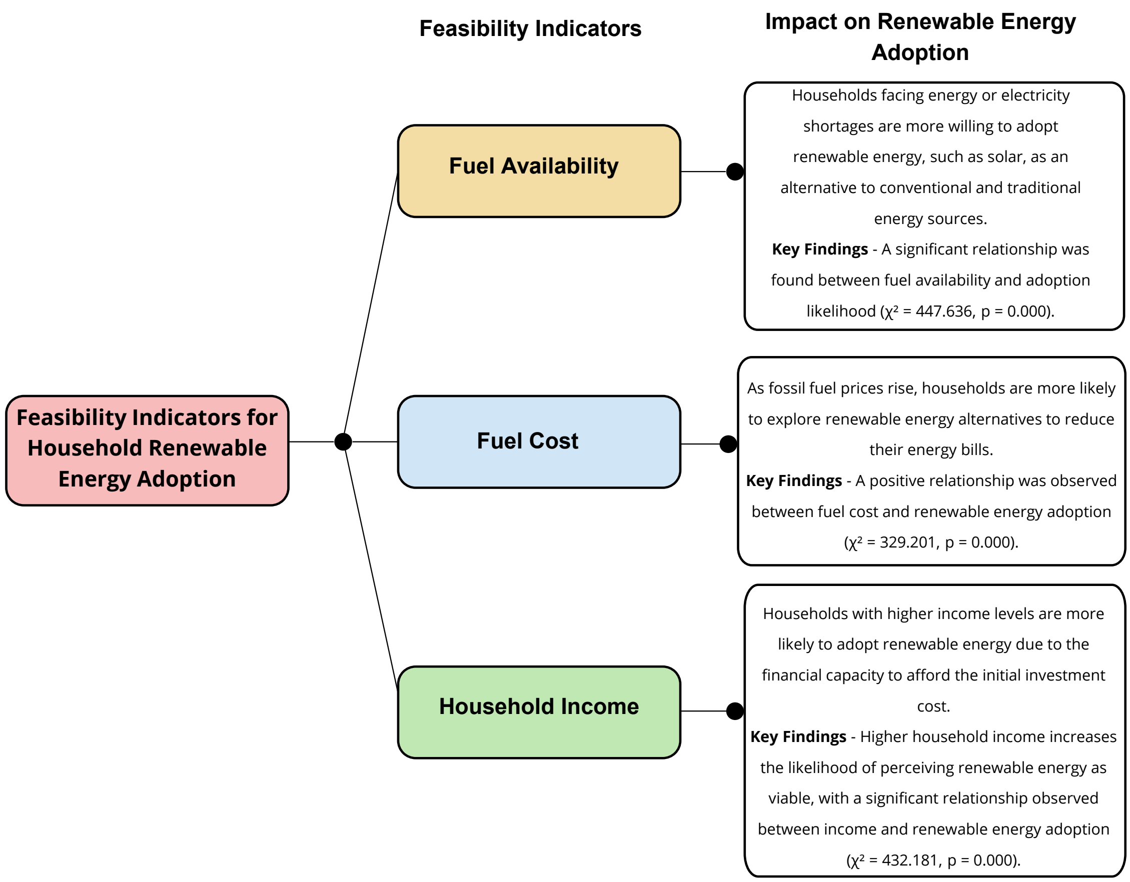

Figure 7. 1 Summary of Feasibility Indicators for Household Renewable Energy Adoption

Source: Author's Own.

7.3. Discussion of Qualitative Findings

The primary objective of conducting semi-structured interviews in this study was to gain deeper insights into the integration of renewable energy within Nigerian households from the perspective of key policymakers in the energy sector. Thematic analysis of the interview transcripts revealed valuable findings across five key themes: inadequate energy supply, untapped renewable energy sources, gaps in renewable energy policy implementation, financial barriers and investment constraints to renewable energy adoption and lack of awareness and public support. The following sections discuss each of these themes in detail, linking them to the research objectives and demonstrating how they contribute to addressing the study's research questions (see Table 7.2).

Table 7. 2 Alignment of Research Questions with Qualitative Findings

Research Questions (RQ)	Research Objectives (Obj)	Qualitative Findings
RQ1. What are the current household energy challenges in Nigeria?	Obj 4. To investigate the household energy challenges driving a shift towards integrating renewable energy technologies in Nigerian households.	• Section 6.2 – Inadequate Energy Supply
RQ2. What renewable energy policies exist in Nigeria, and what underlying factors inhibit renewable energy policy implementation?	Obj 2. To assess the progress of renewable energy development in Nigeria and identify the various renewable energy technologies employed in the Nigerian household energy mix. Obj 3. To identify and discuss the renewable energy policies in Nigeria targeted at promoting renewable energy adoption.	• Section 6.4 - Policy Gaps and Legislative Failures • Section 6.3 – Untapped Renewable Energy Resources
RQ3. What are the main drivers and barriers of household renewable energy adoption in Nigeria?	Obj 5. To assess the public's behaviour towards accepting renewable energy technologies in lieu of government subsidies on fossil fuels. Obj 6. To identify the factors influencing household renewable energy adoption amongst Nigerian households.	• Sections 6.5 – Financial Barriers • Section 6.5 – Public Awareness

7.3.1. Inadequate Energy Supply: A Key Driver for Renewable Energy Adoption

One of the main themes that emerged from the analysis of interview data was the challenge of inadequate energy supply in Nigeria. At the household level, this study found that insufficient electricity supply, particularly in rural areas, is a primary driver for renewable energy adoption (see Section 6.2). Almost all interviewees emphasised that Nigeria’s existing energy infrastructure has failed to meet the country’s growing household energy demand, compelling households to seek more reliable energy solutions, particularly solar energy. The finding addresses a significant gap in the literature, where previous studies on renewable energy transition in Nigeria have overlooked the direct impact of energy shortages on renewable energy adoption (Nwaka et al., 2020).

Comments from interviewees further highlight the inadequacy of Nigeria's electricity supply and the limitations of the centralised national grid system in meeting household energy needs (see Section 6.2). For example, one participant reported that

> "*The main challenge is the lack of electricity throughout the whole year*" (INV08).

> Similarly, INV04 also noted that "*Because they will tell you inadequate generation, inadequate -- yes, it's one of them. But inadequate transmission capacity is number one. Number two is inadequate generation. Number three is weak infrastructure—weak distribution infrastructure" (INV04).*

These findings are consistent with those from Babajide and Brito (2021), who argue that unreliable electricity supply is a major driver of renewable energy adoption in Nigeria. Moreover, the qualitative findings align with the quantitative findings presented in this study, which also highlighted the shortfall in electricity supply as a key factor driving household renewable energy adoption in Nigeria. The evidence from both qualitative and quantitative findings confirms the literature, which indicates that many households rely on petrol or diesel generators as a backup for electricity generation (Elinwa, Ogbeba, and Agboola, 2021). However, the high cost associated with maintaining and operating these generators have prompted a shift towards seeking cheaper and more sustainable alternatives like solar energy. This finding confirms Jim et al.'s (2025) assertion that energy security challenges, such as insufficient electricity supply, are central to the global push towards renewable energy transition. Overall, recognising energy shortages as a critical factor driving renewable energy adoption contributes to the literature on the wider socio-economic impact of energy poverty in Nigeria.

However, the findings presented in Table 6.2 indicate that, while inadequate energy supply motivates households to adopt renewable energy technologies such as solar energy, it can also act as a barrier to adoption. This dual role emerges from the need for decentralised power systems to support the effective integration of renewable energy technologies into Nigeria's household energy mix, which is lacking in most areas (Obada et al., 2024). This observation aligns with Aparisi-Cerdá et al. (2024), who found that inadequate energy supply serves as a driver by making households seek reliable energy alternatives, while simultaneously acting as a barrier due to infrastructural challenges, lack of technical knowledge and weak policy frameworks that hinder renewable energy adoption. In addition to the challenges discussed, the study reveals reliance on fossil fuels and a lack of professional leadership as barriers to household renewable energy adoption in Nigeria. While existing literature focuses on infrastructural and supply issues, these two factors show deeper institutional and structural barriers that further constrain household renewable energy adoption in Nigeria (Adeniyi and Isah, 2023).

For example, comments by INV08 and INV04 reveal not only technological barriers but also policy and investment bias favouring conventional energy resources (see Table 6.2 and Section 6.2). This has resulted in governance and institutional challenges that continue to hinder household transition to renewable energy in Nigeria, leading to fossil fuel reliance (Adeyemi and Isha, 2023). This fossil fuel dependency hinders the development and integration of renewable energy alternatives, increasing household reliance on environmentally harmful fossil fuels such as petrol and diesel. Consequently, this overreliance on fossil fuels exacerbates household energy poverty by exposing families to high fuel prices and recurrent supply shortages (Olujobi et al., 2023). Similarly, the lack of professional expertise and competent leadership in Nigeria’s energy sector, emphasised by INV09, shows structural barriers to renewable energy adoption. Comments by interviewee INV09 suggest that the lack of technical expertise and the mismanagement of energy agencies not only stall the improvement of existing energy infrastructure but also weaken the implementation of renewable energy policy in Nigeria. This governance and institutional gap align with Sovacool and Drupady. (2016) and Halldén et al. (2025), who argue that the critical role of institutional quality is a key determinant for successful renewable energy transitions. These additional insights show that addressing Nigeria’s energy challenges requires not only technical and infrastructural improvement but demands an integrated governance and policy implementation strategy to drive household renewable energy adoption.

7.3.2. Untapped Renewable Energy Sources: Potential and Underutilisation

Another key objective of this study was to explore Nigeria's renewable energy potential and examine how it could serve as an alternative solution to the household energy challenges in Nigeria. Extant studies indicate that Nigeria has in abundance various renewable energy sources available in the country that could alleviate its current energy challenges (see Section 3.6 and Table 2.4) (Adelaja, 2020). The study found that renewable energy is abundantly available and distributed across different regions of Nigeria, particularly solar, biomass, small hydro, geothermal and wind energy. Comments from several interviewees show regional differences in terms of renewable energy potentials in Nigeria, with solar energy being the most viable in the North, while hydro potential is more prominent in the South. For instance, comments from interviewee INV04 show that the northern part of Nigeria has abundant farmland for solar farms, while the southern delta regions have potential for mini-dams for electricity generation. This spatial distribution of renewable energy resources is crucial for tailoring region-specific interventions that will drive household renewable energy adoption across the different parts of Nigeria. Most interviewees noted that Nigeria's vast solar energy potential could play a significant role in addressing the energy supply gap experienced by households. For example, interviewee INV01 stated that

> *"Solar energy is one of the most widely economically usable energy resources in Nigeria"* (INV01).

The statement by interviewee INV01 aligns with Ogunmodimu and Okoroigwe. (2019) who identified solar energy as one of the most abundant and cost-effective renewable energy resources suitable for integration into Nigeria's household energy mix. Similarly, Okoh and Okpanachi (2023) argue that renewable energy resources present an opportunity for Nigeria to diversify its energy mix, reduce its reliance on fossil fuels, and improve household energy security. They further emphasise the economic benefits of renewable energy, including job creation, industrial growth, and reduced greenhouse gas emissions in Nigeria (Okoh and Okpanachi, 2023). However, despite this potential, renewable energy utilisation at the household level remains low. The findings presented in Section 6.3 reveal that the vast amount of renewable energy resources available in Nigeria, particularly solar and small hydro energy remain untapped. Various interviewees further highlighted that despite Nigeria's abundant renewable energy resources, such as solar energy, these resources are underutilised due to weak energy infrastructure and poor investment. For instance, interviewee INV02 reported that

> *"…. we're not relying on any renewable source of energy, which I think is one of the problems… I don't think they're doing much. Because if they were … we should have different sources of energy now…. Most of the hydro dams are not being looked after"* (INV02).

This finding is consistent with Obada et al. (2024), who noted that despite Nigeria's abundant solar irradiation and numerous rivers suitable for mini hydroelectric systems, these resources remain largely underexplored due to a lack of investment and inadequate policy implementation. Comments by interviewee INV04 show that the lack of policy implementation is a barrier to renewable energy utilisation in Nigerian households. This suggests a disconnect between policy formation and execution, supporting Sovacool and Drupady's (2016) assertion that institutional quality plays a decisive role in the success of small-scale renewable energy deployment in developing countries.

7.3.3. Policy and Legislative Frameworks: Key Barrier to Implementation

The findings from the qualitative study reveal a significant gap in Nigeria's renewable energy policy framework, which hinders household renewable energy adoption in the country. While various energy policies, such as the Renewable Energy Master Plan (REMP), exist, interviewees for this study highlighted weak legislative backing and a lack of political will as constraints hindering renewable energy implementation (see Section 6.4). This finding highlights a disconnect between policy formation and implementation that hinders the adoption of household renewable energy in Nigeria. Comments from interviewee INV01 show a gap between Nigeria's existing energy and renewable energy policies and their implementation (see Section 6.4). This finding aligns with Nwozor et al. (2021), who argue that the policy targets for household renewable energy adoption in Nigeria fail to meet their desired outcome due to a discord between policy formation and execution, hindering their successful implementation. This policy disconnect highlights a significant barrier to household renewable adoption in Nigeria, where policies exist in theory but fail to achieve tangible outcomes (Adelaja, 2020).

The findings from this study also contribute to the literature on energy and renewable energy policy gaps in Nigeria by highlighting the reasons behind the weak policy implementation. For instance, several interviewees noted that despite the renewable energy policies developed in Nigeria, their implementation remains limited due to a lack of political will, inadequate funding and lack of incentives for investors. Interviewee INV01 emphasised that.

> *"The government has put the policy in place, but the political will to implement it is lacking. Even with good policies, inadequate funding makes them ineffective…… No adequate government incentives to encourage the beneficiaries. The market awareness is also very, very low. The political will on the side of the government is also very poor. No legal document in terms of energy law, though they draft policies exist. But there is no legal document. They have not yet passed into law. And this is a very big constraint to investors into the renewable energy, you see it, of Nigeria"* (INV01).

The statement by interviewee INV01 highlights the issue of a lack of political will and adequate funding as major barriers to the implementation of renewable energy policies in Nigeria. Despite the existence of the draft National Renewable Energy and Energy Efficiency Policy (NREEEP) 2015, there remains a major obstacle in converting this draft policy document into actionable laws, which hinders its implementation. This finding aligns with Adelaja. (2020), who argue that policy uncertainty and a lack of political commitment, exacerbated by conflict between key actors in the energy sector, contribute to delays in policy implementation. Furthermore, the quest for political influence among various actors in the energy sector has created an environment of stagnation, hindering the implementation of renewable energy policies in Nigeria. As multiple actors, from government agencies to private sector firms, compete for control and influence, this creates fragmentation of agendas (Adelaja, 2020). This lack of unity among key actors in Nigeria's energy sector further undermines the efforts to achieve a successful policy formation and implementation. This finding is further emphasised by Nwozor et al. (2021), who argue that, despite the development of renewable energy policies by successive governments, the lack of commitment and failure to evaluate previous policies have resulted in policy uncertainty, with no clear plan for implementation.

In addition to the concerns discussed above, the findings presented in Section 6.4 also reveal delays in signing agreements and a complex bureaucratic approval process as barriers to the implementation of renewable energy policy in Nigeria. Interviewee INV05 stated that

> *"…… Signing agreements is delayed due to stringent conditions and lack of funding to support private sector participation"* (INV05).

This finding aligns with Shao et al. (2025), who highlighted the challenges of bureaucratic delays and complex regulatory processes as obstacles hindering the implementation of renewable energy policies and projects in Nigeria.

7.3.4. Financial Barriers and Investment Constraints

The study reveals several financial and investment barriers that hinder the successful adoption of renewable energy in Nigerian households. Significant financial barriers highlighted in this study include the high initial cost of renewable energy technologies, such as solar energy, and the lack of government subsidies to encourage household adoption of renewable energy. For example, the view of interviewees presented in Table 6.5 indicates that the high initial cost of renewable energy technologies is a significant obstacle to household adoption of renewable energy. One interviewee stated that

“The cost of procurement of renewable energy facilities are very expensive for the beneficiaries” (INV01).

The findings presented in Section 6.5 highlight the need for targeted government intervention in the form of incentives and subsidies to promote renewable energy adoption and make renewable energy more affordable and accessible for households. This finding is consistent with Oyeniran and Isola. (2023) who emphasised financial incapacity as a significant barrier to household renewable energy adoption, particularly for low-income households in Nigeria. The findings also reveal that despite the acknowledgement of renewable energy as a viable alternative to Nigeria’s energy crisis, the absence of financial incentives such as government loans and subsidies impedes widespread adoption of renewable energy. For instance, interviewee INV03 identified the absence of government incentives as a discouraging factor for households considering solar energy as a viable option to address their energy crises (see Table 6.5). INV03 stated that

"There is no incentive for Nigerians to use renewable energy. The government is not investing, which discourages individuals from participating"

The comments by interviewee INV03 suggest that most Nigerian households face affordability challenges when considering renewable energy as an alternative to unreliable fossil fuel energy.

In addition to the financial barriers, the study also reveals that the lack of competitive pricing for renewable energy technologies compared to fossil fuels was another major barrier to widespread adoption. As noted by interviewee INV01

“People will tend to go where they spend less… subsidies on fossil fuels make renewable energy less attractive” (INV01)

This finding aligns with Ozoegwu and Akpan (2021), who argue that fossil fuel subsidies in Nigeria have consistently reduced the competitiveness of renewable energy sources, thereby discouraging households from transitioning to cleaner energy alternatives. The subsidies on fossil fuels previously made renewable energy less attractive, as the government's financial incentives made petrol and kerosene more affordable for households. However, with the recent removal of fossil fuel subsidies, the prices of petrol, diesel, and kerosene have risen significantly, making them unaffordable for many households in Nigeria (Gamette and Oteng, 2024). This price increase has heightened the demand for renewable energy solutions, as households seek more cost-effective options. Nevertheless, renewable energy technologies remain too expensive for most Nigerian households, creating a dual challenge of rising fossil fuel prices and the high initial investment required for household renewable energy adoption (Adeniyi and Isah, 2023; Farinloye et al., 2024).

Conversely, the study also reveals the existence of some government incentives, as some interviewees indicated the availability of some government incentives such as tax holidays and waivers for renewable energy projects in Nigeria (see Section 6.5). Comments by interviewees INV05 and INV07 highlight the presence of tax holidays and waivers for power-generation renewable energy projects. However, these incentives primarily target power-generation companies rather than households. Interviewee INV05 emphasised that while tax holidays and waivers exist, their approval processes are often "cumbersome" and do not benefit households (see Section 6.5). Interviewee INV05 stated that

> *"Yes, we have such incentives. Like as I said, we have tax holidays. Apart from tax holidays, we also have waivers. But these waivers need an approval process. At times a bit cumbersome… We've not been able to exhaustively test the policies"* (INV05).

This finding suggests that while incentives are available, their implementation is slow and ineffective in promoting widespread household adoption of renewable energy. This is due to the focus on larger power-generation projects, leaving households with limited access to the financial support needed to encourage renewable energy adoption in Nigeria.

7.3.5. Lack of Public Awareness and Negative Public Awareness

The findings presented in Section 6.6 and Table 6.6 revealed that public awareness and negative household perception of renewable energy are significant barriers to renewable energy adoption in Nigeria. The lack of awareness of renewable energy technologies, combined with a negative perception despite their potential benefits, can hinder widespread adoption (Thomas et al., 2022). The interviewee comments presented in Table 6.6 indicate that public awareness of renewable energy technology in Nigeria is low, despite its abundant availability and potential benefits for households. For instance, interviewee INV01 stated that

> *"In the case of renewable energy, the awareness is very, very poor. Not many people really understand the benefit of renewable energy"* (INV01).

Similarly, interviewee INV02 suggested that a lack of government-led publicity and outreach to encourage the use of renewable energy in Nigeria, and that households are not actively involved in the development or implementation of renewable energy projects (see Table 6.6). INV02 further added that there is more support and publicity for fossil fuel-powered generators than renewable energy technologies, thereby hindering awareness of renewable energy technologies in Nigeria. This finding aligns with existing literature, which emphasises the lack of government-led publicity and stakeholder outreach as a major barrier to renewable energy adoption (Radtke and Renn, 2025).

In addition to the challenge of low awareness, the study also found negative household perceptions of renewable energy due to scepticism about its reliability. Interviewee INV04 stated that

> *“Nigerians are sceptical about solar because they do not trust its reliability… they prefer familiar sources like kerosene and firewood”* (INV04).

The comment by interviewee INV04 reveals a household preference for traditional energy sources, such as firewood, which is considered reliable due to its familiarity of use and widespread availability in households. This preference for conventional energy sources is further complicated by the lack of government-led publicity to promote renewable energy among households and build trust in renewable energy technologies. This finding aligns with Sütterlin and Siegrist. (2017), who argued that negative household perception of renewable energy is a result of a lack of awareness of renewable energy technologies and knowledge of their drawbacks.

In contrast, the study also reveals that awareness of renewable energy is limited to an institutional context in Nigeria. As interviewee INV07 commented that some organisations have undertaken several initiatives to educate their workforce about energy efficiency and the installation of solar panels within the organisation. While these initiatives demonstrate an increasing recognition of renewable energy, they are only restricted to specific organisational environments rather than widespread adoption among households. Despite the various renewable energy policies available and a focus on institutional awareness, the study also finds that the broader residential sector remains unaware of the benefits of renewable energy technologies, particularly in rural areas. This aligns with Oyeniran, Omojolaibo and Alasinrin. (2025) who argue that while renewable energy policies and organisational programs exist to increase organisational renewable energy awareness, household-level awareness remains significantly low to drive a change in attitudes towards renewable energy utilisation in Nigeria. Therefore, one of the interviewees, INV08, suggested that it is the responsibility of the government to raise awareness of renewable energy technologies and shift public perception through effective sensitisation and public engagement (see Section 6.6). The comment by INV08 implies that an effective awareness campaign from both local and national governments is crucial to ensuring public trust and encouraging the utilisation of renewable energy sources among households in Nigeria. This is further supported by Ibrahim et al. (2021) and Oyeniran, Omojolaibo and Alasinrin. (2025), who advocate for greater emphasis on community-based energy educational programs to increase household awareness for renewable energy adoption.

7.4. Summary

This chapter provided a detailed discussion of the data and findings from the quantitative survey and qualitative interviews presented in the previous chapter. Chapter 7 critically discussed the main findings from both datasets, comparing the study findings with existing literature to demonstrate this study's contribution to the identified knowledge gaps. The discussion provided valuable insights into Nigeria's energy situation and the current adoption of household renewable energy in the country. The quantitative discussion revealed that most Nigerian households experience severe energy shortages, which are characterised by frequent electricity outages, overdependence on costly fossil fuel-powered generators, and inequitable metering processes. The findings show that these challenges create severe energy insecurity problems for households, driving the need for a decentralised power system and renewable energy alternatives. The discussion shows that most Nigerian households exhibit patterns of fuel stacking when performing various domestic activities, including cooking, lighting, and electricity generation. The quantitative findings also reveal that fuel availability, affordability and cultural preferences were significant divers of household energy choices in Nigeria. However, the quantitative discussion on gender-differentiated analysis shows that women are the primary energy users in households, expressing more support for renewable energy alternatives than men. This highlights the gender vulnerabilities that women face in households, underscoring the need for gender-inclusive energy policies.

Complementing the above findings, the qualitative discussions provided more profound insights into the systemic barriers to household renewable energy adoption in Nigeria. Policymakers in the Nigerian energy sector highlighted that, despite the abundance of renewable energy sources in Nigeria, weak policy implementation processes, a lack of legislative backing, and competing interests among stakeholders hinder the widespread adoption of renewable energy. The discussion also reveals that the high initial cost and lack of government incentives hinder household renewable energy adoption. In contrast, low household awareness and scepticism of renewable energy technologies further impede adoption rates. The outcome of both discussions reveals the dual role of energy shortages as both a driver and barrier to household renewable energy adoption in Nigeria, highlighting the need for effective governance approaches and support.

Chapter 8. Development of a Framework for Renewable Energy Utilisation in Nigerian Households

8.1. Introduction

Frameworks in energy research serve as valuable tools for illustrating concepts and developing an in-depth understanding of complex energy challenges (Matthey-Junod et al., 2022). These frameworks integrate insights from multiple disciplines, including socio-economic analysis, stakeholder engagement, and sustainability assessment, to identify effective and sustainable energy solutions (Berjawi et al., 2021). The use of frameworks provides a structured and systematic approach to understanding complex phenomena by showing interrelationships between key concepts (Sale and Carlin, 2025). Frameworks also help researchers to integrate methodological components of a study to strengthen the study's design, approach and effectiveness (Clark, Ivankova and Yang, 2023).

8.2. Rationale for Developing a Framework

In the context of this study, developing a tailored framework is essential to address the specific energy challenges faced by Nigerian households. By systematically analysing the collected data and key findings, this framework ensures that renewable energy solutions align effectively with local household energy needs, facilitating the successful integration of renewable energy sources into Nigeria's household energy mix. Additionally, the study found that the Nigerian household energy sector continues to experience frequent electricity outages, high dependence on fossil fuels, rising energy fuel costs and slow integration of renewable energy sources in households. Given the complexities and interconnectedness of these energy challenges, developing a structured framework is crucial in guiding a successful transition to renewable energy among households in Nigeria. The development of the framework for this study is informed by in-depth insights from both the qualitative and quantitative data analyses conducted in this study. The quantitative data analysis reveals the significant factors influencing household energy decisions, including: Fuel availability, cost, affordability, family income and gendered dynamics. Acknowledging these factors allows the framework to highlight the critical areas of intervention, making renewable energy adoption feasible and affordable (Aparisi-Cerdá et al., 2024).

Similarly, the qualitative data analysis identified barriers to household renewable energy adoption, such as policy and legislative barriers, financial barriers, low public awareness, and negative renewable energy perception. Recognising these barriers requires a systematic approach that identifies mechanisms to reduce their impact on the likelihood of households adopting renewable energy. Therefore, the framework addresses these barriers by suggesting approaches for improved stakeholder coordination, public awareness, policy implementation, and financial support. Additionally, the framework is designed to understand the different roles, responsibilities and interactions of stakeholders within the Nigerian energy sector, including federal government bodies, regulatory agencies, private energy companies, state and local government bodies and households. Clearly mapping out the roles and the interactions between the different stakeholders facilitates effective interdisciplinary collaboration to overcome institutional barriers that impede the adoption of renewable energy in households (Sadeq et al., 2024).

However, based on the extensive literature review and empirical analysis conducted during this research, coupled with significant insights derived from key policy makers in the Nigerian energy sector, resulted in a significant contribution provided by this research. The findings and insight derived from both the survey and interview from this research are used to develop a framework to assess the feasibility of utilising renewable energy technologies in Nigerian households. As a result, Figure 8.1 presents a new framework to aid and evaluate renewable energy development in Nigeria.

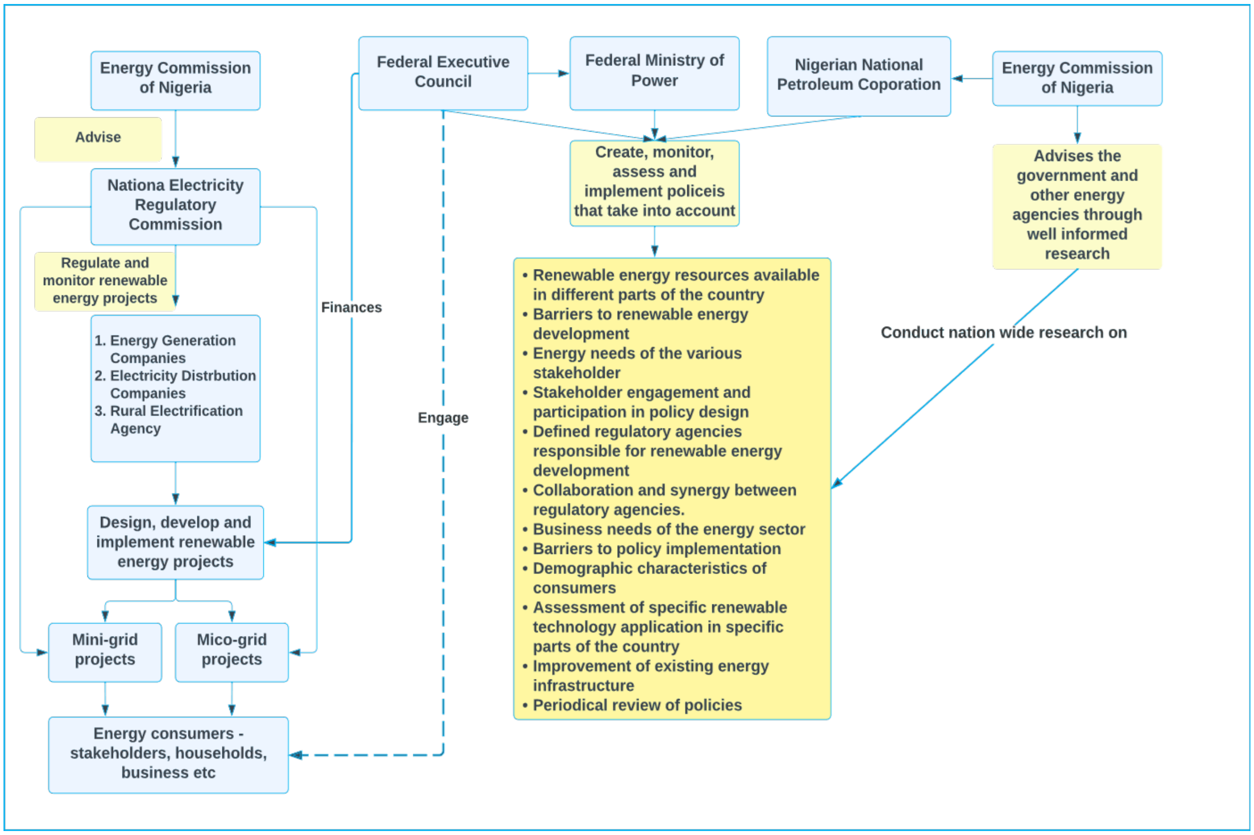

Figure 8. 1 Initial Framework for the Utilisation and Development of Renewable Energy Technology in Nigeria based on Interviews with Policy Makers

Source: Author

This initial framework has been designed to aid policy development, implementation, and the development of renewable energy technologies in Nigeria. The initial framework considers the unique dynamics of energy development in Nigeria by considering likely barriers to renewable energy development in Nigeria, barriers to policy design, stakeholder engagement and the need for more research into energy and renewable energy development in Nigeria. One essential contribution of this framework is the delegation of clear roles and responsibilities for regulating renewable energy development and policy design in Nigeria. This has been identified as one of the significant barriers to renewable energy development in the country, as too many agencies are often involved in creating policies and handling renewable energy projects simultaneously in Nigeria. This creates inefficient management systems, unnecessary bureaucracy, and a lack of accountability. However, the initial framework proposed suggests that the Energy Commission of Nigeria (ECN) should act as an advisory body to the government, the Ministry of Power, and the National Petroleum Corporation, which are to develop and implement policies on renewable energy.

The initial framework focuses on continuous engagement with key stakeholders, particularly households in rural areas, as they are often excluded during policy design and planning phases. This ensures that the government and regulatory agencies are well-informed on the energy challenges and energy needs of households. The framework also stresses the need for increased research and development into the various renewable energy sources that can be applicable in the different regions of the country, as renewable energy resources differ from region to region. This will ensure efficient development of renewable energy technologies that meet the specific needs of communities where they are to be implemented.

A key policymaker from the Nigerian National Petroleum Corporation (NNPC) reviewed the proposed framework to test its robustness and credibility. The Interviewee commented that it was added.

> *"The proposed framework suggests key considerations that must be taken into account when assessing the potentials of renewable energy development in Nigeria… especially for communities and residents as they are often not consulted before embarking on projects…. Also, the need for synergy between energy regulatory bodies cannot be overemphasised. As we have various agencies developing their own policies and commissioning projects as such it is difficult to monitor what has been done from a nation-wide level".* (INV10)

However, upon evaluating the framework by another policymaker in the Nigerian energy sector, suggestions were made to include multi-partner actors to reflect the sector's current governance structure.

> *"From what I have observed, there is no real structure connecting federal initiatives to local realities. Local government agencies are barely involved in the planning or implementation of renewable energy projects, even though they are closest to the households. If we want*

any framework to work, it must reflect the actual drivers and barriers households face, like affordability, unreliable supply, and lack of awareness .... otherwise, it will just stay on paper." (INV11).

8.3. Proposed Enhanced Framework for Household Renewable Energy Utilisation in Nigeria

Based on the comments of interviewee INV11, a new framework was proposed for utilising renewable energy among households in Nigeria.

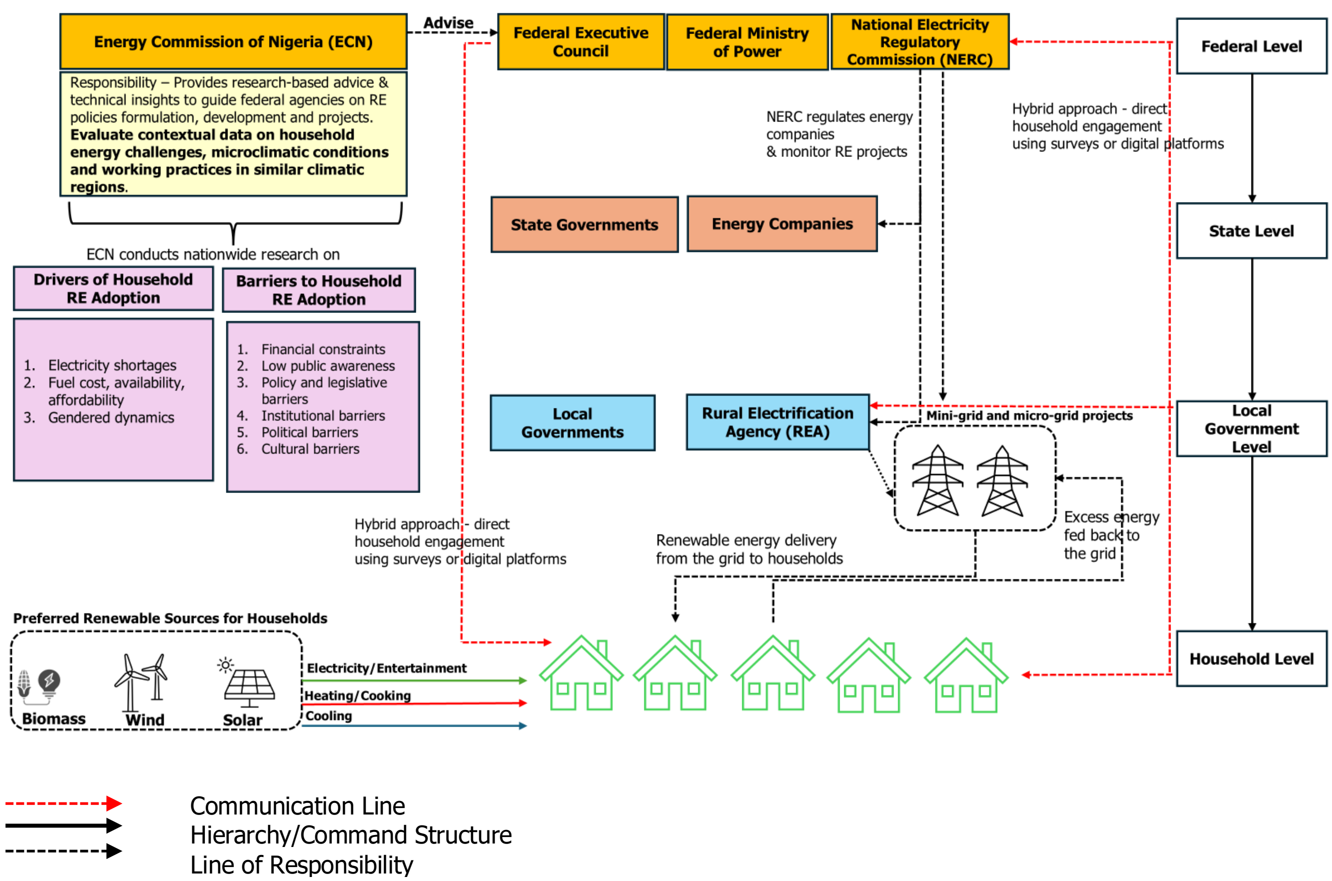

Figure 8. 2 Enhanced Framework for Household Utilisation of Renewable Energy in Nigeria based on Feedback from Field Expert

Source: Author's Own

Figure 8.2 shows the enhanced final framework for the utilisation of renewable energy among households in Nigeria. The enhanced framework has been developed in response to the energy challenges experienced by households and the barriers to household renewable energy adoption in Nigeria. It is aimed at encouraging household-level utilisation of renewable energy sources in Nigeria to reduce dependence on finite fossil fuels. The enhanced framework requires multi-level government partnerships, private and residential actors to work collaboratively to achieve a gradual transition towards renewable energy sources in the Nigerian residential sector. The multi-level governance structure depicted in the framework highlights four key levels of governance, including federal, state, local and household levels, with each playing distinct roles but interdependent responsibilities.

One significant contribution of the proposed framework is the delegation of clear roles and responsibilities for regulating renewable energy policy design, implementation, and project development in Nigeria. This was crucial as the study found that a lack of coordination regarding policy formation hindered renewable energy adoption efforts (see Section 6.4). This has emerged as a major barrier to renewable energy development in Nigeria, where multiple agencies are often involved in policy formulation and project implementation simultaneously. The overlap in responsibilities creates confusion, delays, and inefficiencies, undermining coordinated efforts to scale up renewable energy adoption (Lah, 2025). However, the proposed framework suggests that the Energy Commission of Nigeria (ECN) acts as the advisory body to the Federal Executive Council (FEC) and other federal agencies. In this role, the ECN would offer research-based insights into household energy challenges and renewable energy preferences to inform and guide the design of renewable energy initiatives across Nigeria. The framework highlights the crucial role of the ECN in advancing research-led development on renewable energy sources in Nigeria. Given the regional variation in renewable energy sources in Nigeria, the ECN is tasked with identifying which renewable energy sources are most suitable for households in specific regions. This regional approach ensures that renewable energy projects are efficient and responsive to the unique energy needs of households in different areas (Olabi et al., 2023; Shao et al., 2025).

At the federal level, the Federal Executive Council (FEC), which is Nigeria's federal council of ministers led by the president, plays a crucial role in the formulation and implementation of energy policies in Nigeria (OSFG, 2023). The FEC ensures policy coherence in alignment with national renewable energy and sustainability objectives, while efficiently allocating resources through the approval and funding of renewable energy projects across the country. The Federal Ministry of Power is responsible for strategic planning and policy direction in alignment with the national renewable energy and sustainability objectives. The National Electricity Regulatory Commission plays a key role in ensuring regulatory compliance and supportive markets for household renewable energy adoption. Collectively, federal agencies play a significant role in influencing the regulatory and financial mechanisms needed for household adoption of renewable energy.

At the state level, state governments across the country are responsible for contextualising federal renewable energy policies and have a pivotal role in co-financing renewable energy projects in their states. Public-private partnerships, regulated by state governments with various energy companies, can contribute to developing regional renewable energy projects aligned with regional energy needs. This partnership is mutually beneficial, as state governments could gain access to private capital and technical expertise to develop renewable energy projects, while private energy companies benefit from the opportunity to expand into new and underserved markets (World Bank, 2025). Within this framework, local governments act as intermediaries to facilitate and monitor community-level renewable energy projects. Despite being a federal agency, the Rural Electrification Agency (REA) could work closely with the local governments to implement mini-grid and micro-grid solutions to rural communities that have limited access to the national grid. Households in this framework are the key end-users whose decision to adopt renewable energy is influenced by fuel cost, affordability, availability and culture (see Table 5.12). Therefore, placing household interest as the focal point of Nigeria's energy transition objectives emphasises their relevance and importance to tailored interventions (Pokubo, Pepple and Al-Habaibeh, 2024).

The framework stresses the need for tailored interventions that focus on household energy needs, drivers of household energy choices, and barriers that hinder the adoption of renewable energy. Developing interventions that address specific household energy needs and identify motivations for household energy choices is crucial for successful renewable energy adoption (Boateng, Bloomer, and Morrissey, 2024). The framework identifies various factors that enhance household feasibility of adopting renewable energy. For example, the framework recognises that the prolonged electricity shortages experienced by households prompt a search for sustainable alternatives. The framework also acknowledges that the removal of fossil fuel subsidies has resulted in an increase in fossil fuel costs, thereby creating cost competitiveness of renewable energy alternatives. In addition, gender dynamics also play a pivotal role, as women who are the primary energy users in households favour clean, renewable options.

Despite the identified drivers, the framework also recognises several barriers that hinder household renewable energy adoption. One key barrier is the high initial cost of renewable energy technologies, which are unaffordable for most households. Households also experience financial constraints due to the lack of access to incentives or renewable energy subsidies from the government. The framework also highlights gaps in policy formation and implementation as a barrier to household renewable energy adoption, as this undermines the effectiveness of federal renewable energy efforts and policies. Institutional barriers and a lack of coordination between stakeholders remain key barriers. Lastly, a lack of public trust in the reliability of renewable energy due to low-level awareness further slows household willingness to adopt renewable energy. Therefore, addressing these barriers can significantly improve households' perceptions of renewable energy and reduce the high initial cost of adopting solar energy as their most preferred renewable energy source. One practical approach to achieving improved household perception is to implement education and awareness programmes that highlight the benefits of renewable energy (Zeng et al., 2022).

Additionally, to address the challenges and improve policy implementation, the framework suggests a hybrid communication and feedback model. This model is proposed to enhance the effectiveness of renewable energy adoption strategies and reduce bureaucratic delays to policy implementation. The model recognises the need for structure and hierarchy across the key levels of governance, including the federal, state, and local governments. However, it highlights the benefits of implementing a streamlined, open, and direct communication with households. In the top-down direction, renewable energy policy design, funding allocation, and strategic decisions flow from the federal level to state and local governments. Simultaneously, direct feedback loop from households through the ECN and REA involving real-time data on household energy dynamics using digital platforms, surveys or pilot projects is fed back to the federal agencies. This hybrid communication and feedback model could bypass bottlenecks and allow data triangulation to aid the successful implementation of renewable energy initiatives (Bangero, 2025). This will ensure the efficient development of renewable energy technologies that meet the specific needs of communities where they are to be implemented. The proposed framework will act as a guide to policymakers and the government by creating the need to consider all energy stakeholders when designing policies and setting a timescale for policy implementation.

Chapter 9. Conclusion, Contributions and Recommendations

9.1. Introduction

The aim of this thesis was to investigate the feasibility of renewable energy utilisation in households in West Africa with a specific focus on Nigeria. Employing a mixed methods approach, by combining household surveys and semi-structured interviews with key energy stakeholders, the study provided an in-depth insight into household energy dynamics in Nigeria from a multidimensional perspective. The study then uncovers a comprehensive understanding of the drivers, barriers, and governance approaches that shape household renewable energy adoption in Nigeria. Subsequently, this chapter summarises the study's aims and objectives, synthesises the key findings, presents the study's contribution to knowledge, recognises the limitations of the study, and proposes directions for future research.

The study utilised various approaches to achieve the objectives set in Chapter 1 of the thesis. Chapter 1 outlined the research context, providing the background, rationale, and significance of the study. This chapter sets out the research aims, problems, research questions and objectives, and the methodological approaches used in conducting the research. Subsequently, Chapter 2 presented a comprehensive review of the literature on the energy dynamics in West Africa, focusing on regional energy use patterns. This chapter also examined the energy landscape in Nigeria, discussing rates of electrification and the socio-economic and environmental implications of the country's current energy consumption patterns. Chapter 3 focused on reviewing relevant literature on household-level renewable energy adoption in Nigeria. The chapter explored Nigeria's adoption trends and barriers to adoption, assessed the country's renewable energy potential, and provided an overview of Nigeria's renewable energy policies. The philosophical underpinnings and methodology used for conducting the research were presented in Chapter 4. Chapter 4 also provided justification for adopting a pragmatist research paradigm and the use of surveys and interviews for data collection. Chapter 5 presented quantitative findings from the household survey, examining energy use behaviours and identifying feasibility indicators for household renewable energy adoption in Nigeria. Chapter 6 presented the study's qualitative findings from interviews with key policymakers, highlighting barriers to household renewable energy adoption. Chapter 7 then produces a critical discussion of quantitative and qualitative findings. The chapter examines the relationship between household energy consumption patterns and systemic governance issues inhibiting renewable energy adoption in households. Chapter 8 introduces the framework for household renewable energy utilisation in Nigeria. The chapter also proposes a hybrid model of communication between the different actors in Nigeria's energy sector to facilitate collaboration and direct feedback. Based on the empirical findings, Chapter 9 concludes the study by summarising the main study findings and the study's contribution to knowledge. This chapter outlines recommendations and the new framework as a guide to aid policymakers in creating an inclusive and sustainable household renewable energy transition in Nigeria.

9.2. Addressing the Research Questions

The study was guided by three research questions: (1) What are the current household energy challenges in Nigeria? (2) What renewable energy policies exist, and what factors hinder their implementation? (3) What are the main drivers and barriers to household renewable energy adoption? The following sections will present summaries of answers to the study's research questions.

9.2.1. Research Question 1 – Household Energy Challenges in Nigeria

The study revealed that most Nigerian households are energy-deficient, experiencing severe electricity shortages, frequent blackouts, and heavy reliance on expensive fossil fuel-powered generators. The study found that these household energy challenges are due to Nigeria's centralised and underperforming electricity infrastructure, resulting in severe socio-economic implications for households. The study found that frequent blackouts and electricity shortages disrupted the daily lives of families. This results in a financial strain, where most households resort to self-generation using petrol or diesel generators, which are unaffordable due to increasing fuel prices. The study also found that the energy challenges in Nigeria exhibited patterns of gender inequality, with women and girls disproportionately affected due to their role as domestic caregivers and primary energy users. The female participants reported gender inequalities due to the time spent collecting firewood or performing domestic chores, with adequate lighting and refrigeration negatively impacting their education and well-being. Collectively, these energy challenges were recognised as drivers for decentralised household-level renewable energy sources. As households have a keen interest in seeking renewable options, especially solar energy, which is the most preferred renewable energy resource for households.

The study revealed widespread dissatisfaction with Nigeria's electricity billing system. Many households reported receiving estimated bills due to inadequate metering infrastructure, which has led to a general distrust of electricity distribution companies. These estimated billing practices often result in inflated charges that do not reflect actual electricity consumption, placing additional financial pressure on households. The lack of metering was identified as a major issue, with only a small proportion of households having access to functional electricity meters. This gap undermines transparency and accountability in energy billing. While full metering coverage is a desirable goal, it remains a significant challenge, especially in multi-tenanted dwellings where implementing individual meters is logistically complex and costly for distribution companies (Soyemi et al., 2021).

9.2.2. Research Question 2 – Assessing Renewable Energy Policies and Barriers to Implementation

The study provided rich insights into Nigeria's renewable energy policies and the factors that hinder their implementation. It found that Nigeria has a portfolio of energy and renewable energy policies such as the Renewable Electricity Policy Guideline (REPG), National Economic Empowerment and

Development Strategy (NEEDS), Renewable Energy Master Plan (REMP) and the National Energy Policy (NEP). However, the empirical evidence and literature review reveal a gap between policy formation and implementation. The study found that a lack of political will, weak legislative backing, and a lack of funding inhibit renewable energy policy implementation, undermining the development of renewable energy initiatives in Nigeria. While the existing policies are designed to encourage the development and delivery of renewable energy technologies across the country, they remain drafts and have yet to be enacted into law. For example, despite the development of the Renewable Energy Master Plan (REMP) in 2012 and its revision in 2005. The REMP remains a draft and has not been passed into law, hindering its effectiveness and relevance in the household renewable energy transition process. The study also found that institutional barriers and competing interests among various energy stakeholders contributed to delays in policy implementation. As empirical evidence showed, overlapping responsibilities and poor coordination among key energy stakeholders hinder policy implementation. Specifically, the study highlighted overlapping duties between the federal-level agencies responsible for energy and renewable energy policy development. This shows a lack of governance structure that contributes to policy formation and implementation delays, as the different actors embark on different mandates, leading to inefficiencies in policy design and implementation.

Additionally, the study revealed bureaucratic delays in the approval of agreements for renewable energy projects in Nigeria. Qualitative comments from interviewed policymakers show that the complex bureaucratic approval process deters private sector participation, negatively impacting foreign direct investment in the energy sector. The study also identified financial barriers as a key constraint to renewable energy policy implementation. Globally, renewable energy policies often contain subsidies and financial incentives such as tax holidays, import fee exemptions and fee waivers (Bai, Zheng and Wang, 2021). However, the study found that in Nigeria, these financial incentives were mainly targeted towards large-scale power generation companies and large grid-based projects instead of households. Therefore, leaving households with limited access to the financial support needed to encourage renewable energy adoption in Nigeria. Adding to the factors that hinder policy implementation, the study found that subsidies on fossil fuels have historically distorted the Nigerian energy markets. Historically, the subsidies on fossil fuels favoured conventional energy sources like petrol and diesel, making them more affordable than renewable energy sources. Therefore, households were more inclined to self-generation using fossil fuel-powered generators instead of using solar energy. However, the removal of fossil fuel subsidies has led to increases in the prices of petrol, diesel, and kerosene, making them unaffordable for many Nigerian households. In contrast, this has sparked an interest in renewable energy options like solar, which is considered a more cost-effective option. The high upfront cost of renewable technologies remains a major barrier to households. Therefore, creating a dual challenge of rising fossil fuel prices alongside the unaffordability of clean energy solutions.

9.2.3. Research Question 3 - Drivers and Barriers to Household Renewable Energy Adoption

The study found that several factors determine the feasibility of households adopting renewable energy in Nigeria.

9.2.3.1. Fuel Availability

One major factor identified in the study is fuel availability as a key driver of household energy decisions. The study found that the inadequate supply of electricity and persistent blackouts due to grid collapse underscore the need for alternative renewable energy solutions. The current grid-based electricity supply in Nigeria falls short of meeting a growing energy demand from the residential sector, resulting in households relying on fossil fuel sources for their household energy needs. However, these conventional fuels have become unreliable, inadequate, and unaffordable due to the removal of fossil fuel subsidies, pushing households to seek more reliable options like solar, wind, or biomass energy.

9.2.3.2. Fuel Price

Similarly, fuel price also emerged as a significant driver of household renewable energy adoption. The study found that as fuel prices increase, particularly petrol, diesel, and kerosene prices, due to the removal of fossil fuel subsidies, households become more inclined to adopt cheaper, reliable alternatives such as solar energy. However, despite this interest in renewable energy alternatives, the rate of adoption remains low due to the high upfront and maintenance costs of renewable energy sources. The study found that households will only switch to renewable energy sources if the government provides support in terms of renewable energy subsidies or financial incentives. The study also found household affordability and income to be key drivers of household renewable energy adoption. Suggesting that high-income households would be more likely to consider renewable energy due to their capacity to afford the high upfront cost of installing these technologies.

9.2.3.3. Gender Dynamics

This shows that energy transition in Nigeria is not only shaped by economic and technical factors but also by cultural and social factors. The study found that women, as primary household energy users, face greater economic and social risks due to energy poverty. Evidence from the study shows this, as some female participants commented that.

> "*The current electricity problem makes me feel unsafe and insecure when I am on my way home from work. Especially at night as the streets are not illuminated, the streetlights do not work.*" (RP040)
>
> *"…some mornings, I have to go to the mangrove to collect wood for cooking before I get ready for school… or I do that after school."* (RP004)
>
> *"Preserving food becomes difficult, adding to household work."* (RP545)

Empirical analysis from the survey revealed that women had a much higher preference for renewable energy, indicating gendered dimensions of renewable energy transitions. Therefore, ensuring the development of gender inclusive energy policies and interventions to engage women in renewable energy transition processes could ensure successful household renewable energy adoption in Nigeria.

9.2.3.4. Inadequate Energy Supply

The study also found that the inadequate supply of electricity is a key driver of household renewable energy adoption. The centralised nature of the national grid in Nigeria has resulted in widespread electricity shortages affecting both rural and urban households. This persistent grid collapse and undersupply of electricity have resulted in households seeking reliable alternatives, with solar energy emerging as the preferred renewable energy source for most households. However, despite the growing support for renewable energy and solar energy being the most preferred renewable energy sources, the rate of adoption remains slow in Nigeria, suggesting barriers that hinder adoption. The next sections summarise the barriers to renewable energy adoption identified in the study.

9.2.4. Barriers to Household Renewable Energy Adoption

The study revealed three broad categories of barriers: socio-cultural barriers, policy-related barriers, institutional barriers, and political barriers. The barriers are summarised below.

9.2.4.1. Socio-cultural Barriers

The study offers a novel contribution by recognising that household renewable energy adoption is influenced not only by economic and technical considerations but also by socio-cultural factors.

Beyond the economic drivers like fuel availability and price, the study also found that social and cultural factors influence household renewable energy adoption. For example, the study found that due to local cooking practices, some households preferred the use of firewood as cooking fuel despite the benefits of transitional fuels like LPG, electric cookers or even renewable energy options. The study found firewood to be popular among some rural and urban households due to their traditional belief that it enhances the taste of locally made delicacies. This finding suggests that despite the perceived high-income level of urban households, some still revert to traditional fuels like firewood for cultural reasons. This cultural preference for firewood and charcoal makes it challenging to switch to cleaner cooking fuels. For instance, one participant added that.

> *"Let me be honest, food cooked with firewood has this unique taste, especially our local delicacy; even though we use kerosene stoves when it is possible, I still prefer firewood, especially when we travel to the village"* (RP546)

This demonstrates a reverse transition, where cultural preferences disrupt the expected linear progression towards cleaner fuels, as suggested by the Energy Ladder Model. Similar to cultural barriers, the study also found that poverty and low income are barriers to household renewable energy adoption. Households consistently expressed their inability to afford the high initial cost of renewable energy technologies, citing low income as a barrier. Additionally, the study also found low public awareness of renewable energy technology as another barrier. Public awareness of renewable energy technologies remains significantly low across both rural and urban. This indicates a lack of technical knowledge on how these technologies work particularly in rural communities who are often isolated from the national grid.

9.2.4.2. Policy-related Barriers

Regarding policy-related barriers, the study found several factors that challenge the formation and implementation of renewable energy policies in Nigeria. These policy-related barriers identified by the study include a lack of legislative backing and slow policy formation and implementation processes. These policy-related barriers remain major barriers to renewable energy adoption, as most policies have not been enacted into law, making their implementation difficult. For example, polices such as the National Economic Empowerment and Development Strategy (NEEDS) and the Renewable Energy Master Plan (REMP) are still in drafts, hindering their implementation. Furthermore, complex bureaucratic delays and a lack of financing for house-level adoption restrict the progress of policy implementation to support renewable energy adoption.

9.2.4.3. Institutional Barriers

The study found a lack of coordination and overlapping roles as barriers hindering the successful adoption of renewable energy among households. The study uncovered that a lack of clarity among key federal-level agencies remains a core challenge to renewable energy adoption at a household level. For example, the Nigerian National Petroleum Corporation (NNPC), the Federal Ministry of Power and other federal-level agencies, often function in silos with a unified framework. This fragmentation has led to duplication of efforts, policy inconsistencies, and delays in both policy formulation and implementation.

9.2.4.4. Political barriers

Political barriers add additional complexity to the barriers to household renewable energy adoption in Nigeria. The study identified the lack of political will, vandalism, and fragmented political interest as major barriers to renewable energy adoption. It also found that politicians emphasise regional renewable energy projects for political gain rather than supporting national renewable energy initiatives. For example, one interviewee suggested that.

> *"….. the politicians are greedy set of people who are only interested in their own pocket. They're not thinking of how they will benefit the constituency they're representing."* (INV08)

Another key political barrier uncovered by the study was the lack of clear leadership structures in major federal-level regulatory agencies, as one interviewee suggested.

> *"…. Technocrats that are professional in those areas should be put in charge of such agencies and ministries. You cannot put a lawyer to be in charge of the health sector or the engineering sector, and you expect it to work. And that is a problem we're having. The same thing, you cannot put an accounting officer to head a utility or a power utility company. It will not work."* (INV08)

This highlights the broader issues of political gains, politically motivated appointments and a lack of worthy leadership in the country's energy sector.

To address the challenges identified in the study, the study developed a framework for utilising renewable energy in households. The proposed framework is designed to promote household-level adoption of renewable energy sources in Nigeria, with the aim of reducing reliance on finite fossil fuels. It calls for collaborative action between multiple stakeholders, including various levels of government, private sector actors, and households. The framework outlines a multi-level governance approach involving federal, state, local, and household levels, each with defined but interdependent responsibilities in advancing renewable energy integration. A key contribution of the framework is its straightforward assignment of roles for policy design, implementation, and project execution. This clarity is particularly significant, as the study identified poor coordination in policy development as a major barrier to renewable energy adoption. By addressing these governance gaps, the framework supports more coherent and effective strategies for transitioning to cleaner household energy sources across Nigeria.

9.3. Contribution to Knowledge

The study explored the feasibility of using renewable energy in Nigerian households and identified the drivers and barriers to household renewable energy adoption in Nigeria. The study contributes to academic literature, practice, and policy on renewable energy utilisation for households in several notable ways. Firstly, the study presents comprehensive and contextual insights into household energy dynamics in Nigeria, an understudied area in existing literature. Previous studies on Nigeria tend to focus on other sectors or individual energy sources, often overlooking the complexities and dynamics of renewable energy adoption within the residential sector. Additionally, while other studies have focused on broader renewable energy technologies and rural electrification, this study places households as a critical factor in nationwide energy decision-making and transitions in Nigeria.

Secondly, the thesis contributes to the theoretical underpinning by proposing a hybrid governance model for energy transitions at a household level. The study suggests linking top-down policy implementation strategies with bottom-up household engagement. The proposed new framework interconnects policy and practice by integrating not only governmental and private sector roles but also household-level behaviour, gender dynamics and cultural considerations. Thirdly, the study proposes a hybrid communication and feedback model to ensure a responsive and effective policy implementation process. By creating dual feedback channels from household consumers directly to federal government agencies and through local intermediaries, the model could enhance policy responsiveness and effectiveness.

9.4. Theoretical Implications

This study makes a significant theoretical contribution by developing a framework that addresses the feasibility of household renewable energy adoption in Nigeria. It extends existing theories on energy transition by integrating economic, socio-cultural, gender, and institutional dimensions into household energy decision-making. By doing so, it provides a comprehensive understanding of the multifaceted drivers and barriers to renewable energy adoption, particularly in low-income and energy-insecure contexts.

The study also contributes to academic literature by offering a context-specific analysis of household energy behaviour in Nigeria, enriching theoretical discourse on energy poverty and renewable energy transitions in developing countries. Notably, the framework developed in this study provides a novel lens through which future research can examine household-level energy transitions and assess the alignment between policy design and real-world implementation. It emphasises the need for theoretical approaches that consider both systemic and localised barriers, including governance, affordability, and socio-cultural norms.

9.5. Policy Implications

The findings of this study offer vital insights for policy formulation and implementation. It reveals that despite the existence of renewable energy policies in Nigeria, weak legislative backing, fragmented institutional responsibilities, and lack of political will remain major obstacles. Therefore, the study calls for a coherent policy framework that clearly defines stakeholder roles, includes enforceable timelines, and ensures the alignment of national objectives with local realities. The framework proposed by this research highlights the importance of inclusive policy development that engages all energy stakeholders, including government agencies, local authorities, households, and the private sector. Policymakers are encouraged to design adaptive and regionally tailored policies that reflect the diverse energy needs, barriers and drivers of household energy choices and resource availability across Nigeria.

Additionally, the study stresses the relevance of solar energy as a scalable, regionally adaptable solution for Nigerian households. Policymakers are urged to prioritise investments and incentives that support solar energy adoption, particularly through subsidies, financing schemes, and the removal of fossil fuel subsidies that distort market competitiveness.

9.6. Practical Implications

On a practical level, the study identifies several actionable pathways for accelerating household adoption of renewable energy. It emphasises the need to address financial barriers through targeted subsidies, micro-financing schemes, and affordable credit facilities, particularly for low-income households. The findings also underscore the importance of increasing public awareness and technical education on renewable energy technologies, especially in rural communities where knowledge gaps are more prominent. The study introduces cultural barriers as a new category in the practical discourse on renewable energy adoption in Nigeria. It notes that cultural preference for firewood and charcoal makes transitioning to renewable energy challenging for households. Therefore, calling for greater sensitisation of local communities on the benefits of cleaner cooking fuels. As culture can be a catalyst for the transition towards renewable energy. The study also identifies political barriers as major factors hindering the widespread adoption of renewable energy. Suggesting that individual political agendas and regional marginalisation can impede project implementation and community buy-in. Therefore, it calls for greater transparency and decentralisation in project planning and execution, with active local participation and oversight.

Furthermore, Nigeria's heavy dependence on fossil fuels makes its economy vulnerable to price shocks, with direct implications for household energy access and affordability. By transitioning to renewable energy, the country can diversify its energy mix and enhance resilience. The study also highlights the environmental and health costs associated with reliance on fossil fuels, reinforcing the need for cleaner alternatives. Finally, although the study focuses on Nigeria, the insights and framework have broader applicability to other ECOWAS member states and developing countries facing similar energy challenges. The study offers a replicable approach to identifying locally relevant solutions, engaging stakeholders, and promoting inclusive energy transitions at the household level.

9.7. Significance of the Results

Studies investigating the feasibility of household energy adoption of renewable energy have, for decades, mainly adopted a quantitative approach. These studies have paid less attention to other socio-cultural issues that can act as barriers to household energy adoption. Therefore, the significance of the main findings for this research is presented below:

- Renewable energy is possible for Nigerian households due to the country's renewable energy potential.
- Renewable energy can be used for different household activities, ranging from cooking to cleaning and heating.
- The energy challenges in Nigeria present severe living challenges for almost 50% of Nigerians.
- The demand for household energy outweighs the supply and generation capacity in Nigeria.
- The current energy generation capacity does not meet the energy demand of the growing population of Nigeria.
- Public perception greatly favours adopting renewable energy for households, as various literature and the empirical findings of this study affirm.
- The public indicates support for solar energy development and views solar energy as the future of energy development to meet current supply gaps.
- Solar energy is likely to be the most suitable renewable energy resource to be adopted across all parts of Nigeria due to the dispersed nature of solar radiation in the country.
- Wind energy is likely to work in a selected region, as wind speed varies across the different areas in Nigeria.
- Policy inertia and a lack of workable regulatory laws impede the development of renewable energy.
- There are no frameworks in place to speed up the enactment of policies into laws to make policies binding on energy consumers, distributors, and producers.
- A lack of political will prevents the spread of renewable energy projects across regions of the country.

- Renewable energy adoption is halted by a lack of awareness of the benefits and the technical know-how to operate renewable energy systems.

However, based on the extensive literature review and empirical analysis conducted during this research, coupled with significant insights derived from key policy makers in the Nigerian energy sector, resulted in the important contribution provided by this research. The findings and insight derived from both the survey and interview from this research are used to develop a framework to assess the feasibility of utilising renewable energy technologies in Nigerian households.

9.8. Limitations of the Research and Implications for Future Research

The research employed a concurrent mixed-methods approach to investigating the feasibility of renewable utilisation in households, combining both inductive and deductive indicators. Although the study has focused on different regions of Nigeria, further quantitative studies might be needed to ensure higher validity. Therefore, this study recognises that although the approach used provides a basis for a critical investigation into the research aim, it cannot claim to include a rigid statistical assessment of the investigation into the feasibility of renewable energy utilisation in households in Nigeria. Therefore, future research should concentrate on comparative analyses of renewable energy adoption across different cities. Such studies would identify how regional differences influence energy choices, thereby enabling the creation of targeted renewable energy solutions. These tailored strategies could promote wider, more sustainable uptake of renewable technologies within urban contexts, both in Nigeria and other developing regions. Additionally, future research should be directed towards investigating the possibility of other renewable energy sources such as geothermal, tidal and bioenergy.

Furthermore, the research focused on gaining insight into the perception and experiences of energy stakeholders in Nigeria on the energy challenges in the country. Thus, the findings highlight the experience and notions of Nigerian households.

9.9. Summary

Research into the feasibility of renewable energy adoption for households is significant to energy diversification in Nigeria. Therefore, this study examined the barriers to successful adoption and the drivers of household fuel decisions that could facilitate a successful household adoption of renewable energy in Nigeria. Despite Nigeria's abundant natural and renewable energy resources, significant challenges remain, including unreliable electricity supply, inadequate infrastructure, vandalism, and limited access to clean cooking fuels. Approximately 60% of Nigerian households still rely heavily on conventional energy sources, exacerbating environmental and climate-related concerns. This study achieves the aim of the research by articulating the results from the investigation in this chapter and presenting a discussion on how the findings fulfil the research objectives. The various contributions and significance of the study are presented. Afterwards, the limitations and recommendations for future research were outlined.

The study adopted a concurrent mixed-methods approach, gathering quantitative data from household surveys and qualitative insights from key policymakers. Findings indicated several barriers to renewable energy adoption, including financial constraints such as high initial costs, limited financing options, inadequate infrastructure, and insufficient policy support. Despite these challenges, the study revealed increasing household awareness and positive attitudes towards renewable energy, driven by concerns about energy security, rising costs, and environmental sustainability. A significant contribution of this research is the development of a comprehensive understanding of household energy dynamics, including socio-economic, policy-related, and technological factors influencing renewable energy adoption. The proposed framework clearly delineates roles for different governance levels, federal, state, local, and household, emphasising coordinated policy design and implementation. This framework addresses identified policy and implementation gaps, offering practical recommendations to enhance renewable energy adoption among Nigerian households.

Future research should focus on comparative analyses of renewable energy technology adoption between cities, assessing how regional variations can inform targeted and enhanced renewable energy solutions. Such comparative studies would support the development of tailored renewable energy strategies, effectively facilitating broader and more sustainable adoption across urban contexts in Nigeria and similar developing regions.

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Appendix A.

Examples of Cooking with Solid Biomass in Poorly Ventilated Kitchen in Nigeria