# THE EFFECT OF ENERGY MIX ON ENERGY DEFICIT IN 10 MILES IN CHIBOMBO DISTRICT.

**BY**

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A Dissertation submitted to the University of Zambia as a partial fulfillment of the requirement for the award of a Master of Science degree in Environmental and Natural Resources Management

**THE UNIVERSITY OF ZAMBIA**

**LUSAKA**

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## DECLARATION

I, **Rodgers Phiri,** hereby declare that this dissertation is my original work. It has never been submitted wholly or in part at this university or any other university for the award of any academic qualification. All materials, which were incorporated from other sources that are either published or unpublished, were properly acknowledged by means of complete references. I therefore present this dissertation for examination for the award of a Master of Science degree in Environmental and Natural Resources Management to the University of Zambia.

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**(20020078)**

**Date: 16$^{th}$ April, 2024**

## CERTIFICATE OF APPROVAL

This dissertation of Rodgers Phiri has been approved as fulfilling the requirements for the award of Master of Science in Environmental and Natural Resource Management by the University of Zambia.

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# DEDICATION

I dedicate this dissertation to the Almighty God for giving me strength, wisdom and good health throughout my journey in pursuit of this piece of work. In addition, I dedicate this dissertation to the Phiris and everyone who continuously supported and encouraged me.

# ABSTRACT

The study aimed to evaluate how the energy mix impacts the energy deficit, focusing specifically on the accessibility within a 10 Mile radius in the Chibombo district of the Central province. This region, like many parts of Zambia, faced energy deficits due to its reliance on hydroelectricity, which is hampered by drought-induced water shortages (Silimina, 2023). While prior studies, such as Kaela's work in 2018, have projected Zambia's energy mix by 2050, they have not explored its effects on accessibility and availability, creating a research gap. Failure to investigate the energy mix's impact on energy deficit could perpetuate detrimental activities like charcoal production, a major driver of deforestation and forest degradation in Zambia, leading to high carbon emissions and depletion of wood resources.

The objectives of the study included identifying the types of energy used at 10 Miles, determining the drivers behind these choices, and assessing how the energy mix influences the energy deficit in the area.

The study employed a qualitative research approach, focusing on three focus groups comprising 10 households each and 20 key informants from diverse backgrounds such as business houses, village Chiefs, council officials, churches, and schools. Primary data collection utilized interviews and focus group discussions, while secondary data was gathered from libraries, media, and open educational resources. Data analysis involved content analysis for interview data and thematic analysis for focus group discussions.

Findings revealed five primary energy sources at 10 Miles: solar power, hydropower, biomass, Liquefied Petroleum Gas (LPG), and wind power. Despite this variety, access to reliable and affordable energy remains challenging, with traditional biomass dominating with over 50% accessibility rate. Electrification rates in Chibombo district were notably low, with only 6% compared to the national average of 5%. Additionally, clean cooking solutions were scarce, with merely 5% of households having access to LPG, biogas, and improved cook stoves.

Factors that affected energy availability include resources, infrastructure, policies, climate, geography, and technology. Solutions include off-grid renewables, efficiency measures, capacity building, and public-private partnerships to overcome challenges.

The study advises investing in off-grid renewables (solar, wind, hydropower) for remote areas, suggesting mini-grids for community service. Implementing energy-efficient technologies and fostering partnerships with the private sector while providing financial support and training are recommended for sustainability.


**KEY WORDS:** Energy Mix, Energy Deficit, Effect, Energy

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## LIST OF ABBREVIATIONS AND ACRONYMS

| | | |
|---|---|---|
| **BTOE** | - | Billion Tons of Oil Equivalent |
| **ERB** | - | Energy Regulation Board |
| **EU** | - | European Union |
| **FGD** | - | Focus Group Discussion |
| **GDP** | - | Gross Domestic Product |
| **GRZ** | - | Government of the Republic of Zambia |
| **LPG** | - | Liquid Petroleum Gas |
| **METNR** | - | Ministry of Environment, Tourism and Natural Resources |
| **MW** | - | Mega Watts |
| **NASREC** | - | Natural and Applied Sciences Research Ethics Committee |
| **NGO** | - | Non Governmental Organization |
| **PV** | - | Photovoltaic |
| **REA** | - | Rural Electrification Authority |
| **RET** | - | Renewable Energy Technologies |
| **SADC** | - | Southern African Development Commission |
| **TAZAMA** | - | Tanzania Zambia Railway Authority |
| **UNDP** | - | United Nations Development Programme |
| **USAID** | - | United States Agency for International Development |
| **WHO** | - | World Health Organization |
| **ZRA** | - | Zambezi River Authority |

# CHAPTER ONE: INTRODUCTION

## 1.1 Overview

This chapter covers the background of the study, the research problem, the aim of the study, the research objectives, the research questions, the significance of the study and conclusion.

## 1.2 Background of the study

At global level, the collective segment of coal, oil and gas in the energy mix in 2018 was close to 85%, with hydro (6.8%), other renewables (4%) and nuclear (4.4%) struggling far behind (Planet Energies, 2020). In Europe, renewable energies (15.5%) and nuclear (10.3%) are more developed, but fossil fuels remain the dominant energy source (74.2%) (Planet Energies, 2020). Europe leads in renewable energy, with 38% of its energy mix. North America follows with 18%, Asia with 16%, and Africa with 5%, showcasing regional disparities in renewable energy development. While the figures differ essentially starting with one region then onto the next, fossil fuels rule the energy mix at the worldwide level, representing more than 80% of the aggregate (Planet Energies, 2020).

Africa has undergone rapid economic and population growth in 21st century, with an equivalent increase in the demand for energy. Keeping pace with rising energy needs is at the top of the agenda for policy makers such as Zambia’s Ministry of Energy (Ministry of Energy, 2019), to enable economic growth and extend access to modern energy to those lacking it now. In Africa, increasing energy demands pose significant challenges as supply struggles to keep pace. For instance, rapid urbanization and industrial growth lead to heightened electricity requirements, exacerbating issues of power shortages and hindering economic development. In as many as 30 countries in Africa recurrent electricity outages and load shedding are the norm (Azizalraman & Hasyimi, 2019).

Africa's current energy needs are met through a mix of biomass and fossil fuels (Azizalraman & Hasyimi, 2019). Biomass accounts for approximately 50% of Africa's total primary energy supply (Azizalraman & Hasyimi, 2019). Coal and natural gas account for about 14% each, and oil approximately 21%. Hydropower represents about 1% of the total primary energy supply in Africa (Azizalraman & Hasyimi, 2019). Zambia on the other hand, is potentially self-sufficient in sources of electricity, coal, biomass and renewable energy (Ministry of Energy, 2019). The only energy source where the country is not self-sufficient is petroleum energy (Ministry of Energy, 2019). Zambia is confronted with an increasing energy demand, resulting from demographic and socioeconomic factors, at an average of 6% or 150-200 MW each year (Ministry of Energy, 2019).

In terms of policy guideline, the Energy sector in Zambia comprises both public and private actors (Ministry of Energy, 2019). The Ministry of Energy supervises the following statutory bodies: Energy Regulation Board (ERB); Zambezi River Authority (ZRA); and Rural Electrification Authority (REA) (Mwape, 2015). The Ministry also provides guidance to the following State-owned enterprises: Indeni Petroleum Refinery Company Limited; Tanzania Zambia Mafuta pipelines Limited (TAZAMA); and ZESCO Limited (Mwape, 2015).

Energy mix refers to a blend of various essential energy sources from which auxiliary energy for direct use like electricity is produced (Planet Energies, 2020). Energy mix alludes to all direct sources of energy such as coal, cow dung, fire wood, solar, hydropower and wind energy, so it is not be mistaken for power generation mix, which alludes to generation of electricity (Planet Energies, 2020).

Clean cooking solutions are initiatives and technologies designed to address the challenges associated with traditional cooking methods, predominantly reliant on solid fuels like wood and charcoal (Khambalkar, Kathede, Dahatonde, & Korp, 2010). These solutions aim to improve indoor air quality, reduce deforestation, and alleviate health risks posed by indoor air pollution. In the Zambian context, clean cooking solutions may include the adoption of cleaner-burning stoves, promotion of renewable energy sources such as biogas and solar cookers, and implementation of improved ventilation systems in households. By embracing these initiatives, Zambia may enhance environmental sustainability, public health, and socioeconomic development.

To meet its energy needs, every nation utilizes the sorts of energy accessible to it, in varying extents (Mudenda, Makashini, Malama, & Abanda, 2018). This is what is referred to as energy mix.

Zambia largely depends on hydroelectricity but hydropower has a fatal flaw. Drought has lowered water levels to the point where power production is severely curtailed. Droughts in recent years have contributed to electricity shortages estimated at nearly one-third of Zambia's total installed hydroelectric capacity of 2,380 megawatts (Silimina, 2023). Zambia's reliance on hydroelectricity presents challenges like susceptibility to climate variability, droughts, and fluctuating water levels, leading to power shortages and hindering economic development and stability.

According to Silimina (2023), water levels in the Kariba Dam in 2019 plunged to their lowest level since 1996, falling to 10 percent of the normal level. Late 2022, the level of usable water in Kariba, tapped by both Zambia and Zimbabwe, stood at 2.68 percent of the normal.

To the knowledge of the researcher, scanty information is available on the effect of energy mix on energy deficit at 10 Miles.

Chibombo is a district in Zambia's Central Province, with 10 Miles located 78km south of Chibombo town and 17km from Lusaka. This area, with an elevation between 3828ft and 3880ft, hosts a diverse population of approximately 172,372, experiencing rapid growth and residential expansion. The local economy thrives on both formal and informal employment, with notable activities in agriculture, small businesses, and services. Chosen for its energy deficit amidst development, 10 Miles presents a unique case for studying the impact of energy mix on such deficits. The settlement's history dates back to the 1980s, initially established as a farm zone, now evolving into a densely populated area with varied socio-economic dynamics.

### 1.3 Statement of the Problem

Zambia is over-dependent on hydro energy, a fuel source that is subject to the unpredictability of the weather. According to the United States Agency for International Development (USAID), the country draws 85% of its power from hydro projects. The study area (10 Miles) has been facing energy deficit to support their day to day activities. This includes the challenge of energy accessibility.

Energy deficit occurs when demand surpasses available supply, impeding activities reliant on energy. This imbalance can result from resource scarcity, infrastructure limitations, or inefficient distribution systems, impacting various sectors including transportation, industry, and households (Super, 2012).

Previous studies such as the one conducted by Kaela (2018) predicted the levels of energy mix in Zambia by the year 2050, but did not discuss the effect of energy mix on energy deficit in the study area, the problem this study assessed. In Kaela's (2018) study, predictions were regarding the composition of Zambia's energy mix up to the year 2050, but it lacked a thorough examination of how this predicted energy mix might influence the prevailing issue of energy deficit within the study area.

If the effect of energy mix on energy deficit in the study area is not systematically studied, depletion of forest resources would persist and accelerate climate change negative effects which may include desertification, soil erosion, poor crop yield, drought, flooding and increased greenhouse gases in the atmosphere.

The energy deficit exacerbates climate change impacts through various mechanisms. Inadequate energy resources drive deforestation for fuel, thereby contributing to desertification. Additionally, substandard irrigation systems are implicated in soil erosion and decreased crop yield, exacerbating food insecurity. Furthermore, the reliance on fossil fuels amplifies greenhouse gas emissions, underscoring the imperative for comprehensive scholarly inquiry into energy mix optimization.

## 1.4 Aim of the Study

The aim of the study is to determine the effect of energy mix on energy deficit at 10 Miles of Chibombo district.

## 1.5 Objectives of the Study

This study is anchored on the following specific objectives:

i. To describe the types of energy used at 10 Miles.
ii. To establish the drivers of the types of energy used at 10 Miles.
iii. To explore the effects of energy mix on energy deficit at 10 Miles.

## 1.6 Research Questions

1. What type of energy sources are used at 10 Miles?
2. How available are the energy sources at 10 Miles?
3. How accessible is the available energy at 10 Miles?
4. What drives the choice of energy use at 10 Miles?
5. What are the socio-economic drivers of energy use at 10 Miles?
6. What is the effect of energy mix on energy deficit at 10 Miles?

## 1.7 Significance of the study

As far as the researcher is concerned, there was scanty knowledge on the effect of energy mix on energy deficit at 10 Miles. The findings of this study may broaden knowledge on the most available sources of energy at 10 Miles to be accessed by residents. The findings may further provide information on the effects of energy mix on energy deficit for the 10 miles residents to enhance their everyday activities. The research findings may also provide information on people's attitudes towards energy mix, which might assist the Ministry of Energy to successfully devise a management plan for the area. The study findings may also provide information on the clean and unclean energy sources at 10 Miles which may be useful in natural resource management. The residents of 10 Miles may also have knowledge on the types of energy that exist in their area and their effect on energy deficit. This study's significance lies in understanding energy dynamics at 10 Miles: types and availability of energy sources, accessibility, factors driving energy choice, socio-economic influences, and the impact of energy mix on energy deficit.

### 1.8 Organization Structure of the Dissertation

The dissertation is structured into seven chapters as outlined below:

Chapter One introduces the background, research problem, aim, objectives, and significance of the research.

Chapter Two reviews relevant literature, identifying key debates and notable gaps.

Chapter Three describes the study area and justifies its selection.

Chapter Four outlines the methodology, explaining the rationale for using the case study method and discussing data collection methods.

Chapter Five presents the study's findings.

Chapter Six discusses the findings in detail.

Chapter Seven concludes the dissertation and offers recommendations, proposing future directions for mitigating energy deficit through optimized energy mix.

# CHAPTER TWO: LITERATURE REVIEW

## 2.1 Overview

This chapter reviews the literature relevant to the effect of energy mix on energy deficit. It provides the theoretical debates that surround the current study. The chapter consists of seven sections namely: influence of education on energy mix, description of energy mixes at global and Zambia level, determinants of the drivers of types of energy use, the effect of energy mix on energy deficit, evaluation of constraints in accessing energy, energy consumption and availability in Zambia and theoretical framework. Finally, in the last section, a conclusion is presented.

## 2.2 Influence of education on energy mix.

Education is a potent catalyst for change, and its role in shaping the energy value chain has grown increasingly significant (Smith, Johnson, & Brown, Renewable Energy Sources, 2020). As the world grapples with the challenges of climate change and the need for sustainable development, education emerges as a critical driver for transforming the energy sector.

By providing people with knowledge, skills, and awareness, education plays a multifaceted role in advancing the energy value chain, spanning from production and distribution to consumption and conservation (Johnson, Smith, & Brown, 2021). People are at the core of every stage of the energy value chain, from those initiating the chain to those consuming the final product, making them pivotal in every step and aspect of energy chain development.

In terms of governance, education plays a crucial role in shaping energy policy and governance frameworks. Informed citizens who comprehend the social, economic, and environmental implications of various energy choices can actively participate in policy discussions and advocate for sustainable energy solutions (Thiede, Thoben, & Denkena, 2018). Education can act as a facilitator, fostering dialogues among policymakers, scientists, and communities, thus aiding the development of forward-thinking energy policies.

To bolster the development of sustainable energy value chains, educational institutions and research centers can drive innovation in the sector. Through academic programs, research projects, and collaborations, education inspires research and development efforts that can lead to breakthroughs in energy technologies, efficiency enhancements, and clean energy solutions (Kacan, 2015). By encouraging critical thinking and problem-solving skills, education nurtures the next generation of energy innovators who propel progress along the value chain.

In addition to technological advancements, individuals already involved in the energy sector can use education to enhance their technical expertise and practical skills required for energy-related professions (Thiede, Thoben, & Denkena, 2018). Engineers, technicians, scientists, and policymakers can become better prepared to address the intricate challenges of the energy sector. By investing in education and training, countries can cultivate a competent population capable of driving the energy mix forward.

Education possesses the power to transform an uninformed individual into a responsible energy consumer. By imparting knowledge about energy conservation, efficiency, and the potential of renewable resources, education encourages sustainable energy consumption practices (Rebar, Gardner, & Rhodes, 2019). Whether in classrooms, households, or communities, individuals can apply their knowledge to reduce energy wastage and mixes, make energy-efficient choices, and embrace renewable energy technologies. Consumer awareness and behavior play a vital role in stimulating market demand for clean energy solutions, thereby influencing the entire value chain.

As the energy industry continues to evolve, education stands as a powerful tool in shaping a resilient, inclusive, and sustainable energy value chain (Smith, Johnson, & Brown, Renewable Energy Sources, 2020). Governments, organizations, and communities must invest in education to ensure a knowledgeable and empowered society capable of collectively addressing the challenges and opportunities of the evolving energy landscape.

Linking education to local communities for mutual benefit involves aligning programs with both local needs and national energy goals. By incorporating local energy issues and opportunities into curricula, fostering partnerships with local industries for practical training, and emphasizing skills crucial for the transition to sustainable energy sources, such education empowers individuals with employability while driving forward national objectives in energy independence, innovation, and sustainability, thus harmonizing local development with broader national progress (Wiek, Withycombe, & Redman, 2011).

Zambia's energy infrastructure is facing challenges, marked by frequent power shortages (Agency I. E., 2021). Despite abundant hydroelectric potential, insufficient investment and aging infrastructure hinder energy production. While resources exist, funding limitations constrain capacity expansion. Chibombo, a district in Central Province, mirrors national energy dilemmas. Insufficient infrastructure and investment pose significant challenges for Chibombo and the country at large. Addressing these issues is vital to meeting Zambia's energy demand and overcoming obstacles faced by districts like Chibombo

### 2.3 Description of energy mix at global and Zambian levels.

Energy mix undoubtedly constitutes one of the basic factors of economic development for global development (Agency I. E., 2021). Europe is increasingly dependent on oil and gas imports, with a constantly growing demand for these raw materials. The problem is the lack of diversification of energy sources, as well as the issue of security of its supply, directly related to the dimension of European Union (EU) member activities (Agency I. E., 2021). At the same time, there is a need for member states to build competitive internal energy markets and increase energy efficiency, thereby prioritizing energy mix.

The problem of low usage of modern forms of energy and widespread dependence is one that is not peculiar to Zambia alone but is a developing country phenomenon (Masini & Menichetti, 2012). Sub-Saharan Africa is said to be the most energy-poor region on the planet with electrification rates which are much lower than the rest of the developing world (Smith, Johnson, & Brown, 2020). About 80% of the population in this region still depends on traditional biomass, with the main indicator for this trend being the number of households where biomass is the main fuel for cooking (Smith, Johnson, & Brown, 2020). It is interesting to note that biomass itself is a source of renewable energy if used efficiently and sustainably. However, it is often harvested unsustainably (woodlands, in particular) and used inefficiently (Khambalkar, Kathede, Dahatonde, & Korp, 2010), resulting in faster rates of forest depletion than regeneration. This source of energy has been overexploited in Zambia to levels where even the rainfall pattern has been affected. Marked degradation of forests and woodlands surrounding major cities such as Lusaka has been observed (Atteridge, 2013), which signifies a positive correlation between urban energy demand and excessive harvesting of wood for charcoal production.

Lanre (2013) stated that many countries are making conscious efforts in becoming more energy independent and sustainable. In achieving this, all energy options are being considered and in the past ten years, renewable energy sources have been the most prominent. The rationale for any country seeking to be energy independent is clear; to reduce exposure to unreliable energy imports and attain a state of energy security. Africa's energy climate has been perpetually described as appalling. The continent's progress of energy development has varied widely for several years. Very few countries have recorded significant successes while most have stagnated or deteriorated. This has been attributed majorly to lack of policy implementation, incompetent human capital and corruption. Lanre (2013) left a knowledge gap by not including the existing energy options and why countries choose these options.

Kaela's (2018) works revealed the energy mix levels of Zambia by the year 2050, but did not discuss the effect of energy mix on energy deficit in the study area. This research study assessed the effect and accessibility of energy mix at 10 Miles of Chibombo district, as well as the types of energy that exist.

Group (2015) in their study outlined site suitability for solar usage in Zambia due to high sunshine levels between May and September. The knowledge gap left by this study is that the modeling did not state the effectiveness of solar energy in solving energy deficit in Zambia.

## 2.4 Determinants of the drivers of types of energy use.

### 2.4.1 Consumer Preferences

Drivers for energy starts with the various decisions consumers make in their daily lives. These inclinations can move as new innovation empowers choices that better address a consumer's energy needs, for example, lower energy expenses and lower emanations (Mbewe & Ng'ombe, 2020). Consumer inclinations can be changed after some time by strategies that boost decisions, like a carbon tax that encourages lower carbon electricity supply (Mbewe & Ng'ombe, 2020).

### 2.4.2 Policy

Changes in policy can stimulate new innovation and impact consumer decisions (Banda & Bass, 2014). For instance, approaches can energize reception of new innovation (free importation of solar products or debilitate the utilization of a current innovation (limitations on coal based power). On the other hand, approach not empowered by aggressive innovation or not lined up with shopper inclinations can be hard to execute on the grounds that it is difficult to command something that isn't superior to current choices according to the consumer (Banda & Bass, 2014).

### 2.4.3 Technology

Conveying new innovation permits society to accomplish more with less. Best advancements regularly have the supporting approach and business systems to accomplish scale (Agency Z. D., 2014). An approach, similar to burden motivating forces, can prod improvement of new innovation, yet these advancements eventually need to contend without sponsorships to arrive at an enormous enough scale to affect worldwide business sectors (Miciula & Miciula, 2014). Customer inclinations can likewise make a "pull impact" that expands request in the commercial center for new advances.

### 2.5 The effect of energy mix on energy deficit.

The energy mix is more efficient especially in the energy extraction process, less energy is consumed and the negative effects caused by pollution reduce due to the greater weight of renewables and natural gas, at the expense of coal, which is less efficient and more polluting (Roula , 2016). Energy efficiency due to energy mix may bring various economic benefits, such as savings on energy bills for consumers, although it also reduces production in some economic sectors such as dairy companies (Roula , 2016). Nevertheless, the net result is expected to be positive (Roula , 2016). For example, according to estimates by Roula-Inglesi Lotz (2016), an increase in the share of renewables in the energy mix at the global level generates a positive impact on Gross Domestic Product (GDP) growth of 0.089%.

### 2.6 Evaluation of constraints in accessing energy.

The prevailing focus on industry, transport, and household energy issues has obscured the fact that most people in developing countries continue to rely on traditional biofuels, such as wood, crop residues, and animal dung (Winkler, Holzheid, & Taffese, 2019). In fact, one third of all energy consumed in developing countries derives from biofuels (Winkler, Holzheid, & Taffese, 2019). Two billion people remain dependent on biofuels for cooking and equal number lack electricity. Annual biofuels consumption in developing countries exceeds 1 billion tons of oil equivalent (BTOE), which is more than three times the amount provided by coal in Europe (0.28 BTOE) and twice that provided by coal in the United States (0.47 BTOE) or China (0.5 BTOE) (Winkler, Holzheid, & Taffese, 2019).

Developing countries are facing two crucial and related problems in the energy sector (Smith, Johnson, & Brown, 2020). The first is the widespread inefficient production and use of traditional energy sources, such as fuel wood and agricultural residues, which pose economic, environmental, and health threats. The second is the highly uneven distribution and use of modern energy sources, such as electricity, petroleum products, and liquefied or compressed natural gas, which raise important issues of economics, equity, and quality of life. Simply expanding supplies of modern energy will not solve the problems in practice, because even under the most optimistic growth scenarios, many rural and urban poor people in the developing world are likely to depend for the next 20–30 years on traditional fuels produced in rural areas (Winkler, Holzheid, & Taffese, 2019). Hence, an energy strategy for the developing world should be designed to make production and use of traditional energy more sustainable and efficient while expanding and accelerating a broader social transition to clean and efficient use of modern fuels (Smith, Johnson, & Brown, 2020).

### 2.7 Energy Consumption and Availability in Zambia

Main fuel source in the country's power sector has been developing at a normal rate of around 3% per annum essentially because of the expanded financial action in the country particularly in the farming, assembling and mining areas, just as expanded economic activity in the surrounding countries (Agency Z. D., 2014). Besides the nation's developing economy has similarly lead to an expansion in the interest for different types of energy like petrol and coal, as these are key components of production and operations in most financial areas (Banda & Bass, 2014). The interest for sustainable power sources has similarly seen critical development in the new years as the market investigates alternative sources of energy, with sustainable power sources ending up being a feasible other option (Banda & Bass, 2014). The chart below outlines energy consumption by sector in Zambia.

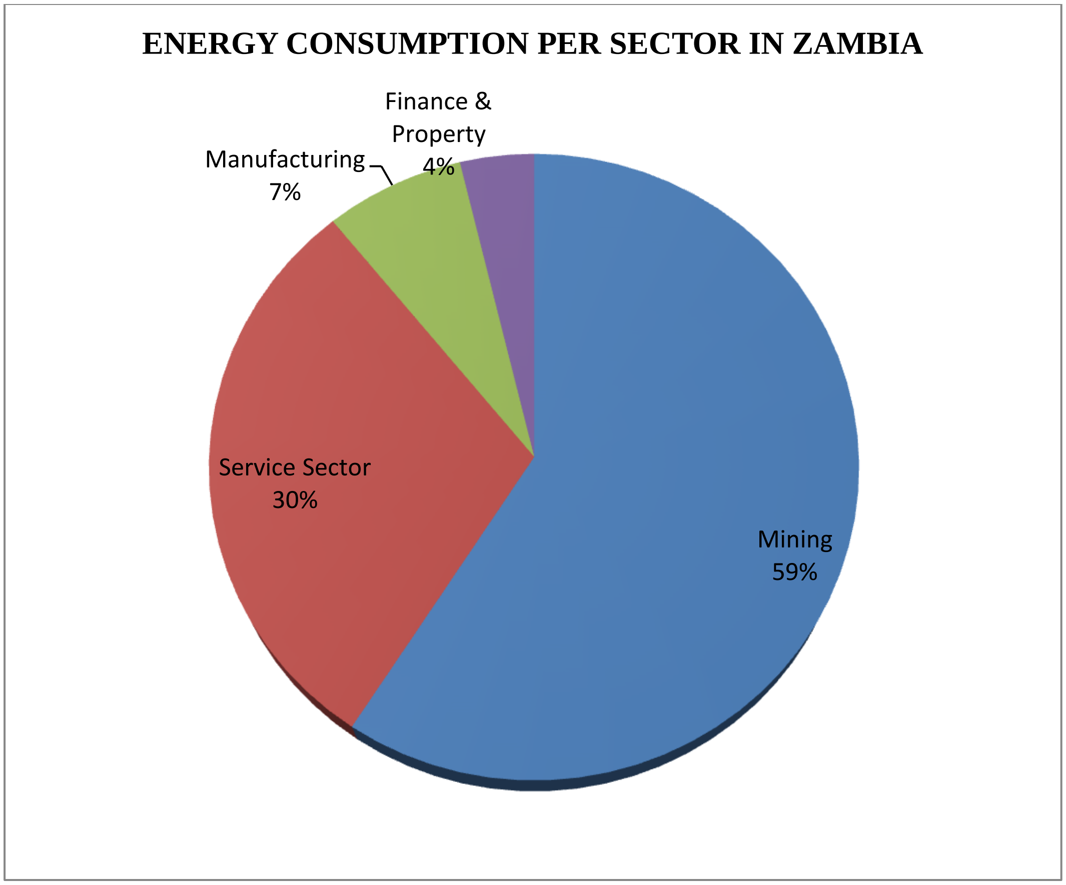


**Figure 1: Energy Consumption in Zambia**
Source: Band & Bass (2014)

Renewable energies provide attractive environmentally sound technology options for Africa and Zambia's electricity industry. Common Renewable Energy Technologies (RET) options for providing energy include wind energy primarily for pumping water; biomass for cooking, solar Photovoltaic (PV) systems which convert sunlight into electricity and small-scale hydropower plants which generate electricity (Watson, 2010). At household level, energy is required for lighting, cooking, heating of water and space conditioning, as well as powering appliances. RETs in Zambia available on the market include solar water geysers, solar lights, solar cookers, improved cook stoves, hot bags and water pumps (REN21, 2015). The Southern African Development Commission (SADC) Renewable Energy and Energy Efficiency Status Report of 2015 (REN21, 2015) shows that although the SADC region is faced with challenges such as energy access, many of the country members are making strides in the adoption of Renewable Energy Technologies.

In addition, The Energy Regulation Board (ERB) in Zambia waived duty and fees for solar products to encourage more investors to enter the energy sector and help reduce the power deficit (Phiri, 2015). ERB Northern Region Manager Allen Polito said "*the move is aimed at increasing the capacity of private companies to contribute to the production and supply of energy in the country*".

The study will review the effect of energy mix on energy deficit at 10 Miles of Chibombo district, find out the determinants of the drivers of energy use and evaluates the constraint to accessing energy. The existing knowledge gap is that the effect of energy mix on energy deficit at 10 Miles is not known.

## 2.8 Theoretical framework

Theoretical framework is defined as a blueprint for a research study which serves as the guide upon which the study is built and supported (Ng'ang'a & Kamau, 2020). It provides the structure which defines how a researcher will philosophically, epistemologically, methodologically and analytically approach the whole study. It is a structure that guides research by relying on a formal theory (Bookchin, 2015).

Theories are very important in research because they provide a way towards tackling the research study undertaken (Braun, 2019). This study is anchored on social practice theory.

It argues that people participate in multiple and variable social contexts. Participation is neither constant nor bound to a particular place: people "participate for longer or shorter stretches of time, on a regular or occasional basis and for various reasons in several contexts" (Mwale, 2021).

From the standpoint of social practice theory, the complexity and diversity of practices in which people participate is not necessarily a burden but is an enriching aspect of life. By moving across settings of social practice, people are able to pursue diverse concerns and become aware of new possibilities for action and arrangements for participation in practice (Nemirovsky, Rasmussen, & Gozalez, 2020).

In addition, they are confronted with dilemmas and contradictions that motivate change and learning (Engestrom & Sannino, 2010). People learn by adjusting their contributions to activities to one another and to fit the demands and structures of local institutions (Nemirovsky, Rasmussen, & Gozalez, 2020). People also learn by inventing new ways to participate in practice, molding it into new cultural forms through our participation (Engestrom & Sannino, 2010).

This theoretical approach entails two core normative claims which are; “practices” and “learning” (Deneulin & McGregor, 2010). On the first claim; it entails that people participate in various “practices” which are initiated by society and institutions, in this case energy use practices. On the second claim, it entails that learning is a very important component in the survival of society, people are capable of learning other means of living to make their lives more sustainable (Deneulin & McGregor, 2010). Under the current study, it entails people are involved in practices as initiated by the society and institutions. It also entails that people are able to learn new possibilities to make their lives and society sustainable.

Social Practice Theory views behavior as embedded within broader social practices. In 10 Miles, examining energy practices through this lens elucidated how daily routines and societal norms influenced energy consumption patterns. Understanding these dynamics revealed how the energy mix affects energy deficit. By considering the community's energy practices, such as cooking methods or transportation choices, the researcher identified how the composition of energy sources impacts overall energy availability and usage in 10 Miles of Chibombo district.

Social practice theory was relevant to this study in exploring energy practices at 10 Miles. This approach helped in understanding how energy mix is impacting the lives of the people at the household level and the community at large in terms of expanding their energy choices and the way it has helped them to live the kind of life they want to live.

### 2.9 Chapter Summary

This chapter has reviewed existing literature fundamental to this study by identifying gaps and has used the objectives as a framework for conducting the review thereby putting the research problem in context. The chapter has further reviewed the effect of energy mix on energy deficit from the global level to Zambian Level. It has also presented the objectives of the study in relation to the existing literature.

# CHAPTER THREE: DESCRIPTION OF THE STUDY AREA

## 3.1 Overview

This chapter describes the study area. It consists of six sections namely: the location of the study area, history of the study area, the justification of the choice of the study area, the population and socio-economic characteristics of 10 Miles respectively. Section six presents the conclusion of the chapter.

## 3.2 Location of the study area

Chibombo is a District in the Central Province of Zambia, and is the headquarters of Chibombo District. The district lies near the Lukanga Swamp (Derman, Chitindi, & Murisa, 2020). It is bordered by Lusaka on the South and by Kabwe on the North boundary. The study area (10 Miles) is located 78km South of Chibombo town and 17Km from Lusaka central business. The elevation of 10 Miles is between 3828ft and 3880ft (Google earth) and has a population approximated to around 172, 372 (Derman, Chitindi, & Murisa, 2020).

## 3.3 Socio-economic Activities

The majority of people at 10 Miles are in both informal and formal employment. The informal sector provides sufficient space for the largest number of economically viable people in the settlement. Also, these people raise their income through different economic activities as evident by several small and household businesses along footpaths, Great North Road and Mungule Road. These economic ventures include, among others, bricklaying, welding, carpentry, saloons, barber shops, groceries, cattle rearing, welding, charcoal, and plastic bag selling, scrap metal gathering, house and shop rentals and Gardening. The formal sector accommodates mainly a small number of people who work for public and private institutions. The private sector accounts for the largest number of employees who are working in the farm blocks doing different jobs, including selling in shops, and others are domestic workers. While the public sector includes personnel such as teachers, nurses, security guards, drivers, policemen and women, clerks, and others who draw their income from their monthly salaries and wages.

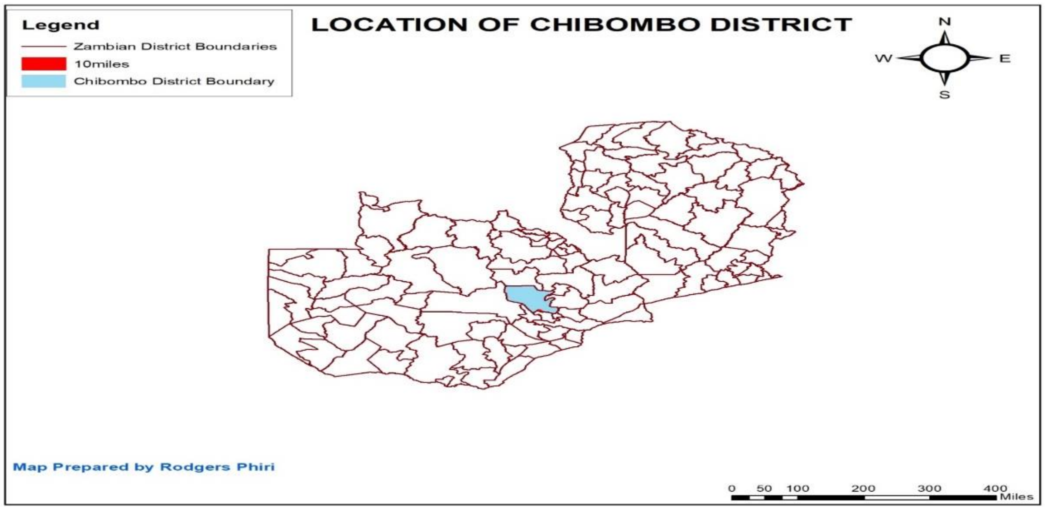


**Figure 2: Location of Chibombo District**
**Source: Author, 2023.**

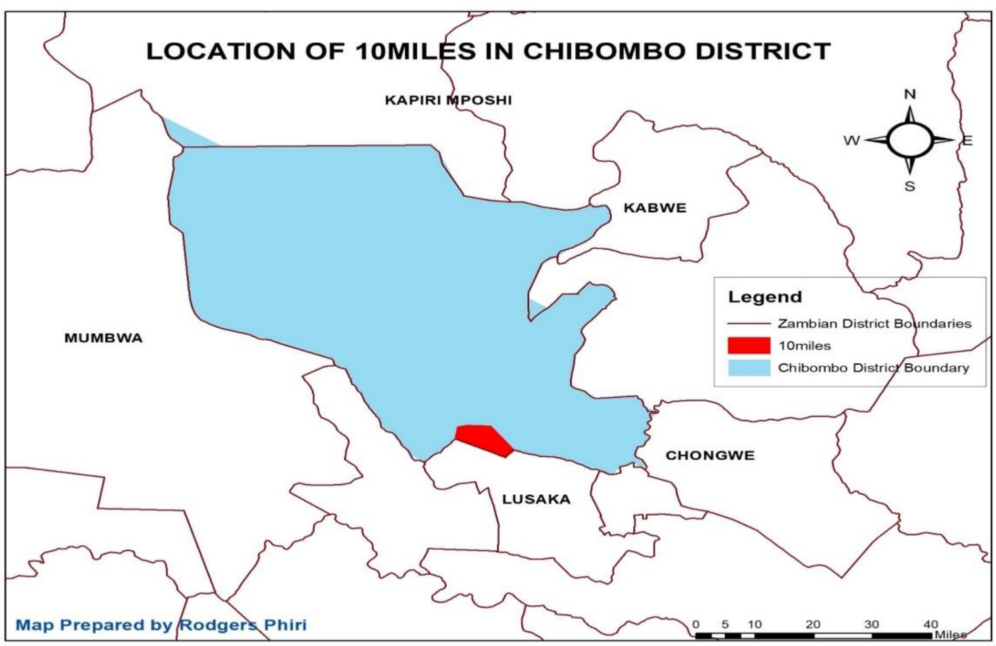


**Figure 3: Location of 10 Miles in Chibombo District**
**Source: Author, 2023.**

### 3.4 Justification for the Choice of the Study Area

Ten (10) Miles was selected as a study site because of its reported cases of energy deficit. The area is more of a medium developed area and is characterized by massive charcoal production, servicing most parts of Lusaka. The area has experienced residential expansion in the past 10 years and is now considered a medium developed area in terms of modern houses. In addition, its population shows a wide range of diversity in terms of socio-economic and demographic characteristics making it desirable to study the effect of energy mix on energy deficit. Some people have lived in the area for decades and have experienced energy demand every year of their life at 10 Miles. Thus, 10 Miles is a unique case worthy of a study on the effect of energy mix on energy deficit.

### 3.5 History of 10 Miles

Ten (10) Miles is one of the oldest settlements in Chibombo and was established in the early 1980s as a farm zone area. In the 2000s, the farm owners started subdividing the farm to make residential plots. The name 10 Miles was derived from the distance from Kabwe roundabout to 10 miles area (Council, 2018). The area has witnessed an increase in residential areas and now classified as a high developing area. Due to the affordability of residential plots which are sold in the area, the area has witnessed an increase in its population.

### 3.6 Population of the Study Area

Ten (10) Miles area is a formal settlement as recognised by the Ministry of Local Government and Rural Development and Chibombo town council. Chibombo district has a population of about 421, 315 (Office, 2022).The study area (10 Miles) has a population of about 172, 372 (Office, 2022), and this population comprises of 96, 186 males and 76, 186 females. The population of the area has greatly increased compared to the 2010 population which was recorded at 93, 765 (Office, 2022).

The average household size was 5.5, with the average size of families headed by women being 4.8 and 5.8 for families headed by men. The unemployment rate was 12.70%. The total fertility rate was 6.3, the complete birth rate was 6.1, the crude birth rate was 36.0, the child–woman ratio at birth was 785, the general fertility rate was 156, the gross reproduction rate was 2.5, and the net reproduction rate was 1.8 (Office, 2022). The labour force constituted 52.20% of the total population. Out of the labour force, 62.7% were men and 42.2% were women. The annual growth rate of the labour force was 2.2%.

### 3.7 Chapter Summary

This chapter presented details of the study area, beginning with a precise geographical delineation. It then delves into the diverse array of socio-economic activities that define the region, describing its economic and cultural activities. We provide a compelling rationale for selecting the study area, elucidating the research gaps it addresses and its broader significance. Additionally, the chapter described the history of the study area and provided up to population statistics.

# CHAPTER FOUR: METHODOLOGY

## 4.1 Overview

This chapter presents the research methodology. It covers the philosophical basis of the study, the sampling techniques, data collection methods, data analysis methods and trustworthiness of the research, limitations and delimitations encountered during the study. It also covers the research ethics and a conclusion.

## 4.2 Philosophical basis

### 4.2.1 Ontological and epistemology

This study is anchored on ontology and epistemology philosophical orientations. Ontology orientation refers to what sort of things exist in the social world and assumptions about the form and nature of that social reality (Moon & Blackman, 2014). Epistemology is concerned with the nature of knowledge and ways of knowing and learning about social reality.

The researcher adopted the realist ontological position which was applied to ascertain the sort of energy mix that exists at 10 Miles. This philosophical position guided the researcher to restrict the study to types of clean energy sources which are used at 10 Miles, drivers of choice of energy use at 10 miles and the effect of energy mix at 10 Miles.

The researcher's decision to focus on specific types of clean energy sources, drivers of choice of energy use, and the effect of energy mix at 10 Miles suggests a belief in an objective reality that exists independently of individual perceptions. By focusing on these specific aspects of clean energy use and their impacts at 10 Miles, the researcher was seeking to uncover underlying structures and mechanisms that shape energy behavior and its impact in the real world.

Objective Epistemological position was adopted by the researcher and was used to know people’s attitudes and constraints towards clean energy as they predicted how much they knew about clean energy. This philosophical position is useful in providing reliability (consistency of results obtained) and external validity which enables applicability of the study results to other contexts.

Realist ontology ensured a grounded investigation into objectively existing energy dynamics, focusing on tangible factors like clean energy sources, driving forces, and their impact at 10 Miles, enhancing empirical consistency and validity. An objective epistemological stance ensured reliable assessment of attitudes toward clean energy, enhancing consistency and external validity, facilitating broader application of study findings across varied contexts with confidence in their generalizability.

### 4.2.2 Target Population

A population is a group of individuals, objects or items from which samples are taken for measurement (Denscombe, 2019). The target population for this study comprised of households, churches, schools, business houses, council officials and head of villages at 10 Miles.  The total population of 10 Miles is about 172, 372 (Office, 2022).

#### 4.2.2.1 Research Approach

The study adopted a qualitative research approach because most of it were narratives from the participants. The research approach was influenced by the aim of getting the beliefs and understanding of the effect of energy mix on energy deficit at 10 Miles. Creswell (2009) emphasized the importance of indicating the research approach as an effective strategy to increase the validity of social research.

The qualitative research approach has been explained by a number of different authors which include Creswell (2017); Vcki & Nataliya (2016) and Creswell (2018). They explained that the key criteria for qualitative research design are  the activities of collecting and analyzing data, developing and modifying theory, elaborating or refocusing the research question, and identifying and dealing with validity threats are usually going on less simultaneously, each influencing all of the others.

Delgado-Romero, Singh and De Los Santos (2018) demonstrated that qualitative research is open and interactive and observation precedes theory whereas quantitative research is structured and theory precedes observation.

Burch & Heinrich (2016) and Bickman & Rog (2020) added the interactivity to these features of qualitative research. The researcher used qualitative approach because of the nature of data needed, also rich and deep to be able to accommodate the researcher's aim. This richness of information is necessary to identify the current energy.

### 4.2.3 Research Design

The research design used in this research was case study. This design was chosen for its use of multiple data collection methods, as highlighted by Hamel, Dufour, and Fortin (2018), which facilitated an in-depth study of the effect of energy mix on energy deficit at 10 Miles in Chibombo District. The selection of this research design was driven by the nature of the research objectives and ultimately by what the research was aiming to achieve. According to Yin (2019), the advantage of the case study approach is that it embodies data collection and data analysis strategies that can cope with the problem of analyzing a complex social phenomenon within its real-life context where the boundaries between the phenomenon and context are not always clear. These data collection methods include the use of multiple methods of data collection such as interviews, focus groups, document reviews, archival records, and direct and participant observations to triangulate findings and provide for detailed descriptions of the phenomena under study (Yin & Merriam, 2018).

The objective of a case study is to do intensive research on a specific case (Alasuutari, 2010). In this study, energy mix of 10 Miles was studied intensively to ascertain the opportunities of meeting the energy deficit been experienced in the area. There are a number of advantages in using case studies.

This study used qualitative research approach which complemented each other with the chosen research design. Croswell (2018 ) cautions researchers not to confuse case studies with qualitative research; he also notes that case studies can be based entirely on quantitative evidence. The detailed qualitative accounts often produced in case studies not only help to explore or describe the data in real-life environment, but also help to explain the complexities of real life situations which may not be captured through experimental or survey research (Han & Anderson, 2017). A case study of energy mix at 10 Miles, for instance, gave access to not only the numerical information concerning the types of energy used, but also the reasons for using each type, and how the energy types were used in relation to other types (Macalister & Nation, 2016).

Despite numerous advantages, case study design has disadvantages which include the following: Its reliance on a solitary case exploration makes it hard to arrive at a summing up resolution (Ng'ang'a & Kamau, 2020). Yin (2019) considered case technique 'microscopic' as a result of the restricted examining cases. Case studies can be extremely time-consuming. Collecting detailed information and conducting in-depth analysis of a single case or a few cases can take a significant amount of time and resources (Yin & Merriam, 2018). Additionally, conducting a comprehensive case study can require substantial resources, including time, money, and expertise Croswell (2018 ).

### 4.3 Sampling Techniques

Sampling involves a process of selecting a sub-section of a population that represents the entire population in order to obtain information regarding the phenomenon of interest. A sample is a sub-section of the population, which is selected to participate in a study. There are two methods of sampling, one yields probability samples in which the probability of selection of each participant is assured. The other yields non-probability samples in which the probability of selection is unknown (Polit & Beck, 2017). In this study, purposive sampling and convenient sampling techniques were implored.

### 4.3.1 Purposive Sampling

Purposive sampling, also known as judgmental or selective sampling, is a type of non-likelihood sampling technique where the units that are investigated are based on the judgment of the researcher (Booth, Colomb, & Williams, 2016).

In this study, Critical case purposive sampling was used as it is particularly useful in exploratory qualitative research, research with limited resources, as well as research where a single case (or small number of cases) can be decisive in explaining the phenomenon of interest (Gorard & Taylor, 2020). This type of purposive sampling was chosen for this study because the researcher expected that using it would reveal insights that could be applied to other like cases (Booth, Colomb, & Williams, 2016). The critical case purposive sampling was used to reveal the effect of energy mix on energy deficit at 10 Miles.

The researcher applied critical case purposive sampling to select key informants exemplifying instances where the impact of the energy mix on the energy deficit at 10 Miles was most significant, as well as other factors around the topic of study. The researcher also applied critical case purposive sampling to select the study area (10 Miles) because the energy deficit was most pronounced.

This type of purposive sampling was preferred from the seven types which include Maximum variation sampling, Homogeneous purposive sampling, Typical case sampling, Extreme case sampling, Total population sampling and Expert sampling because of the advanced purpose as presented above.

### 4.3.2 Convenient sampling

Using convenience sampling, the first available primary data source was used for the research without additional requirements (Saunders, Lewis, & Thornhill, 2012). Convenient sampling was used to select study participants who were conveniently located. Study participants who were willing and available to be studied were conveniently selected (Creswell, 2009). The disadvantage of convenient sampling is that getting responses only from the participants who were easiest to contact and recruit left out many respondents.

In this study, convenience sampling method was used because it made it efficient for the researcher to find research participants and had no inclusion criteria identified prior to the selection of subjects. Convenience sampling was used because it is not costly, simple to use and it's not as time consuming as other sampling strategies.

Convenience sampling was applied to select focus group members by prioritizing individuals who were readily accessible and willing to participate. Absent predefined criteria, the researcher promptly recruited participants, thereby streamlining the process. This method aimed to ensure efficient participant recruitment, emphasizing convenience and practicality in the study.

### 4.3.3 Sample Size

The research study had a sample size of 3 focus groups with 10 members (households) each and 20 key informants, giving a total of 50 participants. Key informants included: 5 business houses, 5 village chiefs, 5 Council officials, 3 churches and 2 schools. This is because 50 participants were estimated to be the optimum number necessary to enable valid inferences to be made about the population. The researcher, for the sake of confidentiality, used pseudonyms for the key informants as follows: SCH stand for schools, CH1 stand for churches, CC stand for council, BB stand for businesses and HH stand for village chiefs.

Focus group discussions (FGDs) were used to collect data from households at 10 Miles area. The 30 participants were divided into three groups of 10 members each. Key informants were drawn from energy users from the study area. Participants from public sector such as schools and business houses in the area were also considered. Government documents, especially those from the Ministry of Environment, Tourism and Natural Resources (METNR) provided secondary data on the phenomenon under inquiry.

## 4.4 Data collection methods

### 4.4.1 Primary methods

Primary methods are modes of collecting information in which the researcher is involved directly (Collodel, De Beer, & Kotze, 2012). This implies that the researcher direct the actual exploration or commissions the information to be gathered for their sake.

The data were collected through in-depth interview guide and focus group discussions. These data mainly focused on the types of energy used, the drivers of types of energy used and the effect of energy mix on energy deficit at 10 Miles respectively.

In-depth interviews and focus group discussions were chosen for their ability to provide detailed exploration of individual and group perspectives, flexibility in probing specific areas of interest, active participant involvement, and facilitating contextual understanding. This approach aimed to ensure a comprehensive understanding of energy dynamics in 10 Miles, including types of energy used, drivers of energy use, and the effects of energy mix on energy deficit.

### 4.4.2 Secondary methods

Secondary methods involved using already existing data from libraries, archives, internet, research material published in research reports and similar documents (Schreier, 2012). Existing data were summarized and collated to increase the overall effectiveness of research (Schreier, 2012).

Secondary data collection methods were selected based on accessibility, reliability, cost-effectiveness, time efficiency, and complementarity. Leveraging existing resources from libraries, archives, and the internet saved time and resources. Reliability was ensured through peer-reviewed materials, enhancing data validity. This approach facilitated timely analysis and interpretation, complementing primary data and optimizing the research process's effectiveness and efficiency.

### 4.4.3 Research Instruments

The researcher used interview guide and focus group discussion as primary methods. Interview guides were used during interviews in primary data collection (Creswell, 2009). This technique allowed the researcher to get as many views as possible on the phenomenon which was under investigation (Creswell, 2009).

Interview guides were used to collect data from council officials, business houses, churches, headmen and headwomen and schools. Questions on the interview guide were read out to the participants and explained further were necessary. The answers were written in the appropriate blank spaces on the interview guide (Ng'ang'a & Kamau, 2020).

Focus group discussions were held with a number of household owners in different sections of the study area. The focus group discussion comprised of participants chosen using convenient sampling method and constituted participants who use any form of energy (Chsristensen, Han, & Philips, 2021).

For churches, schools, headmen and headwomen and council officials' participants, the researcher used interview guide. The key informants were selected purposively and included individuals relevant to the phenomenon under study. Household Research participants were selected using convenient sampling.

The advantage of focus group discussion is a kind of interaction which is the basis of the social constructivist philosophical assumption or worldview (Booth, Colomb, & Williams, 2016). The other advantage of the technique is the fact that it yields thick description of the phenomenon under study. Merriam (2019) contends that the primary benefits of this method are that it can deliver a top to bottom investigation of wonders in setting, support the improvement of recorded points of view and assurance high inner legitimacy which is to say that the noticed marvels are valid portrayals of the real world.

The focus group discussions, and individual interviews, were conducted in English, Bemba, Lenje and Nyanja, depending on the language the participants preferred (Ng'ang'a & Kamau, 2020). Information collected from personal interviews was recorded in English in the spaces provided on the interview guide during the interviews, while focus discussions recorded electronically and later transcribed the verbatim in English for analysis (Azizalraman & Hasyimi, 2019).

### 4.5 Data Analysis

Thematic and content analysis methods were used to analyze the data collected.

Deductive thematic analysis was used to analyze data. The data was grouped into the following generated themes:

(1) Drivers of the choice of energy use at 10 Miles (2) Impact of energy mix at 10 Miles (3) Form of energy accessible at 10 Miles (4) Challenges in accessing other types of energy.

The answers in the interview guide were tailored to the five categories. This is in accordance with thematic analysis, which is an inductive system of information analysis. The themes were created based on the study objectives indicated above.

The themes were created based on the goals or objectives of the study. The questions in the interview guide were organized to help gather information related to the specific study objectives. This approach helped the researcher organize and make sense of the information that was collected.

When analyzing the data, Schreier (2012), the researcher searched-out underlying themes in the data collection material. The core and central tool of any thematic analysis is its system of categories: every unit of analysis was coded, that is to say coded in one or more categories.

The central characteristic of thematic analysis is that of categories. Alasuutari (2010) define thematic analysis as a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns. Mayring (2014) defines thematic analysis as an approach to documents that emphasizes the role of the investigator in the construction of the meaning of and in texts. There is an emphasis on allowing categories to emerge out of data and recognizing the significance for understanding the meaning of the context in which an item being analyzed (and the categories derived from it) appeared. The procedure that was used to conduct thematic analysis has been outlined below

1. Familiarization with the data: The researcher began by thoroughly reading and becoming familiar with the data collected which include transcripts from interviews and focus group discussions. Notes were taken on initial impressions, interesting observations, and potential patterns.
2. Generating initial codes: The researcher systematically coded the data by identifying and labeling meaningful segments or excerpts. Codes represented the most basic units of analysis and captured key concepts, ideas, or themes within the data.
3. Searching for themes: The researcher organized the coded data to identify recurring patterns, topics, or themes across different segments. The researched also looked for similarities, differences, and connections between codes to identify overarching themes.
4. Reviewing themes: The researcher evaluated and refined the identified themes by reviewing the coded data in relation to each theme. The researcher ensured that each theme is internally coherent and distinct from others, representing a meaningful pattern in the data.
5. Defining and naming themes: The researcher defined and described each theme in detail, providing clear explanations of its content and significance. The researcher also used descriptive and concise language to name each theme, capturing its essence and relevance to the research question.
6. Generating a thematic map: The researcher created a visual representation (thematic diagram), to illustrate the relationships between themes and sub-themes. The themes were arranged hierarchically or spatially to demonstrate their interconnections and organization.
7. Writing the analysis: The researcher wrote a detailed narrative summarizing the findings of the thematic analysis. The researcher described each theme, providing illustrative quotes and examples from the data to support interpretations. The researcher discussed the implications

of the themes in relation to the research objectives and broader theoretical and practical implications.

8. Validating the analysis: The researcher engaged in peer debriefing to validate the accuracy and credibility of the thematic analysis. The researcher sought feedback from participants to ensure that the identified themes accurately reflected their experiences and perspectives.
9. Reporting the findings:

The researcher presented the findings of the thematic analysis in a clear and coherent manner, adhering to relevant conventions and guidelines for qualitative research reporting.

Thematic analysis was used because it helped the researcher understand those aspects of the effect of energy mix on energy deficit that participants talked about frequently or in depth, and the ways in which those aspects of a phenomenon may be connected.

As indicated earlier, the researcher also used content analysis. Content analysis, as a method, has a number of approaches. This study adopted thematic content analysis which is defined by Braun (2019) as a process performed within major analytic tradition (such as grounded theory). It involved identifying, analyzing, and reporting patterns (themes) within data. It organized and described the dataset in (rich) detail. Content analysis enabled the researcher to identify the types of energy which were appearing from the focus group discussions and interview guides.

Content analysis was use because there is some quantification of data, as content analysis helped the researcher count instances of codes such as the energy sources. Content analysis was used by the researcher because can be applied to other textual data and not just interviews.

### 4.6 Trustworthiness

The researcher put in place measures to ensure trustworthiness of his data to show the credibility, transferability, confirmability and dependability. It is vital to establish how this study is credible, transferable, confirmable and dependable.

#### 4.6.1 Credibility

Credibility is a measure of the truth value of qualitative research, or whether the study's findings are correct and accurate (Sagor, 2018).

In order to achieve credibility of the qualitative data, the researcher focused on ensuring the focus on multiple perspectives in the process of data collection (Sagor, 2018). The researcher employed interview guides and focus group discussions to triangulate data collected. Validation of participants was done by checking their demographic characteristics to ensure they belonged to the category of participants they professed and were appropriately sampled. The data collection process was undertaken under strict control and moderation by the researcher. This gave confidence that the findings would be truthful and representative of the phenomena regarding the effect of energy mix on energy deficit at 10 Miles.

#### 4.6.2 Dependability

Dependability in qualitative research is linked to reliability and is the measure of the extent to which a research study could be repeated by a separate researcher and reveal the same findings (Sagor, 2018).

This explains the extent to which other researchers can replicate the study. The current study from the researcher's knowledge has not been done before at 10 Miles. The variables related to energy mix and energy deficit have not been studied in one research to determine the effect of the former on the later (Sagor, 2018). The study was conducted under the supervision of the University of Zambia (UNZA), a trusted institution with special support and supervision to ensure that the study meets the set standards. This included review of the study and review of the research process and data analysis under the supervision of a qualified research supervisor.

### 4.7 Limitations of the study

The study faced some challenges such as would be participants' failure to be ready for interviews on time, limited time and attention given to the researcher during the interview process. The political situation led some key informants to decline taking part in the study for fear of victimization. Due to other commitments, some respondents were unable to participate fully despite making prior arrangements.

### 4.8 Delimitations of the study

The study area (10 Miles) of Chibombo district was selected as a study area owing to its seemingly energy crisis. The area is characterized by massive charcoal production, servicing most parts of Lusaka. It was also chosen because of its reported cases of energy deficit. The area has experienced rapid expansion in the past 10 years and is now considered a medium developed area in terms of modern houses. Further, its population shows a wide range of diversity in terms of socio-economic and demographic characteristics making it desirable to study the effect of energy mix on energy deficit.

### 4.9 Ethical consideration

Ethics is a matter of principled sensitivity to the rights of others. Being ethical, limits the choices we can make in the pursuit of truth. Ethics says that, while truth is good, human dignity is better, even if in the extreme case, the respect of human dignity leaves one ignorant of human nature. This was important to consider during the study (Babbie, 2010).

The research process ensured the participants' dignity, privacy, and safety (Collodel, De Beer, & Kotze, 2012) and this was done by obtaining informed consent from the participants. Informed consent was obtained through conversation between the researcher and the study participants which took place to help the participant understand the study he or she may enter. Through informed consent, the study participants agreed to take part in the study.

Ethical clearance letter was obtained from the University of Zambia through the Natural and Applied Sciences Research Ethics Committee (NASREC).

After getting in the research area (10 Miles), self-introduction to the chairmen, headmen and headwomen was done and the introductory letter from the University of Zambia was presented for verification. After identifying the households, businesses and the groups which were to be involved in the study, the information was sent to the would be participants prior to the visit.

### 4.10 Chapter Summary

This chapter provides the philosophical basis on which the study was grounded. It also outlined the research design used in the study as well as the target population. The chapter outlined the methods used in the collection of data and methods of analysis and data validation. The chapter also presented the limitation encountered during the research study and the ethical obligation considered during the study.

## CHAPTER FIVE: FINDINGS OF THE STUDY

### 5.1 Overview

This chapter presents the findings of the study. It addresses the research questions of the study under various sections. The first part deals with participants' profile and the second part addresses various aspects of the research questions. The last section provides a conclusion to the chapter.

### 5.2 Participant Profile

All the participants were asked how far they went into education. Figure 4 presents the responses.

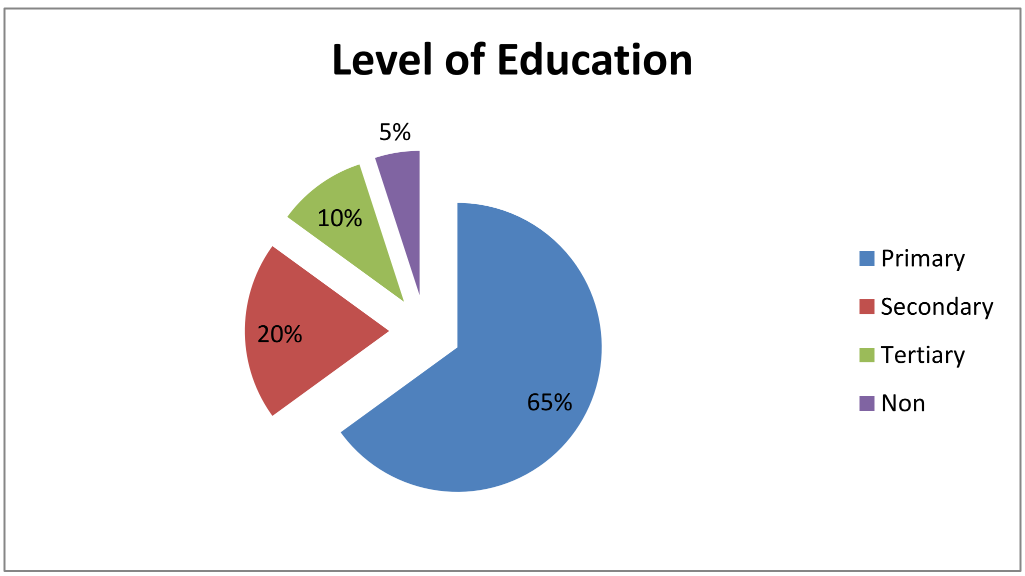


**Figure 4: Level of Education of Participants**
**(Source: Field data, 2023)**

Findings from Figure 4 indicate that the majority (65%) of the participants' level of education was primary, followed by secondary with 20%, tertiary with 10% and the minority (5%) did not indicate any education background. This gives about 95 percent of participants who had some form of education.

Research question one sought to establish the types of energy sources found at 10 Miles. This was presented under various themes.

### 5.3 Types of energy that exist at 10 Miles

The study targeted households, business owners and institutions at 10 Miles. Of the 50 participants interviewed through interview guides and focus group discussions, 67 percent were females, and 33 percent were males. 68 percent of the participants had lived at 10 Miles for more than 10 years. The researcher asked all the participants on the types of energy mix that existed at 10 Miles and the following were their responses indicated in themes and subthemes:

#### 5.3.1 Renewable Energy Sources

Hydropower: Energy generated from flowing water, mentioned by Focus group A, B, C, and key informants.

Wind: Energy harnessed from the wind using turbines, mentioned by Focus group A and B.

Biomass: Energy derived from organic materials, including cow dung, mentioned by Focus group A, B, C, and key informants.

Solar power: Energy obtained from sunlight, mentioned by Focus group A, B, C, and key informants.

#### 5.3.2 Non-renewable Energy Sources

Paraffin oil: A fossil fuel used for heating and lighting, mentioned by Focus group A and B.

Petrol/diesel: Conventional fossil fuels used for transportation and electricity generation, mentioned by key informants.

Liquefied Petroleum Gas (LPG): Versatile fossil fuel used for cooking and heating, mentioned by Focus group C and key informants.

#### 5.3.2 Theme 3: Historical Energy Sources

Cow dung: Historically used as an energy source, particularly when the population of cows was high, emphasized by key informant HH.

These themes and subthemes categorize the types of energy sources mentioned by the participants, providing insights into the energy landscape at 10 Miles.

## 5.4 Reasons for using types of energy at 10 Miles

Another question sought to establish reasons why participants used the technologies of energy at 10 Miles. The responses are shown in Table 1 below.

**Table 1: Reasons for using the types of energy found at 10 Miles**

| Solar Energy | Hydropower | Biomass | LPG | Petrol/ Diesel |
|---|---|---|---|---|
| ✓ Renewable and Sustainable<br>✓ Cost-effective compared to other sources.<br>✓ Environmentally Friendly.<br>✓ Energy Security:<br>✓ Versatile and sustainable source of energy. | ✓ Cost-effective when connected to the national grid.<br>✓ Energy Security. | ✓ Renewable:<br>✓ Availability:<br>✓ Carbon Neutral.<br>✓ Waste reduction.<br>✓ Local production.<br>✓ Flexible use.<br>✓ Use of biomass as an energy source can help reduce greenhouse gas emissions.<br>✓ Promote energy independence, and create economic opportunities. | ✓ Mostly available<br>✓ Sustainable<br>✓ Convenience<br>✓ Availability<br>✓ Affordability<br>✓ Environmental benefits<br>✓ Safety to use | ✓ Easy Transportation.<br>✓ Electricity generation using generators. |

**(Source: Field data, 2023)**

Based on the findings in Table 1, all three focus groups said they preferred biomass and solar energy because they were convenient, available, cost effective, renewable, environmentally friendly and waste reduction. They also differed in using hydropower and LPG because hydropower was expensive to connect to the national grid and take longer and LPG is difficult to access.

> *Key informant HH indicated that she preferred solar because it was renewable, sustainable and cost-effective compared to other sources as she tried to connect to Zesco power grip but I did not receive the quotation after waiting for more than one year, so I forgot about it.*

Key informants CH1 and SCH indicated that they preferred wood fuel (biomass) because it is carbon neutral, waste reduction, local production and flexible use. Key informants CC and HH indicated that they preferred Liquefied Petroleum Gas (LPG) and hydropower because they were mostly available, sustainable, convenience, availability, affordability, environmental benefits and safe to use. Key informant BB indicated that they preferred petrol and diesel because it was easy to transport, and electricity generation was guaranteed using generators.

### 5.5 Availability and accessibility of energy mix at 10 Miles

Participants were asked how accessible energy mix at 10 Miles was. Their responses were:

The participants in Focus Groups A and C indicated that there were significant challenges in accessing reliable and affordable energy in Chibombo district. The majority of the population at 10 Miles, particularly in rural areas, relied on traditional biomass (such as firewood and charcoal) for their energy needs.

Key informants CH1 and BB indicated that the electrification rate in Chibombo district was 6%, which was relatively low compared to the national average of 5%. The reasons stated for the existing challenges included high connections fees to hydroelectricity and regular replacement of solar batteries. The overall response indicated that accessibility to energy mix was a challenge at 10 Miles.

Key informants CC and CH1 indicated that in terms of clean cooking solutions, only 5% of households in Chibombo district had access to clean cooking solutions such as Liquefied Petroleum Gas (LPG), biogas, and improved cook stoves.

> *Key informant BB and CC indicated there are ongoing efforts to promote the use of clean cooking solutions in the area through various projects implemented by NGOs and international development organizations such as REA and UNDP.*

### 5.6 Factors that influenced energy availability and accessibility at 10 Miles

Another question sought to find out factors that influenced energy availability and accessibility at 10 Miles.

Findings indicate that there were five major influences which included natural resource availability, infrastructure, government policies and regulations, climate and geography and technology advancement.

Focus group A and B indicated that government policies and regulations, natural resource availability and energy infrastructure influenced the availability and accessibility of energy at 10 Miles, while focus group C indicated that climate, geography of the area and technology advancement influenced availability and accessibility of energy at 10 Miles.

Key informants BB, CH1 and CC indicated that technology advancement, climate and geography of the area influence availability and accessibility of energy, while key informants SCH and HH indicated government policies and regulations.

### 5.7 Strategies put in place to access energy mix at 10 Miles.

Participants were asked on the strategies that households and institutions had put in place to access energy mix at 10 Miles.

Findings indicate that there were four strategies that households and institutions had put in place to access energy mix at 10 Miles. These strategies included off-grid renewable energy solutions, Energy efficiency, capacity building and public-private partnerships.

Focus groups A and C indicated that they had connected their households to off-grid renewable energy solutions and engaged in capacity building in order to access energy mix. Focus group C indicated that they had connected their households to off-grid renewable energy solutions and ensured energy efficiency in order to access energy mix.

Key informants BB and CC indicated that they had entered into public-private partnership, off-grid renewable energy solutions and engaged in capacity building in order to access energy mix.

Key informants CH1 and BB indicated that that they had entered into public-private partnership, off-grid renewable energy solutions and energy efficiency in order to access energy mix, while HH indicated that they had implemented off-grid renewable energy solutions.

## 5.8 Chapter Summary

This chapter presents the findings of this study. It drew its findings from data collected from interviews and focus group discussions. The chapter provides insight into the education levels, types of energy sources, reasons for energy technology choices, challenges in accessing energy, influencing factors, and strategies used by participants at 10 Miles area to meet their energy needs. These findings can inform energy-related initiatives and policies in the region. In the next chapter, the foregoing findings of the study are discussed with the reviewed relevant literature concerning specific research objectives.

# CHAPTER SIX: DISCUSSION OF THE FINDINGS

## 6.1 Overview

This chapter discusses the findings of the study. It addresses the objectives of the study.

## 6.2 Participant Profile

Based on the findings regarding the education status of the 10 Miles participants in relation to the effect of energy mix on energy deficit, it became clear that the majority (95%) of them had been to school and in the researchers view; they were in a position to understand the effects under discussion. The minority (5%) although they showed that they had not received formal education, it may not be concluded that they had no idea about energy mix and energy deficit because they were in a community which experienced the effect. These findings show to a larger extent that education plays a greater role in making people understand and interpret information.

This finding is consistent with the words of Kahle (2019) and Dias, Mattos & Balestier (2021) who said that education possesses the power to transform an uninformed individual into a responsible energy consumer and user. This is also in conformity with social practice theory which holds that people's behaviour tends to change as they learn new practices.

Education shapes individuals' energy awareness, behavior, choices, and advocacy, thereby impacting their contribution to a diverse energy mix. While Figure 4 provides data on the education levels of participants, it is essential to consider how these education levels might impact energy-related decisions and behaviors.

Education has a multifaceted impact on energy-related decisions and behaviors, influencing various aspects of individuals' engagement with energy mix. Higher education levels tend to lead to greater awareness and knowledge of energy-related issues, including renewables and sustainability (Johnson, Smith, & Brown, 2021). This awareness enables more informed and responsible energy consumption. In contrast, lower education levels can result in limited exposure to energy-related knowledge, hindering comprehension of sustainable energy's significance.

Education also shapes energy consumption patterns. Highly educated individuals are more likely to adopt energy-efficient technologies and practices, reducing overall energy demand. Conversely, lower education levels may lead to less awareness of energy-efficient options and potentially higher energy consumption (Masini & Menichetti, 2012).

Moreover, education plays a role in advocacy and policy influence. Educated individuals are more likely to engage in discussions about energy policy, supporting clean energy initiatives. In contrast, those with lower education levels may have limited involvement in such discussions and less influence on energy-related policies (Johnson, Smith, & Brown, 2021).

Career choices are impacted too, with higher education offering access to renewable energy careers, contributing to clean energy development. Individuals with limited education may find fewer opportunities in the renewable energy sector, potentially working in high-energy consumption industries (Mwale, 2021).

Education also affects behavioral change, as it fosters an environmentally responsible mindset. Highly educated individuals are more inclined to adopt sustainable behaviors and influence others to do the same. This is in conformity with the social practice theory which holds that people are able to pursue diverse concerns and become aware of new possibilities for action and arrangements for participation in practice (Nemirovsky, Rasmussen, & Gozalez, 2020).

On the other hand, limited education may result in less awareness of environmental impacts, reducing motivation for energy-related behavioral changes. This is not in conformity with the data collected from the participants.

### 6.3 Energy types at 10 Miles

On energy types, the majority (75 percent) of the key informants indicated that there were five types of energy that existed at 10 Miles. The five energy types were supposed to have a positive effect on the energy deficit at 10 Miles. Participant's ability to provide different types of energy showed that participants were aware of the energy mix at 10 Miles.

By implication, energy consumers should be free to select from the variety of energy technologies that were usable in a particular area. The primary national electrical grid is powered by hydro technology at 10 Miles; however the levels of electrification are low. As a result, many individuals could not use it. Biomass, solar and liquefied petroleum technology, such as solar light fixtures and gas and improved wood-burning cook stoves, are examples of alternative sources. This finding is consistent with the study by Energies (2020) that biomass, solar and liquefied petroleum technology are the major energy alternatives. This is also in conformity with the social practice theory which holds that people are able to pursue diverse concerns and become aware of new possibilities for action and arrangements for participation in practice (Nemirovsky, Rasmussen, & Gozalez, 2020).

**6.4 Motivation for using the types of energy at 10 Miles**

From the findings, the motivations for using certain types of energy include affordability, accessibility, environmentally friendly and dependability. Renewable Energy Types (RETs) for example, are the less expensive option at 10 Miles. This was indicated in the responses provided for by Focus Group B and Key informant B1. Solar utensils require once expenditure and very affordable, biomass on the other hand is free and readily available.

From the researcher's point of view, energy mix requires a lot of resources up front and has high startup costs. Connection to the national electrical grid is economically possible but needs large construction expenses because the bulk of rural poor people live in remote and frequently inaccessible places. As a result, novel and cost-efficient technologies are needed.

In line with the study conducted by Allen & Janda (2020), the cheaper sources of energy such as biomass and solar are preferred because they require once off expense. This is conformity with the social practice theory which holds that people practice certain actions with the view of benefiting, materializing or gaining a skill from that practice. The bulk of the poor in rural and peri-urban areas could not afford the services provided by Zambia Electricity Supply Corporation Limited (Zesco) (Mbewe & Ng'ombe, 2020).

### 6.5 Accessibility and Availability of energy mix at 10 Miles

Majority (80 percent) of the participants indicated that 10 Miles faced significant challenges in accessing reliable and affordable energy. These challenges to energy access included outdated infrastructure such as wind mills owned by some villagers and not in use, high upfront costs for modern technologies such as hydro-electricity, limited financial incentives, geographic constraints, and insufficient attention from energy providers. The majority (80 percent) of the participants in the area especially those in the rural parts of the district, only had access to traditional biomass (such as firewood and charcoal) and clean cooking solutions (liquefied petroleum gas and wood pellets) for their energy needs. According to the researcher's point of view, these factors collectively hindered the establishment of reliable and affordable energy solutions, thereby hindering energy mix at 10 Miles.

These finding are in conformity with the study by Barnes (2020) who indicated that there were significant challenges in accessing reliable and affordable energy in most rural area. The proportion of each energy source in the energy mix significantly affected the effect of energy mix on energy deficit at 10 Miles.

### 6.6 Factors that influenced energy availability and accessibility at 10 Miles

Concerning the factors that influenced the accessibility and availability of energy at 10 Miles, these included natural resources, infrastructure, government policies and regulation, climate and geography and technology advancement. These are important factors in that they cannot be overlooked. For instance, you need natural resources such as wood and agricultural residues for sustainability.

The accessibility and availability of energy are intricately linked to a multifaceted interplay of elements. Natural resources serve as the foundation, determining the energy potential of an area. Infrastructure dictates the means to harness and distribute energy, while government policies and regulations set the framework for the energy sector. Climate, geography, and technological progress further mold the energy landscape, collectively shaping the accessibility and abundance of this vital resource.

### 6.6.1 Natural Resources

Natural resource influenced accessibility and availability of energy in the area. The availability of natural resources such as biomas has a significant impact on the availability and composition of the global energy mix. Biomas such as organic matter, wood, crop residues, and animal waste that can be used as fuel to generate energy plays a significant role in ensuring energy mix. This finding is consistent with the works of Atterridge (2013) who said that the availability of natural resources such as biomass greatly influenced the availability of energy mix. In most parts of 10 Miles where biomass is abundant, such as rural areas with large forests or agricultural lands, it has historically been a primary source of energy for heating and cooking. However, with advances in technology, biomass can also be converted into electricity and biofuels, which can contribute to the diversification of the energy mix.

Other natural resources such as natural gas, and renewable energy sources such as wind, solar, and hydropower, also play a significant role in the energy mix. The availability of these resources varies across different regions, and their relative importance in the energy mix can also depend on economic, political, and environmental factors.

The absence of natural resources at 10 Miles has several implications which include dependence on imported energy (such as LPG used a number of households), vulnerable to power supply disruptions, limited energy diversity, high environmental impact and energy poverty causing low income households struggling to afford basic energy services for heating, cooling and lighting. The lack of natural resources for energy leads to high environmental impact due to increased use of fossil fuels, causing air and water pollution, habitat destruction, waste generation, and global environmental injustice. This is consistent with social practice theory which says that individuals and communities engage in daily practices that shape and are shaped by the material and social contexts in which they exist. In many rural areas where biomass is abundant, its use as a primary source of energy for heating and cooking is deeply embedded in cultural practices. Generations have relied on the availability of wood, crop residues, and animal waste for their energy needs.

Social practices related to biomass use have evolved over time, influenced by local traditions, knowledge, and the availability of these resources. People have developed skills and rituals related to gathering, preparing, and using biomass for energy.

### 6.6.2 Infrastructure

The absence of infrastructure such as power grids, transmission lines, and distribution networks had largely affected the accessibility and availability of energy at 10 Miles. The quality and quantity of this infrastructure has also impacted the reliability of energy supply. The infrastructure required extracting, producing, transmitting, and distributing different types of energy sources can vary widely, and the level of infrastructure development can greatly influence the cost and availability of different energy sources.

For example, regions with a well-developed natural gas infrastructure may rely more heavily on natural gas as a primary energy source (Azizalraman & Hasyimi, 2019). Similarly, regions with abundant hydroelectric resources may rely more heavily on hydroelectric power, while regions with limited access to water resources may need to rely more heavily on other sources of energy, such as coal or natural gas. In the case of 10 Miles, the area has no infrastructure to enhance the availability of hydroelectric power, solar plants and other energy sources to ensure accessibility and availability of energy mix.

Additionally, the availability of infrastructure can also impact the integration of renewable energy sources into the energy mix. For example, the development of a robust transmission and distribution network is essential for the widespread adoption of wind and solar power, as these sources of energy are often located in remote areas far from population centers.

Overall, the availability of infrastructure is a critical factor in shaping the energy mix of a region, and investments in infrastructure development can play an important role in promoting the adoption of cleaner and more sustainable sources of energy. This is consistent with social practice theory as social practices are influenced by the availability of infrastructure. In regions with a well-developed natural gas infrastructure, individuals and businesses are more likely to incorporate natural gas into their daily practices. This includes using natural gas for heating, cooking, and electricity generation. These practices become entrenched and normalized within the community.

Similarly, regions with abundant hydroelectric resources develop practices centered on hydroelectric power. People in these areas may use electricity more liberally for various purposes, knowing that it is derived from a clean and reliable source.

The level of economic development at 10 Miles has greatly influenced the availability and accessibility of energy. A more developed economy may have greater demand for energy, leading to greater investment in energy infrastructure and technologies.

### 6.6.3 Economic development

Economic development refers to the process by which an economy becomes more advanced, diversified, and prosperous over time (Deaton, 2013). As an economy develops, the demand for energy typically increases, which can put pressure on the energy infrastructure and supply chain.

At 10 Miles, which is an area in Chibombo district in Zambia, the level of economic development (emerging of other economic activities such as welding, creation of roads and grocery shops) has influenced the availability and accessibility of energy in a number of ways. For example: as the economy of Chibombo grows, there may be greater investment in energy infrastructure such as power plants, transmission lines, and distribution networks. This can lead to greater availability and reliability of energy for households and businesses. Information from the business owners indicated that the increase in economic activity in the area greatly contributed to bring hydroelectric power closer.

Economic development can also lead to an increase in incomes, which can make energy more affordable for households and businesses. This can improve accessibility to energy and allow for greater use of energy-intensive technologies. Most of the participants interviewed who were in employment are connected to at least one or two energy sources such as solar energy, hydropower, LPG and biomass.

In less developed areas, such as rural parts of Chibombo, the level of economic development can influence the availability and accessibility of energy through programs and policies aimed at rural electrification, as evidenced from the programmes by REA and UNDP. As the economy develops, there may be more resources available for such programs, which can expand access to energy in rural areas.

Economic development can also lead to greater adoption of energy-efficient technologies and practices, which can help to reduce demand for energy and improve the overall efficiency of the energy system. This can improve availability and accessibility of energy by reducing strain on the energy infrastructure.

Overall, the level of economic development at 10 Miles can have a significant impact on the availability and accessibility of energy. There are three types of industries at 10 Miles and these are primary industry (farming, poultry farming and building sand extracting), secondary industry (small scale hummer mills, peanut butter production and block making) and tertiary industry (transportation services). As the economy develops, there may be greater investment in energy infrastructure, increased affordability of energy, and expanded access to energy in rural areas. Additionally, the adoption of energy-efficient technologies and practices can help to improve the overall efficiency of the energy system, further improving availability and accessibility of energy. This is consistent with social practice theory which says that economic development can impact the affordability of energy for different social groups. In some cases, increased income levels may make energy more affordable for a larger portion of the population.

However, social practice theory also highlights the potential for unequal distribution of benefits. As the economy develops, there may be disparities in access to affordable energy, with marginalized communities facing challenges in accessing modern energy services.

Government policies and regulations have impacted energy availability and accessibility in Chibombo. For instance, subsidies for renewable energy such as solar make it more cost-effective to generate electricity from renewable sources such as solar and wind. Chibombo, like many other regions, is impacted by government policies and regulations that affect energy availability and accessibility.

### 6.6.4 Government Policies and regulations

Government subsidies on energy increased energy availability and accessibility in Chibombo by making it more affordable for households and businesses. By reducing the cost of energy, households and businesses will be more likely to use energy sources that were previously unaffordable, such as electricity or gas. The use of solar energy in at 10 Miles became more pronounced when government removed tax on the importation of solar panels and other solar equipment.

Government policies that promote renewable energy can increase the availability of renewable energy sources in Chibombo, such as solar or wind power. By setting targets for the production of renewable energy, the government can encourage investment in renewable energy technologies, which can help to increase the amount of renewable energy available in Chibombo. Government regulations that mandate energy efficiency standards for buildings, appliances, and vehicles can help to reduce energy consumption at 10 Miles. By reducing the amount of energy required to power homes, buildings, and transportation, the government can help to ensure that energy resources are used more efficiently and are therefore more widely available.

Fuel taxes: Government taxes on fossil fuels can impact the availability and accessibility of energy sources at 10 Miles. By making fossil fuels more expensive, the government can encourage households and businesses to switch to alternative energy sources, such as renewable energy, which can help to increase energy availability and accessibility.

Overall, government policies and regulations can have a significant impact on energy availability and accessibility at 10 Miles. By promoting renewable energy, energy efficiency, and reducing the cost of energy, the government can help to ensure that energy resources are available and accessible to all.

### 6.6.5 Climate and Geography

The study area (10 Miles) is located in Chibombo district of central province of Zambia, Africa. The local climate and geography in Chibombo has had a significant impact on the availability and accessibility of energy. Chibombo experiences a tropical climate, characterized by hot and humid conditions throughout the year. This can impact energy availability in several ways. For example, high temperatures can cause power outages due to reduced water levels at hydropower stations. Additionally, heavy rainfall during the rainy season can lead to flooding and damage to energy infrastructure, further reducing energy availability.

Geography can also play a role in energy accessibility in Chibombo. The district is located in a rural area with a dispersed population, which can make it difficult and expensive to extend energy infrastructure to all areas. In addition, the terrain in Chibombo is relatively flat, which can make it more challenging to harness renewable energy sources such as wind and solar power.

Despite these challenges, efforts are being made to improve energy availability and accessibility in Chibombo. For example, the Zambian government has launched initiatives to increase access to electricity in rural areas, including Chibombo. Additionally, there is potential for the district to benefit from renewable energy sources such as hydropower, which can be harnessed from nearby solar plants in Lusaka and other surrounding areas.

### 6.6.6 Population growth

Population growth can increase the demand for energy in Chibombo District, as more people require energy to power their homes, businesses, and other activities. This increased demand for energy can put pressure on existing energy infrastructure and resources, leading to potential energy shortages or blackouts. Population growth at 10 Miles has greatly contributed to the depletion of biomass at 10 Miles.

To meet the growing energy demand, 10 Miles and Chibombo District may need to invest in new or expanded energy infrastructure, such as power plants, transmission lines, or renewable energy sources like solar or wind power. This can require significant financial resources, as well as careful planning and coordination with local communities and stakeholders.

These findings are in consistent with the words of Atterridge (2013), Azzizalramna & Hasyimi (2019) and Sen (2013) who said that energy accessibility and availability are impacted by natural resource availability, infrastructure quality, government policies, population growth climate and geography, and technological advancements. These factors collectively shape the energy landscape and its distribution.

Efforts to increase energy efficiency and conservation can also help to reduce the demand for energy in Chibombo District, while providing benefits such as cost savings and reduced environmental impact. Overall, managing the energy demands of a growing population requires careful consideration of multiple factors, including technology, economics, and social and environmental concerns.

### 6.7 Efforts to improve the effect of energy mix on energy deficit at 10 Miles

There were ongoing efforts to promote the use of clean cooking solutions in the area through various projects implemented by NGOs and international development organizations such as REA and UNDP. Overall, the availability of modern forms of energy at 10 Miles was still relatively low.

The Zambian government has embarked on various strategies to increase access to modern forms of energy, such as electricity and clean cooking solutions. For instance, the Rural Electrification Authority (REA) is working to increase access to electricity in rural areas by implementing various electrification projects, including solar mini-grids and grid extensions.

According to the Rural Electrification Authority (REA), as of 2021, the electrification rate at 10 Miles was 6%, which means that only a small percentage of the population had access to the grid electricity (Ministry of Energy, 2019).

Other efforts to increase access to electricity in the area included the implementation of various electrification projects such as solar mini-grids and grid extensions.

These strategies further confirm what the majority (75 percent) key informants indicated that with assistance from the Japanese government and the Rural Electrification Master Plan (REMP), the Zambian government had started a project to improve access to electricity in rural areas through the development of mini-hydropower plants, solar household systems, and the extension of the national grid.

### 6.8 Implication of the study

If the findings of this study are not addressed to improve the impact of the energy mix on energy deficit, several implications may arise. Inadequate attention to natural resource availability may result in continued reliance on traditional biomass, contributing to environmental degradation and health issues at 10 Miles. Insufficient infrastructure development could lead to unreliable energy supply, hindering economic growth and technological advancement. The infrastructure encompasses the physical components and systems necessary for the generation, transmission, distribution, and consumption of energy, including electricity and other forms such as natural gas.

Government policies and regulations, if not supportive, may impede the transition to cleaner and more sustainable energy sources, exacerbating environmental concerns. Neglecting climate and geography considerations may lead to vulnerabilities, with extreme weather affecting energy infrastructure and accessibility. Without embracing technological advancements, the energy sector may struggle to diversify and integrate renewable sources effectively.

Failure to address the factors that influence the availability and accessibility of energy mixt in the context of 10 Miles, economic development may result in disparities in energy access, limiting the potential benefits for marginalized communities. Additionally, population growth without corresponding investments in energy infrastructure and efficiency may lead to chronic energy shortages, hindering overall development.

In essence, neglecting these factors that influenced the availability and accessibility of energy mix could perpetuate energy poverty, environmental degradation, and economic disparities, undermining the overall well-being and sustainability of 10 Miles and similar regions. Addressing these challenges through strategic planning, investment, and policy interventions is crucial for achieving a resilient and inclusive energy landscape.

### 6.9 Chapter Summary

This chapter discussed the findings of the study. It points out the effectiveness of energy mix on energy deficit. At 10 Miles of Chibombo district, the availability and accessibility of energy mix are influenced by various factors. These factors include the level of education, economic development, natural resource availability, infrastructure, government policies and regulations, climate, geography, technology, and sustainable energy behaviours, while economic development can lead to greater investment in energy infrastructure and affordability. Natural resources availability, such as biomass, plays vital role, while government policies and regulations can shape energy accessibility through subsidies and incentives. The local climate and geography can pose challenges, and population growth increases energy demand, necessitating infrastructure expansion. Overall, these multifaceted factors collectively impact the energy mix's impact on energy deficit at 10 Miles area of Chibombo District, highlighting the need for strategic planning and sustainable energy solutions.

# CHAPTER SEVEN: CONCLUSION AND RECOMMENDATIONS

## 7.1 Overview

This study aimed to assess the effect of energy mix on energy deficit at 10 Miles of Chibombo district. The chapter covers two sections, conclusion and recommendations.

## 7.2 Conclusions

The energy mix refers to the combination of different sources of energy that are used to meet the energy demands of a particular region or district. The energy deficit, on the other hand, refers to the shortfall or gap between the energy supply and the energy demand in a given area. The energy mix can have a significant impact on the energy deficit at 10 Miles of Chibombo District, as it determines the availability, reliability, and sustainability of energy sources to meet the energy needs of the local population.

Objective one assessed the types of energy used at 10 Miles. The study concludes that energy mix at 10 Miles included traditional biomass fuels (such as firewood and charcoal), fossil fuels (such as diesel and kerosene), and renewable energy sources (such as solar, hydro, and wind energy). However, the reliance on traditional biomass fuels has contributed to deforestation, environmental degradation, and health issues due to indoor air pollution. If the energy mix at 10 Miles continues to be heavily reliant on traditional biomass fuels, it can result in increased pressure on local forests and natural resources, leading to an energy deficit in the long run.

Objective two established the drivers of types of energy used at 10 Miles, namely affordability, availability and convenience. Other types of energy sources such as fossil fuels were not used regularly because their availability and affordability could fluctuate due to market forces and geopolitical factors, which could impact the energy deficit at 10 miles.

Objective three explored the effects of energy mix on energy deficit at 10 Miles. The study concludes that the negative effects of energy mix at 10 Miles included over-reliance on traditional biomass fuels and fossil fuels, (which were significantly contributing to environmental degradation, health issues, and energy insecurity). From the positive effect point of view, energy mix reduced energy deficits (by enhancing security, stabilizing prices, and lowering emissions). It minimized reliance on a single source, reduced vulnerability to supply disruptions, while fostering innovation and job creation. In addition, it promoted energy independence and contributes to a more sustainable and secures energy landscape.

## 7.3 Recommendations of the study

1) Because of the finding that biomass is the major source of energy at 10 Miles, this study recommends that the Government of the Republic of Zambia (GRZ) and its cooperating partners invest in renewable energy such as solar energy which can help to reduce reliance on traditional biomass fuels and fossil fuels, mitigate environmental impacts, and improve energy access and affordability for the local population.
2) Because of the findings on the drivers for using certain types of energy which were affordable, available and convenient, such as solar and cow dung, this study recommends the need by the GRZ and its cooperating partners to facilitate the planning and implementing of a strategic development and utilization of a combination of various energy sources and technologies to meet 10 Miles' energy needs efficiently, economically, and with minimal negative environmental and social impacts. The strategic development plan should consider the availability, reliability, affordability, and environmental impacts of different energy sources and what role they can play in addressing the energy deficit at 10 Miles in Chibombo district.
.
3) Because of the finding that there is negative effect of energy mix on energy deficit at 10 Miles, the study recommends dealing with the

challenges in meeting its energy demand such as lack of infrastructure, limited access to modern energy services, and unreliable energy supply by the government through the area member of parliament and cooperating partners. This will ensure diversifying the energy mix with renewable energy sources that can provide a sustainable and clean solution to meet the energy demand and reduce the energy deficit in the long term.

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# 8. APPENDICES

## 8.1. Focus Group Guide

**FOR HOUSEHOLDS AT 10 MILES OF CHIBOMBO DISTRICT**

**<u>Participant's Profile</u>**

i. Sex of participant;

**MALE** ☐ **FEMALE** ☐

ii. Average number of years of inhabitation?

**MINIMUM** ☐ **MAXIMUM** ☐

iii. Level of Education?.........................................

**<u>Types of Energy Technologies</u>**

iv. List the most common sources or technologies of energy at 10 Miles?

………………………………………………………………………………………

………………………………………………………………………………………

v. What are the reasons for using the technologies of energy at 10 Miles as listed in (v) above?

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………………………………………………………………………………………

**<u>Availability and Accessibility of Energy Mix at 10 Miles</u>**

vi. How accessible are the types of energy listed under (v) above?

………………………………………………………………………………………

vii. How available are these types of energy at 10 Miles?

………………………………………………………………………………………

………………………………………………………………………………………

viii. Suggest possible factors that influence energy availability and accessibility at 10 Miles?

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………………………………………………………………………………………………

ix. List strategies if any, your institution has put in place to access energy mix at 10 Miles?

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………………………………………………………………………………………………

**The Effect of Energy Mix on Energy Deficit at 10 Miles**

i. What is the effect of the available energy mix at 10 Miles on energy deficit?

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………………………………………………………………………………………………

## 8.2 Interview Guide

**FOR KEY INFORMANTS AT 10 MILES OF CHIBOMBO DISTRICT**

**Participant's Profile**

i. Sex of participant: ……………………………………………………………………
ii. Institution you work for: ...........................................................................................
iii. Your position at the institution you work for: .......................................................
iv. For how long have you been working in this area...

v. Level of Education?.........................................

**Types of Energy Technologies**

vi. List the most common sources or technologies of energy at 10 Miles?

……………………………………………………………………………………

……………………………………………………………………………………

vii. What are the reasons for using the technologies of energy at 10 Miles as listed in (v) above?

……………………………………………………………………………………

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**Availability and Accessibility of Energy Mix at 10 Miles**

viii. How accessible are the types of energy listed under (v) above?

……………………………………………………………………………………

ix. How available are these types of energy at 10 Miles?

……………………………………………………………………………………

……………………………………………………………………………………

x. Suggest possible factors that influence energy availability and accessibility at 10 Miles?

…………………………………………………………………………………………
…………………………………………………………………………………………
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xi. List strategies if any, your institution has put in place to access energy mix at 10 Miles?

…………………………………………………………………………………………
…………………………………………………………………………………………

**The Effect of Energy Mix on Energy Deficit at 10 Miles**

xii. What is the effect of the available energy mix on energy deficit at 10 Miles?

…………………………………………………………………………………………
…………………………………………………………………………………………

## 8.3 Ethical Clearance from Directorate of Research and Graduate Studies.

**THE UNIVERSITY OF ZAMBIA**
**DIRECTORATE OF RESEARCH AND GRADUATE STUDIES**

Great East Road Campus | P.O. Box 32379 | Lusaka 10101 | **Tel:** +260-290 258/291 777
**Fax:** (+260) 211 290 258/253 952 | **Email:** director.drgs@unza.zm | **Website:** www.unza.zm

**APPROVAL OF STUDY**

***IORG No. 0005376***
***NASRECREC IRB No. 00006465***

15th March, 2023

**REF NO. NASREC-2023- FEB - 005**
Mr. Rodgers Phiri,
The University of Zambia,
School of Natural Sciences,
P.O. Box 32379,
**LUSAKA.**

Dear Mr. Phiri,

**RE: "AN ASSESMENT OF THE EFFECTS OF ENERGY MIX ON ENERGY DEFICIT IN A CASE STUDY OF 10 MILES- CHIBOMBO DISTRICT"**

Reference is made to your protocol dated as captioned above. NASREC resolved to approve this study and your participation as Principal Investigator for a period of one year.

| REVIEW TYPE | ORDINARY REVIEW | APPROVAL NO. NASREC-2023-FEB. 005 |
|---|---|---|
| Approval and Expiry Date | Approval Date: 15th March, 2023 | Expiry Date: 14th March, 2024 |
| Protocol Version and Date | Version - Nil. | 14th March, 2024 |
| Information Sheet, Consent Forms and Dates | • English. | To be provided |
| Consent form ID and Date | Version - Nil | To be provided |
| Recruitment Materials | Nil | Nil |
| Other Study Documents | Questionnaire. | |

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

*Towards Improving Service and Excellence in High Education Beyond Fifty Years*

**CONDITIONS OF APPROVAL**

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.

- All unanticipated or Serious Adverse Events (SAEs) must be reported to NASREC within 5 days.

- All protocol modifications must be approved by NASREC prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.

- All protocol deviations must be reported to NASREC within 5 working days.
- All recruitment materials must be approved by NASREC prior to being used.

- Principal investigators are responsible for initiating Continuing Review proceedings. NASREC will only approve a study for a period of 12 months.

- It is the responsibility of the PI to renew his/her ethics approval through a renewal application to NASREC.

- Where the PI desires to extend the study after expiry of the study period, documents for study extension must be received by NASREC at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Documents received within 30 days after expiry will be labelled "late submissions" and will incur a penalty fee of K500.00. No study shall be renewed whose documents are submitted for renewal 30 days after expiry of the certificate.

- Every 6 (six) months a progress report form supplied by The University of Zambia Natural and Applied Sciences Research Ethics Committee as an IRB must be filled in and submitted to us. There is a penalty of K500.00 for failure to submit the report.

- When closing a project, the PI is responsible for notifying, in writing or using the Research Ethics and Management Online (REMO),both NASREC

- and the National Health Research Authority (NHRA) when ethics certification is no longer required for a project.

- In order to close an approved study, a Closing Report must be submitted in writing or through the REMO system. A Closing Report should be filed when data collection has ended and the study team will no longer be using human participants or animals or secondary data or have any direct or indirect contact with the research participants or animals for the study.

- Filing a closing report (rather than just letting your approval lapse) is important as it assists NASREC in efficiently tracking and reporting on projects. Note that some funding agencies and sponsors require a notice of closure from the IRB which had approved the study and can only be generated after the Closing Report has been filed.

- A reprint of this letter shall be done at a fee.

- All protocol modifications must be approved by NASREC by way of an application for an amendment prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address or methodology and methods. Many modifications entail minimal risk adjustments to a protocol and/or consent form and can be made on an Expedited basis (via the IRB Chair). Some examples are: format changes, correcting spelling errors, adding key personnel, minor changes to questionnaires, recruiting and changes, and so forth. Other, more substantive changes, especially those that may alter the risk-benefit ratio, may require Full Board review. In all cases, except where noted above regarding subject safety, any changes to any protocol document or procedure must first be approved by NASREC before they can be implemented.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of NASREC, we would like to wish you all the success as you carry out your study.

Yours faithfully,

*Dr. Mususu Kaonda*

**VICE-CHAIRPERSON**
**THE UNIVERSITY OF ZAMBIA NATURAL AND APPLIED SCIENCES RESEARCH ETHICS COMMITTEE - IRB**

cc: Director, Directorate of Research and Graduate Studies
Assistant Director (Research), Directorate of Research and Graduate Studies
Assistant Registrar (Research), Directorate of Research and Graduate Studies

## 8.4 Published Paper by International Journal of Novel Research and Development.

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An International Open Access, Peer-reviewed, Refereed Journal

# AN ASSESSMENT OF THE EFFECT OF ENERGY MIX ON ENERGY DEFICIT IN ZAMBIA: A CASE STUDY OF 10 MILES IN CHIBOMBO DISTRICT.

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**UNIVERSITY OF ZAMBIA**

**LUSAKA**

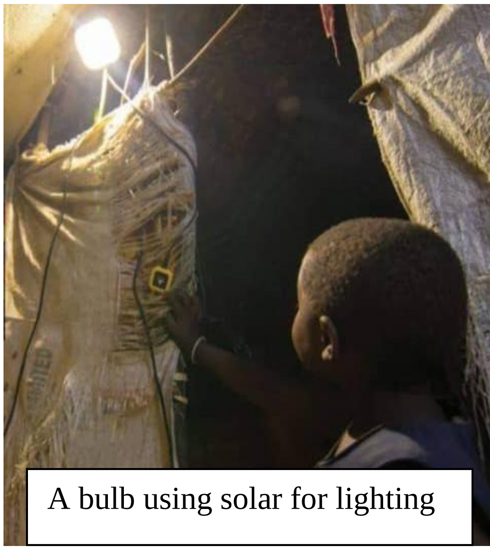
**2023**

**Abstract**

This abstract is based on the study conducted in 10miles of chibombo district of central province. 10 miles experiences energy deficit just like many parts of Zambia. Zambia largely depends on hydroelectricity but hydropower has a fatal flaw. Drought has lowered water levels to the point where power production is severely curtailed. Droughts in recent years have produced electricity shortages estimated at nearly one-third of Zambia's total installed hydroelectric capacity of 2,380 megawatts. Despite these studies, little attention, if any, has been paid to the effect of the mix of different energy technologies on energy deficit in the study area.

The extent of the effect of energy mix on its accessibility and availability at 10miles was not known to the researcher. This created a problem worth investigating. Previous studies such as Kaela's (2018) predicted the energy mix levels of Zambia by the year 2050 but did not discuss the extent of its effect on its accessibility and availability in the study area, the gap this study wished to assess. If the extent of the energy mix on energy deficit was not investigated, 10 miles area would have continued exploiting detrimental activities such as charcoal production.

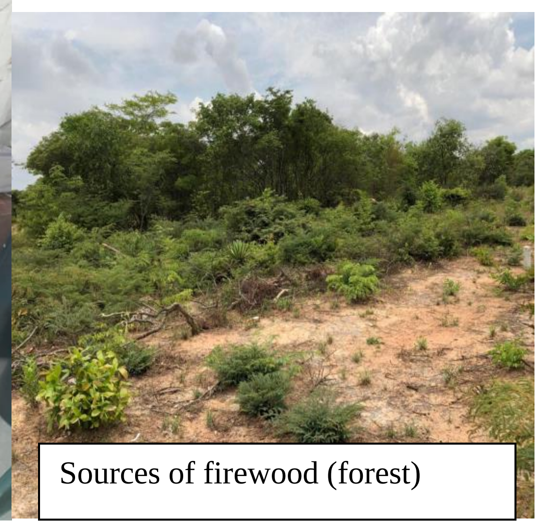
**8.5 Pictorial presentation of some sources of energy observed at 10 Miles.**



A bulb using solar for lighting

Solar equipment used for lighting and charging phones by villagers

Use of LPG



Sources of firewood (forest)

Cooking using firewood