A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

Transition to renewables and the impact on energy poverty in Kenya

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July 2020

Budapest

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ABSTRACT OF THESIS submitted by: Trizer OMUGAR for the degree of Master of Science and entitled: Transition to renewables and the impact on energy poverty in Kenya.

July 2020

Renewable energy (RE) is increasingly being fronted as the energy future in response to climate change discourses and global impacts. Worldwide, nations are pursuing different energy transition pathways but with the common agenda of reducing greenhouse gas emissions and developing or sustaining their economies. Africa's energy transition studies are unique in that they involve more of expansion and modernization of their RE systems rather than shifting from heavy fossil fuels as exemplified by Kenya; one of the continental leaders in RE transitions. The current energy transition is exposing energy poverty as a considerable challenge to Kenya's energy demands and future socio-economic development goals. Despite the uniqueness demonstrated in Kenya and Africa as a whole in energy transition, research on the drivers and hindrances towards their transition pathways are comparatively scarce. Studies on the interconnection between energy poverty and energy transition are also limited. Hence, this research sheds light on Kenya's energy transition and energy poverty nexus by using qualitative interviews and literature review. The results of this research demonstrate that Kenya's RE systems are highly associated with techno-economic, socio-technical and political drivers and the challenges facing the transition are related to gradual rate of change experienced in institutional, financial, policy and social frameworks. Additionally, the energy poverty nexus to energy transition indicate that the availability of RE has increased significantly, while accessibility, affordability and reliability are still lagging. This research concludes by recommending that energy poverty should not be sidelined in the transition process and calls for the holistic integration of all RE technologies and sectors if the ambitious transition targets are to be attained.

Keywords; climate change, energy poverty, energy transition, renewable energy, Kenya, political, socio-technical, techno-economic

Acknowledgements

This thesis would not have been a success without the constant support and strategic guidance of my thesis supervisor Prof. Michael LaBelle who devoted his time from the start of the proposal writing to the completion and submission of this thesis.

Special thanks to Prof Aleh Cherp for his wonderful insights into the energy transition and climate change cluster courses that culminated into this thesis.

Immense gratitude goes to my faculty advisor, Prof Alexios Antypas who walked the entire graduate school journey with me while providing the needed academic, professional and personal nourishment and encouragement.

Special thanks to the Head of Environmental Science and Policy Department, Prof Laszlo Pinter whom I consulted with on a regular and provided a 'breathing space' in between thesis writing for the departmental students. By extension, I'm grateful to all the faculty and staff of my department for support and insights in the academic journey.

To my parents Mr. Omugar Oriango and Mrs. Monicah Omugar, thank you for the inspiration, the support and the push to finish this degree.

To Kalosh, Lavly, S.T and Mau Tum, Stijn, you are amazing!

To my siblings and friends, you encouraged me throughout the whole process, and I am indebted to you forever.

Lastly, to the wonderful MESP classmates, you were the G + G and we did it. To the MESPOMers, thank you for being part of the family and for always encouraging us to finish the thesis and for co-creating with us imprints on the world canvas.

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List of Abbreviations

AREI- Africa Renewable Energy Initiative

BAU- Business As Usual

CBO- Community-Based Organization

CSOs- Civil Societies

ERB- Electricity Regulatory Board

ERC- Energy Regulatory Commission (ERC)

EU- European Union

FiTs- Feed-In-Tariffs

GDC- Geothermal Development Corporation

GDP- Gross Domestic Product

GESIP- Green Economy Strategy and Implementation Plan

GW- Gigawatts

IEA- International Energy Agency

IPP- Independent Power Producers

IRENA- International Renewable Energy Agency

LDCs- Least Developed Countries

LTWP- Lake Turkana Wind Power

LPG- Liquid Petroleum Gas

KenGen- Kenya Electricity Generation Company

KETRACO- Kenya Electricity Transmission Company

KOSSAP- Kenya Off-Grid Solar Access Project

KPLC- Kenya Power and Lighting Company

KWh- Kilowatt hour

LEDS- Low Emission Development Strategies

LULUC- Land Use and Land Use Changes

MW- Megawatts

MtCO2eq- Metric tonne of CO2 equivalent

NCCAP- National Climate Change Action Plan

NDC- Nationally Determined Contribution

PIDA- African Union Programme of Infrastructure Development in Africa

PAYG- Pay-As-You-Go

PJ- Picojoule

PV- Photovoltaic

UN- United Nations

VAT- Value Added Tax

RD & D- Research, Development and Dissemination

RE- Renewable Energy

REREC- Rural Electrification and Renewable Energy Corporation

SDGs- Sustainable Development Goals

SHS- Solar Housing System

Chapter 1.

1.1 Introduction

In response to climate change and the volatility of oil markets, global discourses have transitioned into discussions of cleaner, sustainable and low -carbon energy production and consumption. Renewable energy (RE) has consequently been thrust as the future of energy, and the members of the United Nations (UN) are continuously re-evaluating their energy needs and opting for sustainable development (IPCC 2018). Cherp *et al.* (2017) infer that this type of transition to renewable energy and cleaner energy is more evident in developed nations which have primarily been heavy users of fossil fuels in their national energy mixes and has resulted into some level of global greenhouse gas emission reductions for these countries. In contrast, Kazimierczuk (2019) notes that most developing nations have not recorded as high greenhouse gas emissions as the developed nations, while some countries have negligible emission statistics on the global scale. The low emissions records are because the industrial and economic development of these developing countries did not utilize higher non-RE in comparison to their developed nation counterparts. Despite that, the brunt of climate change is transboundary; hence the developing nations have also been necessitated to transform their energy systems, expand and modernize their renewable energy systems while endeavoring to reduce energy poverty.

Energy transitions require "*a change in the state of an energy systems''* (Cherp *et al.* 2018), and holistically, this involves changes in the techno-economic, socio-technical and political drivers of energy. Therefore, it is imperative that RE transition studies that evaluate the modern scenarios of RE expansion, and the drivers and hinderances are carried out for the development of informed global and localized energy and climate change policy discourses. Countries are at different stages of energy transition and prioritize different components, depending on their national needs. Due to a myriad of hindrances, it is worth mentioning that there is not a single country in the world that has managed a full transition into a low carbon economy to date (Egging and Tomasgard 2018). According to the IPCC reports (IPCC 2018), coal still plays a significant role in most economies; thus countries committing to RE transition need to be studied to evaluate how they intend to achieve their transition goals and if their pathways to RE are replicable to economies in similar economic growth trajectories.

The transition towards renewables has been unique for most African countries due to the availability of RE resources yet scholarly research on African countries energy transition studies are scarce. Kenya has emerged as one of the RE transition trendsetters in Africa's energy sector (Kazimierczuk 2019) and, just like its counterparts, it has adequate RE technologies driving the energy transition process and significant hindrances that are delaying the transition process (IEA 2019; IRENA 2019b). Notably, its quest for transition has been facilitated by its historical utilization of more RE in comparison to non-renewable energy, with RE accounting for 70 % of the total national production by 2018 (IEA 2019). However, analysis of other transition drivers would be useful in developing a broader picture of the transition process in Kenya and for future studies to evaluate the general differences in energy transition studies between developed and developing countries. Further, Kenya is currently on a mission to attain a low carbon development pathway while also transitioning to a middle-income status by 2030 (Government of Kenya 2018), which renders insights on the feasibility on an RE transition as important – a knowledge gap which this research aims to address .

Sovacool (2012) defines energy poverty in developing countries as being limited by accessibility, availability, affordability and reliability of energy technologies and Kenya meets these evaluation criteria. As the transition to RE is on-going, energy poverty remains a global challenge, especially in developing countries. The UN Sustainable Development Goals (SDG) goals call for universal access to energy by 2030, while George *et al.* (2019) records that 1.3 billion people still do not have access to energy. Shockingly, 90 % of the population without access are based in the Sub-Saharan Africa and some parts of Asia. With over 70% of the population still living in rural areas (World Bank 2019) and with a rising urban poor population, Kenya's energy poverty disproportionately affects these disadvantaged population in the transition pathway. Understanding how Kenya aims to reduce energy poverty throughout its energy transition pathway would be an insightful policy and program interlinkage that requires a detailed research. Based on the current RE policies and programs, a reduction of energy poverty would signify increased availability, affordability, reliability and accessibility of RE technologies and a consequent boost in the economic growth of the country.

1.2 Thesis aims and objectives

This research aims to explore how Kenya addresses energy poverty in its energy transition pathway by providing empirical knowledge, updates and understanding of the energy transition to renewables in Kenya and its nexus to energy poverty. Further, the objectives of the research are:

a. To analyze the drivers of the transition to renewable energy in Kenya,
b. To identify and evaluate the challenges facing the transition to renewable energy in Kenya, and
c. To analyze the impact of the transition to renewables on energy poverty in Kenya.

The research questions aim to fulfil the objectives of the research, and they include:

1. What are the drivers of the transition to renewable energy in Kenya?
2. What hinders the transition to renewable energy in Kenya?
3. What are the impacts on energy poverty that emanate from the transition to renewable energy transition in Kenya?

The findings of this research are generalizable for other energy problems in developing countries facing similar energy challenges. Therefore, the research may be useful for energy practitioners in understanding the frameworks of the modern energy transition to renewables, the challenges faced and the linkage between energy transitions and energy poverty. The findings may also provide recommendations to policymakers, civil societies and private sector actors in Kenya on what should be prioritized in the interlinkage of the two concepts in order to reduce greenhouse gas emissions, grow the country's economy and improve the well-being of the citizens.

1.3 Structure of the thesis

The thesis is divided in six chapters. Chapter one introduces the background and the aim and objectives of the research. Chapter two begins with a review of the literature and theoretical framework on the energy transition, structured under reviews at the global scale, followed by the review on Africa and finally on Kenya energy and policy transition scenario. Literature review is also done on the global, regional and national perspectives on energy poverty and finalizes with the interconnectedness of the energy poverty and transition to RE. Chapter three consists of the methodology section and provides a description of qualitative interviews and review of literature as the methods applied in this research. Chapter four describes and analyzes the research findings, expanding on the themes from chapter three. Chapter five discusses the findings of the research while showcasing how they correspond to the theoretical framework applied and thereafter provides recommendations to energy sector stakeholders and provides areas of future research to scholars. Lastly, Chapter six which serves as the concluding chapter, presents a summary of the research findings to Kenya and the wider implications of the transition to RE and its impact on energy poverty.

Chapter 2. Literature review

2.1 Structure of the literature review

This literature review provides the theoretical and conceptual frameworks, and past research efforts, which exposes knowledge gaps that this research aims to fill. The literature review section is divided into two sections. First, a review of the global history of energy transition provides the basis for the focus on energy transition in the developing countries' context, mainly through the experiences of Africa and subsequently Kenya. A review of modern energy transitions from fossil fuels to RE explores how these transitions influence national choices of energy systems in developing countries. Furthermore, in the second section, the literature review describes the scale of global energy poverty, focuses on developing countries, and narrows down to Kenya's energy poverty scenario. This section provides a detailed description of the leading energy poverty challenges, especially in the developing countries and concludes by locating the intersectionality of energy transition and energy poverty in Kenya.

2.2 Global energy transition

There is no single unifying definition or theory on energy transition and over the years, various scholars have postulated an array of theories and definitions, based on the different parameters that they were looking into. Brown (1976) is among the first scholars to define energy transition and his description focused on historical and futuristic perspectives of energy, by viewing nuclear technology as a long-term replacement for fossil fuels, albeit the current controversies around nuclear power. To think beyond a single technology as an impetus for energy transition, Grübler (2012) defined it as a change in energy system that also incorporates institutional systems and energy markets. To expand the definition by Grübler (2012), Cherp *et al*. (2018) postulated a meta-theoretical framework on three energy transition perspectives— techno-economic, socio-technical and political perspectives— that have characterized the debate on the definition of energy transition from the numerous scholars.

The societal needs and human ingenuity have influenced the evolution of energy transitions from back in history, to present scenarios and to future projections. The First Industrial Revolution Era characterized the rapid transition from biomass to fossil fuels technologies such as coal, oil and gas, majorly in the now developed countries (Egging and Tomasgard 2018). On the other hand, Grubler *et al.* (1999) reports that most of the developing countries did not undergo the energy transition exhibited during the First Industrial Revolution (1720). The later part of the 20th century and the 21st century have seen a surge in global calls to transition from fossil fuels to RE, in order to reverse the emissions from greenhouse gasses emitted from the overexploitation and use of fossil fuels and to subsequently mitigate against climate change (Grubler *et al.* 1999; Van den Bergh and Bruinsma 2008)

The global energy transition pathways are influenced by technological, economic, political, social and environmental factors, each of which play different roles in different countries' energy transitions (Grübler *et al.* 1999; Grübler 2012; Cherp *et al.* 2018). Egging and Tomasgard (2018) infer that a combination of these factors has further determined whether a country opts for a decentralized or centralized energy system or a combination of both systems. Centralized systems have historically been the most preferred though, the current trends indicate a preference for both systems and increased visibility for off-grid systems (Egging and Tomasgard 2018). Despite the considerable progress recorded in these transitions with the aim to achieve universal access to energy, in absolute terms, all countries still experience some forms of energy poverty, with the European Union representing the least levels. In contrast, Sub-Saharan Africa and parts of Asia record the highest levels (IEA 2019). The current transition to RE presents new opportunities and challenges for energy poverty and more so for the developing countries. Against this backdrop, this thesis aims to understand how choices on national energy transition affect energy poverty levels, particularly in Kenya.

Cumulatively, these studies on energy transition imply that the energy transitions are complex and have evolved with the global changes in technology, markets/economics, society and policies. The theoretical framework by Cherp *et al.* (2018) that will be applied in this research gives room for the integration of all if not majority of the energy transition requirements especially in the 21st century. The techno-economic perspective of the theoretical framework provides for analysis on how energy flows from extraction to consumption, which may pan out differently between centralized and decentralized systems. The same techno-economic perspective can be used to define the current energy transition from fossil fuels to RE that involves largescale extraction and production of renewable technology and with the consecutive consumption being determined by market flows and economic power of individual countries. On the socio-technical front, the diffusion of energy technologies is indicated by the level of societal acceptance and knowledge, and this has been a critical parameter in the transition to renewables and in the decentralization of energy systems to bridge the energy poverty gap (Devine-Wright *et al.* 2012; Karlstrøm and Ryghaug 2014). Lastly, the political perspective provides the foundation for anchoring energy legislations, with global, regional and national policies determining and influencing how the techno-economic and socio-technical perspectives interact to define energy transition pathways. Therefore, this research which forms only a small part of the larger system will complement on the application of this meta-framework analysis on energy transition at a national level, using Kenya as a case study.

2.2.1 Energy transition from fossil fuel to renewable energy

There are various factors that result in systemic transitions of energy requirements of a society. Extensive energy transition studies (Grübler 1999, 2012; Cherp *et al*. 2018; Verbong and

Loorbach 2012; Van den Bergh and Bruinsma (2008) have been conducted and comparisons made among different countries and this literature will extensively discuss the factors leading to these transitions while pointing out scenarios in Africa. Bridge *et al.* (2013); Cherp *et al.* (2018) and Karlstrøm and Ryghaug (2014) argue that the key factors that have determined historical energy transitions have been embedded on the roles played by energy technologies and the conversion technologies, as well as political economy and geographical analysis.

The pre-industrial era depended on animal and human power — ranging from water, wood and solar energy—to meet the energy needs and had to deal with challenges relating to efficiency, reliability and accessibility of energy systems. The modernization of energy systems in the industrial revolution period solved most of the challenges of pre-modern societies but introduced new and more insurmountable challenges. While coal, oil and nuclear energy technologies provided large scale options for diversified, affordable, accessible and reliable energy sources, they equally posed serious ecological sustainability and climate change threats. Hence, Bridge *et al.* (2013) and Van den Bergh and Bruinsma (2008) rightfully points out that the goal of current modern energy transition emerged due to global geopolitical aim of providing low carbon development while increasing accessibility, affordability and reliability of the energy technologies, which this research will demonstrate using Kenya as the case study.

When the share of RE grows faster than those of non-renewable energy, then the changes can be termed as transition to cleaner energy (Isoaho, Goritz, & Schulz 2017). Energy transitions from fossil fuels to RE can be traced back to the end of the industrial revolution era. In the 1960s and 1970s, scholars began postulating and making projections about the limits to growth while pointing out the finite nature of natural resources such as coal and oil and rallied for sustainable transitions to alternatives (Carson 2002; Meadows 1972). These reports have motivated the innovation and studies on alternative energy technologies that do not bear negative externalities to the environment, nor fuel global warming and climate change (Nakicenovic *et al.* 2000). These transition studies have taken various definitions ranging from sustainable energy (Steg *et al.* 2015), to RE (Nakicenovic *et al.* 2000) and Low Carbon Emission/Development and are often used interchangeably since they all aim towards ensuring that the socio-economic activities of the society completely or significantly reduce the emission of greenhouse gasses.

According to Grübler (2012) and Verbong and Loorbach (2012), the shift from fossil fuels to RE options have been gradual and majorly regional or country specific. Reports from IPCC and International Environmental Laws have been fundamental in centering political changes towards low carbon development (Nakicenovic *et al.* 2000). Additionally, concerns of energy security posed by the changes in market prices, oil shortages— especially after the 1st global oil crisis of 1973 (Johnson and Silveria 2014)—, war and political tensions and geopolitical rivalries have necessitated countries that do not produce large shares of oil and coal to re-evaluate energy options. To comprehend the differences in continental energy transitions, this research will compare the energy transition pathways in the European Union in this section and that of Africa in the next section.

The European Union (EU) has been at the forefront in championing for member states to transition towards RE primarily due to the political uncertainties and volatilities it has with Russia, — a leading oil and gas producer and supplier to some EU countries— compounded with the need to demonstrate global leadership in tackling climate change (Langsdorf 2011). In 2008, energy related emissions from the EU accounted for 80% of all emissions in the region, despite having had emission reduction targets set as early as the mid-90s. The emission reduction targets have since been updated and more ambitious goals set (European Union 2018). The European Union (2015) and European Union (2018) reports that the EU climate and energy strategies and targets encompass a 20 % cut in greenhouse gases from the 1990 levels, a 20% increase in RE use and another 20 % increase in energy emission reduction targets are enshrined in EU Renewable Energy Directive.

Further, Langsdorf (2011) reports that the long-term goal of EU is to ensure that by 2050, the region is carbon neutral with net-zero greenhouse gas emission that is aligned to the European Green Deal and Paris Agreement. Studies done by Climate Tracker (2020) indicate that as a result of the concerted efforts put by the EU member states, the shares of RE in total energy generation capacity grew by 30% in 2017 and 32% in 2018, signaling a 9% and 4% reduction of emissions from coal and lignite respectively. Nonetheless, majority of these countries are still heavily reliant on their coal, oil, gas and nuclear energy reserves to run their economies and will need to shut all of them down or ensure that the carbon trading markets are increased, if the ambitious 2050 goals are to be met (European Union 2018). The challenges—intermittency, reliability, food-fuel debate— presented by some RE technologies such as solar, wind and bioenergy equally compound the feasibility of a world run purely on RE.

As the research discusses RE in Africa and then Kenya in the sections below, it will become evident that the definition of energy transition within that region is quite different from the discussion on EU, despite the mutual similarity on low carbon development.

2.2.2 Renewable energy transition in Africa

The energy transition in developing countries and particularly Africa has not been extensively studied as other parts of the developed and developing world (Mandeli *et al.* 2014). At the same time, the energy transition studies that have been done are either country or region-specific. The rapidly growing population and economic development in Africa, especially in Sub-Saharan Africa, signify an increase in demand for energy and increase in GHG emissions, thus necessitating the need for radical measures that ensure the sustainability of the energy systems for population growth sustenance (IEA 2019). A delicate dilemma presents itself in the choice between socio-economic development and environmental conservation, with considerable studies (Pachauri & Spreng 2004; Bazilian *et al.* 2014; IEA 2011) arguing that it is highly likely that most African countries will choose economic development over conservation and climate change mitigation.

Sub-Sahara Africa is fronted as one of the fastest growing economies worldwide— grown by more than one-third between 2010 and 2018—, and notably Ethiopia, Rwanda and Kenya have recorded high parallel growth rates in population, economy, and energy demand (IEA 2019). Additionally, Sub-Saharan Africa accounts for the highest number of low development matrix and IEA (2019) reports indicate that 40% of the population within the region still live below the poverty line, measured at less than $1.90 per day. The low level of focus on Africa's energy scenarios amidst a rapidly changing global population and climatic conditions presents an opportunity for this thesis to contribute to the scholarly literature on the changes in energy systems in an African country- Kenya.

An analysis of African countries portrays wide variations on energy intensiveness, with the Northern Africa countries, Nigeria and South Africa commanding a larger share of energy reserves, production and consumption (IEA 2019). Nonetheless, historical analysis indicates that the use of fossil fuels such as coal and oil has not been as intensive in the continent as in developed countries, hence the energy transition has been a bit different in relation to the other developed countries. Statistically, the greenhouse gas emissions from Africa have been negligible on a global scale, represented by 2% of the global energy use (IEA 2019). Despite the differences and low carbon intensity within the region, the transition to cleaner RE has not been smooth and the region is yet to attain full transition. In response to global and continental climate change discourses, the hinderances for the transition to cleaner RE technologies, despite the endowment with RE resources presents a research inquiry.

Kazimierczuk (2019) implies that the best description of the energy transition in Africa should be termed as modernization and expansion of energy systems as opposed to the intensive shut down of non-renewable energy plants and carbon trading that is being carried out in most of the industrialized countries. Like the EU and other regions of the world, the need for accessible, reliable and affordable energy and the global discourses advocating for action against climate change and ecological degradation have propelled the ambitions of African countries to join in the shift to cleaner and sustainable energy. To achieve continental targets, some common policies and development initiatives have been put in place to aid in the transition to low carbon pathways, namely; Africa Renewable Energy Initiative (AREI), Low Emission Development Strategies (LEDS), the African Clean Energy Corridor, the African Union Programme of Infrastructure Development in Africa (PIDA) (Kazimierczuk 2019).

On the transition to renewables, Africa presents some level of uniqueness in that, a significantly higher portion of the total continental supply and consumption of energy is derived from RE (IEA 2019). The geographical location of the continent puts it at an advantage in generating solar, wind and bioenergy, coupled with the high hydropower and geothermal potential. Despite the abundance of RE sources, only 46,269 MW of the total capacity has been harnessed by 2018, up from 26,097 MW in 2009, as shown in figure 1 below (IRENA 2019b; IEA 2019). Statistical mapping and recording of energy transitions did not commence as early as in the industrialized countries, and this presents a lacuna in the historical analysis of energy progressions and comparisons across temporal and spatial scales. Accurate data from IRENA and IEA occur mostly from the late 1990s to 2019, and this will, therefore, form the focus of the research while tracking energy transitions in Africa.

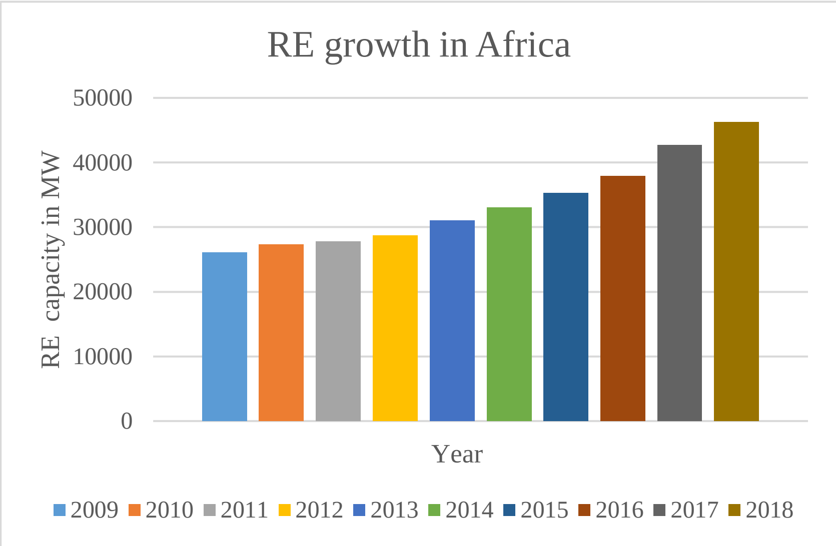

Figure 1: Total RE capacity in Africa by 2018. Source; IRENA 2019

To get an in-depth understanding of the energy modernization and expansion in Africa, the section below discusses the two energy sources that are revolutionary in the transition to RE sources and one that is controversial despite it being a dominant source of energy in the continent and equally, the determinants of RE transition in Kenya.

a. Wind

Wind energy is a crucial source of energy worldwide and is gaining prominence in Africa (IRENA 2019a). Kazimierczuk (2019) notes that the total wind energy potential for Africa stands at 109 GW, and projections indicate that all factors constant, the production will increase four-fold by 2020, representing 21,000 MW. The countries with the highest onshore production potential are Somalia, Sudan, Libya, Mauritania, Egypt, Madagascar and Kenya while those with high offshore potential include the coastal regions of Madagascar, Mozambique, Tanzania, Angola and South Africa. By 2017, only 4370 MW had been harnessed and of the total, 84 % was predominantly concentrated in only 3 countries namely; South Africa, Egypt and Morocco. Additionally, wind energy production has exclusively been onshore but with a mix of centralized and decentralized systems (IRENA 2019b, IEA 2019, Kazimierczuk 2019).

The challenges towards the realization of the full potential of wind energy in Africa are captured in the meta-theoretical framework postulated by Cherp *et al.* (2018). Kazimierczuk (2019) indicate that despite the ambitious targets that have been set, there aren't any wind energy policies set within the continent or even at national levels, except for Kenya. This signifies the importance of legislative guidance and good governance in ensuring that techno-economic and socio-technical aspects of energy transitions are met. IRENA (2019a) supports this by adding that the production of wind energy is capital intensive and most African countries being reliant on donor funding for development projects, signify ingrained dependency syndrome that stalls legislative and development aspirations. Standing out of the crowd is Kenya, which has recently enacted legislative reforms by formulating an Energy Act 2019, Kenya Vision 2030 and the Kenya Rural Electrification Master Plan which created a conducive environment for investment in RE (Kazimierczuk 2019). Following such reforms, this research will evaluate the extent to which RE, and mainly wind energy has been supported to address the transition as well as energy poverty issues in Kenya.

b. Solar energy

Solar energy is the fastest growing and with a recurrent growth alternative source of energy (IRENA 2019a). Solar energy is fronted as a key solution in the transition to low carbon development worldwide and by 2018, approximately 468 GW of solar PV had been installed against an average power potential of 24W/m2 of the earth's surface (Adelakun & Olanipekun 2019). A key advantage of solar energy is the ease of conversion to either grid or off-grid technology and the introduction of Pay-As-You-Go (PAYG) models and Feed-In-Tariffs (FiTs) (George *et al.* 2019). The popularity of solar energy is due to the adequate supply, storage and the ability to generate clean energy that conforms to the global discourses on emission reduction.

Global comparisons rank Africa the highest in terms of abundance of solar resources, with 90 % of the total global horizontal irradiation (GHI) (IRENA 2019b; Prăvălie, Patriche, & Bandoc 2019). Adelakun & Olanipekun (2019) estimates that the total installed solar capacity for Africa in 2018 was 6093 MW and this represents a very negligible fraction of the total global solar installations. Nonetheless, the 2018 statistics of solar capacity still reflect an influx in solar installation since at the onset of the decade, the statistics record were meager to zero installations in Africa. Thus, despite the abundance and global lead in GHI, the continent does not feature among the top countries or regions with the highest installation capacity, since China (175.03 GW) takes the lead, followed by Japan (55.50 GW) and USA (51.45 GW). As of 2018, South Africa had the highest installation of solar PV in Africa (2.96 GW), followed by Algeria, Morocco and Egypt, which again represents the dominance of energy production and consumption by South Africa and North Africa (Adelakun & Olanipekun 2019; Prăvălie, Patriche, & Bandoc 2019). Figure 2 below shows a sample of some countries' solar installation capacity. Just like wind energy, solar energy is also under-developed and remains largely unexploited. Abdullah *et al.* (2011) and George *et al.* (2019) recommend that with adequate investment in technical, political economic and institutional technologies, the transition to renewables in Africa can be powered by solar energy, especially in the solar hotspot regions of the Sahara, Namib, Kalahari and Karoo Deserts.

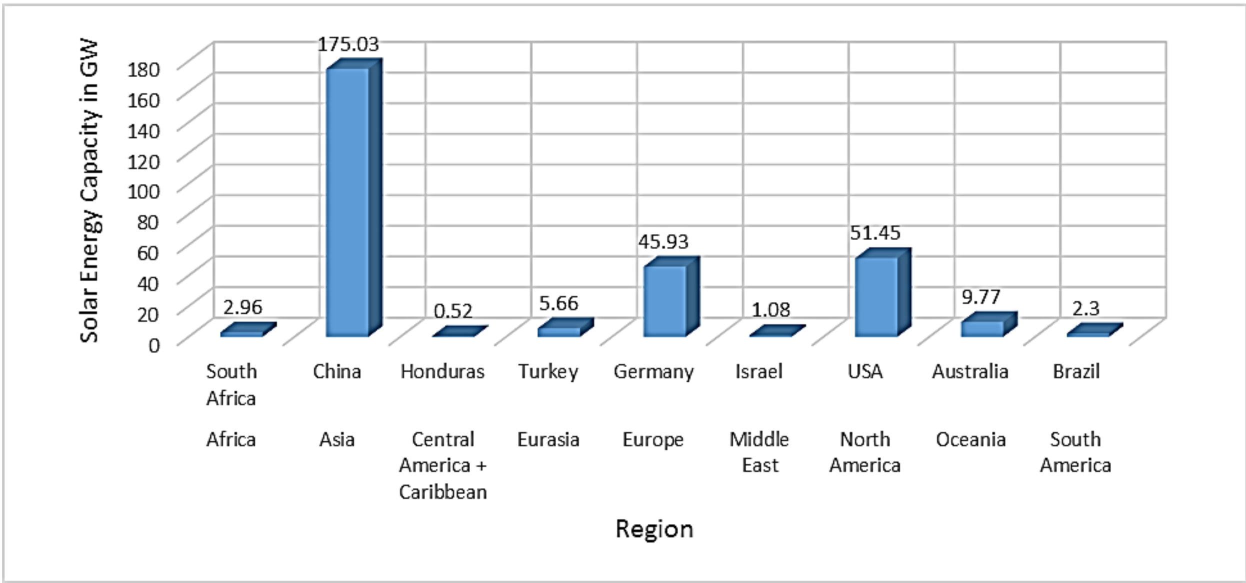

Figure 2: Solar power capacity in GW. Source- Adelakun & Olanipekun 2019

c. Biomass

Biomass is one of the most vital sources of energy even before human civilization and provides the primary source of energy for billions of people globally. In Africa, biomass is derived from forests, woodlands, bushes, farmlands and industrial residues. Based on the recent reports by IEA (2019), solid biomass presents the largest source of energy for Africa since it accounts for 44 % of total energy. Biomass is predominantly produced off-grid but there are instances where the production is centralized and due to this uniqueness, the socio-technical analysis best applies in the analysis of energy transition pathway for biomass (Johnson & Silveira 2014).

Globally, controversy abounds with the classification of biomass as RE due to its unsustainability that compounds deforestation, land use and land use changes (LULUC) and emission of greenhouse gases. In most African households, solid biomass is still utilized in a traditional manner hence very inefficient, wasteful and results in massive environmental degradation and human health complications to the respiratory system (Karanja and Gasparatos 2019). The majority of the households and institutions, especially in the rural areas use open, three-stone fires that use enormous amounts of wood fuel, charcoal or cow dung for the preparation of limited amount of food which is highly inefficient and inhibitive for the RE transitions (Karanja and Gasparatos 2019). The household biomass energy use is largely unaccounted for in the total national and regional energy indices due to challenges of monitoring of household energy use (Kiplagat, Wang and Li 2011).

The popularity of biomass is due to the ease of access and abundance of the resource and the relative affordability in comparison to other sources of energy for the majorly rural poor population (Senelwa and Hall 1993; Hoogwijk 2005; Kiplagat, Wang and Li (2011). For instance, Wicke *et al.* (2011) estimate that the full techno-economic potential of the most accessible fuelwood in Sub-Saharan Africa is 4000 PJ y^{-1}, while bioenergy production from cassava ethanol is 300 PJ y^{-1} and jatropha biodiesel is 600 PJ y^{-1}. IEA (2019) argues that if sustainable used— improving efficiency e.g. use of briquettes, bioethanol, biogas, pellets; modernization of cookstoves and other cooking and lighting technologies; regulated harvesting of biofuels—, bioenergy can potentially assist in bridging the gap between rural energy poverty and reduction of carbon intensity.

Over the years, Africa has seen an increase in the deployment of modern bioenergy technologies. Malawi which is classified as one of Least Developed Countries in Sub-Saharan Africa, has managed to emerge and pioneer the use of jatropha to produce bioethanol for transport, cooking and rural electrification programs (Johnson & Silveira 2014). Karanja and Gasparatos. (2019) studied the adoption of clean bioenergy cookstoves in Kenya and concluded that the increase in commercialization of such cookstoves has resulted in a higher shift towards clean cooking in the urban areas. Additionally, legislative frameworks are being formulated to include the important role of bioenergy in the energy transition narratives and practices.

Ethiopia, Nigeria, Côte d'Ivoire, Botswana, Burkina Faso, Cameroon, Gambia, Ghana, Kenya, Liberia, Sierra Leone, South Africa, Tanzania and Zambia now have either formulated or are in the process of formulating bioenergy policies (Johnson and Silveira 2014; Karanja and Gasparatos 2019; IEA 2019). Therefore, the shift to modernization of biomass technologies as illustrated in this analysis of literature affirms Kazimierczuk (2019) inference about RE transition in developing countries and that the sustainable production and consumption of bioenergy can propel the transition to clean energy in Africa.

The transition — modernization and expansion— of bioenergy technologies in Africa has been met with as much challenges as those of wind energy technologies. On top of the list, is the socio-technical perspective where Everett (1995) noted that the *"the social system determines the rate of adoption of a technology***".** The modern energy transitions have changed the utility-customer relationship, with a significant shift to prosumers (Sioshansi 2017). In Africa, the demand-supply of biomass leans on the former, hence exerting undue pressure on the ecosystems and the resultant impacts on climate change. The global debate on food-fuel that results in large scale production of biofuels has been met with mixed reaction; one side is oblivious of the impacts on the ecosystem and are grateful for the job opportunities and provision of energy, while the other side are opposed to the preferences on bioenergy due to LULUC (Araujo *et al.* 2017; Moula *et al.* 2017). The cost and accessibility factors of traditional solid biomass makes it more popular among consumers in Africa and without changes in the income and low awareness about the need for the transition, most users will still continuously use the traditional energy acquisition and consumption methods. Another challenge with the modernization of technologies involves the limited knowledge and expertise of repair and maintenance of these technologies, especially in the rural areas which results in the run-down or abandonment of these technologies. The modernization of the bioenergy technologies increases the production costs which are then passed to the consumer, hence disenfranchising the poor from acquisition even if they have the will and knowledge pertaining to the transition (Karanja & Gasparatos 2019)

2.2.3 Renewable energy transition and policy scenario in Kenya

Since the research is focusing on Kenya's energy transition, it is essential to contextualize the literature in relation to similarities and differences with the global transitions and other regions such as Africa and the EU. The section below will therefore, present a review of the transition to 100 % renewables as envisioned in Kenya's policy goals and a justification for the choice of the country as a case study.

Historically, the energy mix of Kenya has been more of RE (70%), and supplements with non-renewables such as coal and oil, which are imported and account for approximately 30 % of the total energy supply (IEA 2018). This confirms Kazimierczuk (2019) inference about the energy transition in developing countries which states most developing countries have availability of more RE than nonrenewable energy. The traditional dominance of RE in the country is supported by the abundance of natural reserves mainly from biomass, hydropower, wind, solar and geothermal (IEA 2018).

Kenya's per capita energy use and emissions are very low in the global scale; but having one of the fastest growing population— 48 million in 2019 (KNBS 2019)— and a Gross Domestic Product (GDP) that grows at 6 % annually by 2020, the national energy demand is projected to grow exponentially (IEA 2019). The figure below illustrates the projected increase in energy demand from all energy sources against GDP growth.

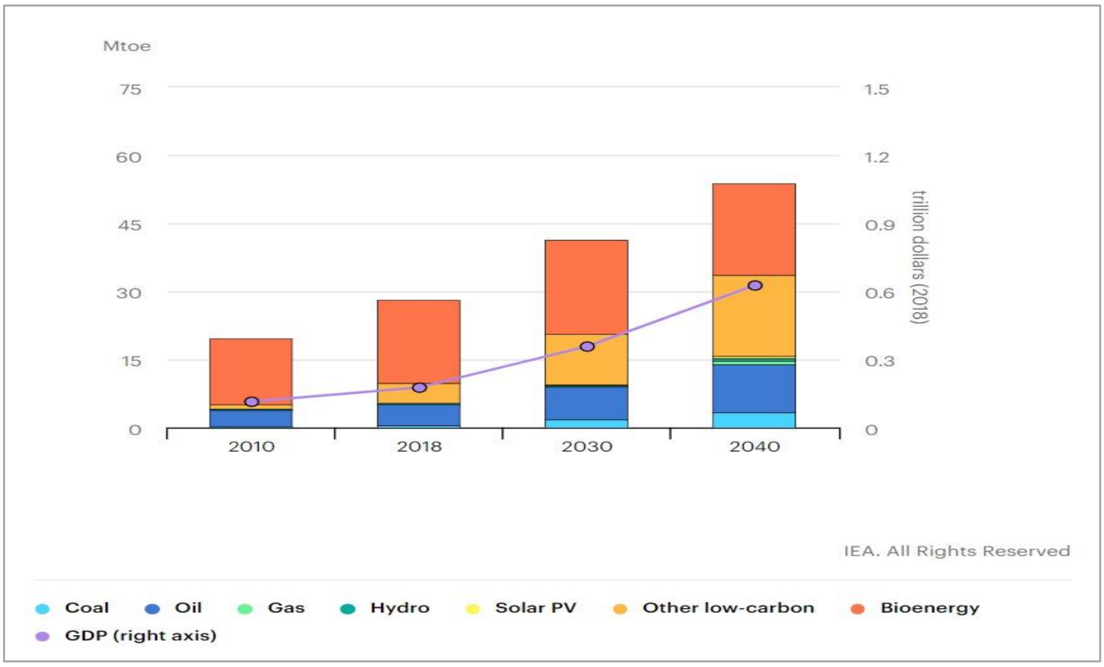

Figure 3: Kenya energy demand and GDP in the stated policy scenario 2010-2040. Source, IEA 2019

Going back into history, energy transmission in Kenya began in 1906 after the establishment of the Nairobi Electric Power and Lighting Syndicate by the colonial government. A few years later, another energy transmission company was formed known as Mombasa Electric Light and Power Company Limited (Government of Kenya 2014). The two were to be merged in 1922 to form the East Africa Power and Lighting Company which was renamed in 1983 to the current Kenya Power and Lighting Company (KPLC). Throughout these changes, the dominant energy generation capacity was heavily reliant on grid hydropower. In the early 1990s, the government was forced to expand and evaluate other energy generation options after hydropower generation was severely affected by drought. This led to the enactment of the Electric Power Act of 1997 (the "Act") by the Ministry of Energy and Petroleum. The key outcomes of the Act were the formation of the Kenya Electricity Generation Company (KenGen) —sole mandate was the generation of power— and the formation of an energy regulatory body known as the Electricity Regulatory Board (ERB). Despite the introduction of these legislative and regulatory frameworks, energy production was still low and highly inaccessible to majority of Kenyans (Government of Kenya 2014; Karanja and Gasparatos 2019).

With the entrance of a new government in 2002, some significant reforms were instituted in the energy sector. A National Energy Policy was passed in 2004 which, gave way to the formulation of the first Energy Act in 2006 (Government of Kenya 2014). The Energy Act 2006 became fundamental in the development of other energy entities that widened the capacity of the nation in energy production, marketing and consumption. Key authorities established during this era include; Geothermal Development Corporation (GDC), Kenya Electricity Transmission Company (KETRACO) and the Energy Regulatory Commission (ERC) which replaced the ERB (Government of Kenya 2014; Kazimierczuk 2019). These reforms allowed for the expansion of energy sources that are not affected by climate variabilities such as drought, particularly with the expansion of commercial drilling of geothermal along the Rift Valley region of Kenya by the state-owned GDC and from a few Independent Power Producers (IPPs) (EPRA 2020).

Despite the first major phase of reforms, energy production and supply were low due to the limited accessibility and unreliability of the main grid run by the central government. At 78%, the centralized KPLC dominates the production and supply of energy (Karanja and Gasparatos 2019). As Kenya aims to be a middle-income country by 2030, the Kenya Vision 2030 was formulated in 2008 and in it, Kenya envisions a transition to a low carbon pathway and to generate 23,000 MW of energy by 2030. To achieve the energy and climate change targets set out in Kenya's Vision 2030, more legal reforms have been instituted. The National Climate Change Action Plan (2013-2017, 2018-2022) sets out the low carbon climate resilient development agenda (Government of Kenya 2018). The Climate Change Act (2016) provides for a legislative framework for action against climate change, which includes the mitigation potential of RE. The ratification of the Paris Agreement and submission of the Nationally Determined Contribution (NDC) that puts Kenya on a greenhouse gases reduction target of 30% by 2030 relative to the BAU scenario of 143 Mt CO_2 eq. (MENR 2018). The 2018

Presidential Decree for the transition to 100 % renewables by 2020 demonstrating the political will for Kenya's desire to pursue a clean energy path (WEF 2018). More fundamentally, the enactment of the Energy Act of 2019 that provides anchorage for the requisite legal ground for energy transformation and citizen right to energy access that had been lacking in the repelled Energy Act of 2016 and in the Constitution of Kenya (The Energy Act 2019). With regards to RE, this act provides numerous opportunities. The institutionalization of the FiTs system gives confidence to investors and IPPS to increase innovative technologies, especially for off-grid energy as is observed from global national leaders of RE technologies. RE accessories and equipment receive enormous subsidies from the government as their importation has been zero rated and the VAT taxes removed (The Energy Act 2019).

These policy and institutional reforms have given room for the expansion into other renewable and clean energy options such as solar and wind energy, liquified natural gas, clean biomass and importation of deficits. Kenya's geographic location along the tropics puts it at an advantage with regards to annual longer sunlight hours. With insolation of 4-6 kWh/m, the reliable solar energy resource is reliable. With the legal recognition of IPPS, encouragement of off-grid systems as a supplement for KenGen and provision of subsidies for the solar energy sector, the production grew rapidly from the 0 MW in 2009 to 93 MW in 2018 (IRENA 2019b). An additional reason for the growth of solar energy has been the ease of technological uptake and diffusion and social acceptance. The influx of prosumer PAYG models for the low-cost solar housing systems has resulted into increased uptake of off-grid and mini-grid solar systems especially in the previously on-grid deprived, rural communities of Kenya (George *et al.* 2019; Abdullah *et al.* 2011).

Equally, the wind energy sector is fronted for high potential in the energy sector in Kenya and argued to be among the highest in Africa (Kazimierczuk 2019). O'keefe *et al*. (1984) add that the Northern and Coastal regions of Kenya have been fronted for having good wind speed and favourable topography. The production of wind energy began in the 1900s and was introduced by the European colonialist, though production stalled in the 70s and 80s due to inadequate environmental assessments and limited funding for the sector. Equally, the production was very minimal and unevenly distributed in the country as they were mainly used in some of the commercial farms run by the colonial government. The global increase of oil prices in 2006 and the progressive legal and institutional reforms in Kenya provided the impetus for re-investment in wind energy. As of 2017, wind energy contributed only 1.9 % of total energy production, representing 26 MW (IRENA 2019b). This figure is expected to rise with the commencement of production at the 310 MW wind farm at Lake Turkana Wind Power (LTWP) plant —the largest wind farm in Africa—and the licensing of four IPPs with a total production capacity of 221 MW (Kazimierczuk 2019; LTWP 2019).

Currently, IEA (2019) ranks Kenya as the highest producer of geothermal energy in Africa and the 9th largest globally. With a production potential of 10000 MW, the current production stands at 630 MW which implies that the production is underutilized.

For generations, biomass has dominated the energy sector in Kenya. As the global focus moves towards sustainability, the utilization of biomass in cleaner forms has picked up. Though, the proportion of the population that uses wood fuel for cooking and lighting is still significantly higher in rural areas. In the peri-urban and urban areas, the uptake of Liquid Petroleum Gas (LPG) and improved cookstoves have risen considerably (Doukas and Ballesteros 2015; Government of Kenya 2018).

Hydropower comes second after biomass in terms of production capacity for the energy sector, majorly due to the early technological and political investments made in the country, coupled with the availability of numerous rivers that are able to support the development of dams (IEA

2018). However, the production of hydropower is dependent on weather patterns and adequacy of rainfall. Droogers *et al.* (2009) reports that as climatic conditions change, Kenya has been one the countries hardest hit by the impacts of drought and flooding which makes the hydropower sector mostly unreliable.

Cumulatively, the total RE production in Kenya was 2016 MW by 2018 (IRENA 2019), which signifies very low exploitation and potential for expansion that can enable the country to transition to 100 % renewables given the right techno-economic, socio-technical and political investments. The figure below illustrates the RE capacity growth in Kenya between 2010 to 2018.

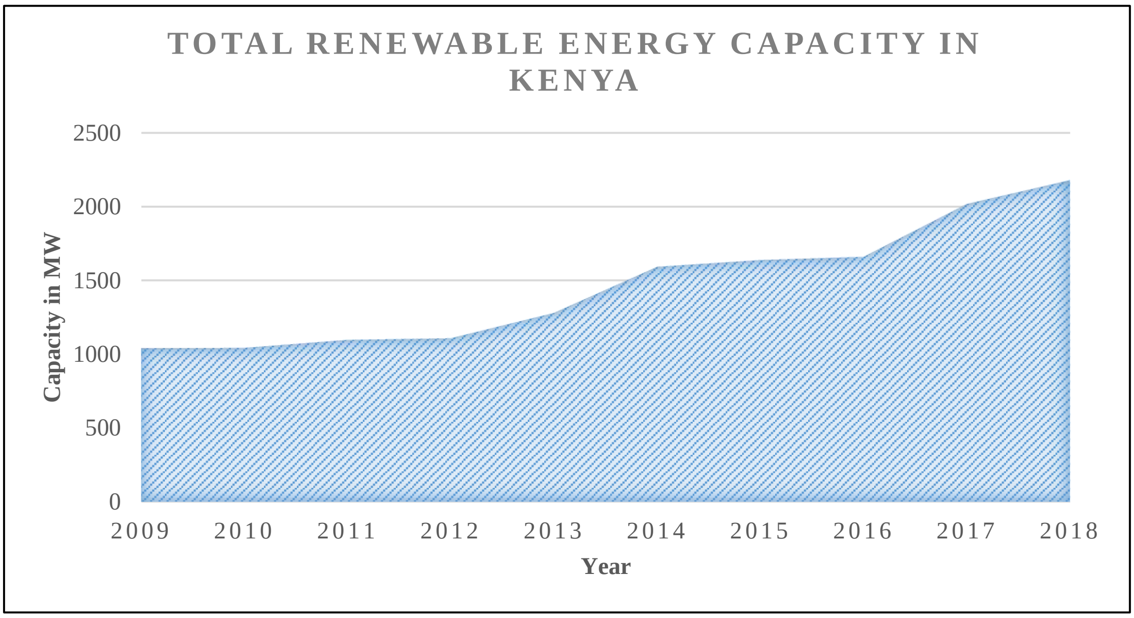

Figure 4: Renewable energy capacity growth in Kenya (2010-2018). Source; IRENA 2019

For generations, the energy sector has been highly controlled and regulated by central governments. Energy prices have also been determined globally, particularly by the Organization of the Petroleum Countries (OPEC) which gives little room for flexibility for the non-OPEC countries in defining their energy security (Bridge *et al.* 2013). RE therefore, enables countries to chart a path of energy security that is not highly pegged on international market prices. Additionally, in the 21st Century era of prosumers and market liberalization, the end users are actively seeking to be part of the energy value chain from production to consumption. Governments are actively seeking for public private partnerships to ensure that the energy sector can both run centrally as well as off-grid (Egging & Tomasgard 2018). Kazimierczuk (2019) reports that as of 2017, energy production was mostly centralized in Kenya, with 74 % of total energy capacity being state-owned. A 100% transition to renewables implies that the role of off-grid energy systems will equally be integral and a good starting point has been the policy reforms in energy legislation in the country and the introduction for FiTs for IPPs for geothermal and hydropower, household solar housing systems, community owned solar mini-grids and wind farms and community/household clean cooking technologies.

2.3 Energy poverty

Energy poverty forms an integral part of the energy transition systems. The techno-economic and political drivers of energy transitions can only be complete when the socio-technical aspects of the system also transit and become operational temporally and spatially. While transitioning to cleaner forms of energy, nations need to equally put commensurate efforts in ensuring that the consumers have universal access to reliable and affordable energy. The section below will discuss components of energy poverty globally and link it with energy transition studies in the previous section. It is divided into the discussion of global energy poverty and in the review of Kenya’s energy poverty.

2.3.1 Global Energy poverty

As the measure of poverty is elusive mainly due to its intersectional comportment and fluid characters which borders predominantly on the multi-dimensional parameters including literacy, housing quality, access to energy, etc. (UNDP, 2010), so can be alleged for energy poverty. Thus, notwithstanding its well-recognized status and consistent deployment by development and energy experts, a unitary definition for ‘energy poverty’ as a terminology/concept is lacking.

Nevertheless, progressive attempts by numerous energy-focused institutions, policy documents and related scholarly arguments have been crucial in capturing a broad scope of the terminology and by extension, providing the needed context for holistic understanding and setting a tone for the prospective discussion. According to the UNDP, energy poverty can be defined as the “*inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset*” (Gaye 2007). Barnes (2010) defined energy poverty as *the point at which people use the bare minimum energy* needed to sustain life”. Due to the increasing attention that energy systems receive from global environmental discourses as a consequence of climate change, the Asian Development Bank provided an expanded perspective, conceives energy poverty as “*the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development*” (Masud *et al.* 2007).

It bears mentioning that although the domineering discourse (Pachauri & Spreng 2004; Bazilian *et al.* 2014; Barnes *et al.* 2015) and multifarious attempted policy interventions (WHO 2006; UN 2005) on energy deficiency centers least developed and/or developing countries, investigations into state-of-affairs within developed countries cannot be overlooked either (Frondel *et al.* 2015; Chester and Morris 2011; Katsoulakos 2011; Harrison & Popke 2011). Remarkably, it must be emphasized that in the comparative assessment of the critical energy needs or deprivation thereof between developed and developing countries within the global context, an existing dichotomy in classification prevails (Li *et al.* 2014). Bouzarovski and Petrova (2015) provided a comprehensive insight into this conceptual binary which are; an ascription of 'fuel poverty' to developed countries and attribution of 'energy poverty' poverty to developing ones.

In the area of measurement, González-Eguino (2015) avers in favor of a comprehensive framework from which energy poverty can be appraised. His theorization of three primary thresholds—technological, physical and economic—positions "the problem in accessing "modern" energy services, minimum energy consumption associated with necessities and the maximum percentage of income that it is reasonable to earmark for energy spending" respectively as core factors that influences the current behavioural patterns in energy consumption choices of the majority of the populace in most developing countries.

Against this backdrop, positing as central propositions to the growing attention and analysis of present-day policy and academic investigations, most countries in the Caribbean, sub-Saharan Africa, Asia, particularly southeastern, and South America, are largely remarked on average as being disproportionately deficient in providing sustainable access to RE within households. Assuming a generic tendency, majority of studies and current policy debates have zeroed in on the energy needs of remote and rural areas in most countries within the aforementioned regions (Fole 1992; Barnes 2007; Pereira *et al.* 2010; Cook 2011). Nonetheless, though rural areas are more deserving of attention considering the evident disparity in economic status. Sovacool (2012) contended that the lack of economic equity which transpires into the default choices made in the principal consumption of "energy of the poor" —mostly fuelwood/biomass due to low cost and availability—should not be limited to the rural areas only as a section of the urban population are equally complicit. In support of this argument, an investigative study by Barnes *et al.* (2004) opined in its concluding note that "the poor in urban areas of developing countries face special problems in meeting their basic energy needs" in 34 cities in Bolivia, Botswana, Burkina Faso, Cape Verde, Haiti, India, Indonesia, Mauritania, Philippines, Thailand, Yemen, Zambia, Zimbabwe. This is largely driven by the continuous reliance on traditional fuels and biomass that are usually assembled form the periphery of urban areas by economic migrants, who in many cases, account as the urban poor.

A more concise breakdown of this ominous challenge was summarized in the findings from the UNDP (2010) and WHO (2015) review on the energy access situation in developing countries. A major point to note is; currently, about 1.5 billion people in developing countries lack access to electricity and about 3 billion people rely on solid fuels for cooking. In sub-Saharan Africa, the number of people without access to electricity and modern fuels is similar (560 and 625 million people respectively). In Asian regions, while people may have access to electricity, they often lack access to modern fuels. In East Asia and the Pacific, less than 200 million people lack electricity access, but almost 1.1 billion people rely on solid fuels for cooking." The findings stressed further that although energy access varies widely across developing countries, it is much lower in poorer developing countries than in other developing countries, placing poorer countries at a huge disadvantage. Seventy-nine per cent of people lack access to electricity in the least developed countries and 74 per cent in sub-Saharan Africa, compared to 28 per cent of those in developing countries. Access to modern fuels is equally constrained in LDCs and sub-Saharan Africa, where 91 per cent and 83 per cent, respectively, lack access to modern fuels. In some cases where the energy source is accessible, the costs of connection or acquisition go further to marginalize the needy populations.

Probing further into focused researches on approximated numbers within sub-Saharan Africa, the IEA (2011) World Economic Outlook recorded that Nigeria, Ethiopia, the Democratic Republic of the Congo, Tanzania, Kenya and Uganda account among them for 63% of all the people with no access to electricity. Furthermore, per the report's estimations, the lowest levels of access to electricity are found in countries such as Malawi (9% of the population), Uganda

(9%), the Democratic Republic of the Congo (11%), and Mozambique (11%). For some success cases, although around 40% of homes currently still use wood for cooking, the IEA argued that access to electricity in Ghana has improved significantly, and the country's set target of attaining universal access to electricity by 2020 provides room worthy of emulation for other sub-Saharan countries.

Although the situations vary according to regions and usually influenced by population sizes, these findings open room for contemporary debate and the needed foundation upon which operational policies and action-driven interventions/recommendations can be fathomed—especially in the case of sub-Saharan Africa, as it boasts of some of the growing fastest economies in the world. Therefore, it can be conclusively deducted that energy poverty in developing countries is more about challenges to access, availability and affordability.

2.3.2 Energy poverty in Kenya

Kenya presents a fundamental case study for the intersectionality of energy transition and energy poverty due to its dominance in RE resources and quick action on climate change in Sub-Saharan Africa. The energy poverty challenges for Kenya fit into the descriptions postulated by Sovacool (2012); González-Eguino (2015) and Li *et al.* (2014), which are similar to those of developing countries comprising of accessibility, availability and affordability. Olang *et al.* (2018) further suggest that household energy poverty in Kenya should be a measure of household size, gender, age of household head, educational level and locality. Therefore, as Kenya transition to 100 % renewables intensifies, it is essential to evaluate its energy poverty indices, mainly due to the inequalities in access and costs.

According to Olang *et al.* (2018), Kenya is experiencing acute energy poverty. With a rapidly growing economy and population, Kenya faces a double energy crisis in terms of demand and supply of energy that meets the needs of both the urban and rural sectors. IEA (2018) records that Kenya's access to electricity increased rapidly within a few years. The access rates increased from 8 % in 2000 to 75 % in 2019 and these changes are credited with improvement and diversification of energy technology, market flows and social acceptance. George *et al.* (2019) support these findings but critiques that the rate of access is still unequally distributed between the urban and rural sectors as over 72 % of Kenyans live in rural areas and 35 % of the population still live below the poverty line (World Bank 2019). The more populous, rural poor in marginalized communities still represent the highest statistic of communities with no access to energy services due to the unavailability of grid connections, inaccessible off-grid energy solutions or the high costs implications for the access to the energy services. On the other hand, the rate of diffusion of clean cooking is still low at only 25 %, since majority still rely on traditional biomass (IRENA 2019b) and a few supplements with kerosene and candles (Senelwa and Hall 1993; Hoogwijk 2005). This justifies Ürge-Vorsatz and Tirado Herero's (2012) conclusion that energy poverty is not only a social justice issue but also an environmental protection one, due to the pressure that biomass utilization creates on forests and land management. Ürge-Vorsatz and Tirado Herero's (2012) therefore recommend that the energy transition and energy poverty should be addressed concurrently due to their interconnectedness. What is not known is if the removal of non-renewables that supplement electricity supply from the energy mix will make a significant impact on energy poverty levels in Kenya.

In support of the findings of IEA, Olang *et al.* (2018) opines that the large-scale development projects on RE—solar, wind, geothermal, hydropower— are majorly channelled to the centralized main-grid energy supply systems controlled by the Kenya Power and Lighting Company thus entrenching the inequalities in the distribution and access to energy across the country. George *et al.* (2019) and Kazimierczuk (2019) recommend a shift in focus towards more of off-grid, low cost RE sources especially in solar, wind and bioenergy that will meet the gap created by centralization. Disruptive technologies in the solar industry have since revolutionized the energy market through solar energy providers giving Pay-As-You-Go options to consumers. These models have resulted in an increase in off-grid solar home systems— composed of a variety of solar lanterns, solar chargers, LED lamps and some have solar powered radios and televisions— due to the ability of payment in instalments that makes it more affordable to customers who are unable to pay the one-off high purchase price George *et al.* (2019). Solving energy access provides a ripple effect to the socio-economic well-being of households as the money saved on energy bills can be channeled into other energy-related expenditures and household needs such as food, school fees, among others. However, Olang *et al.* (2018) research warn that due to the small sizes, their capacity to provide round- the-clock light is limited, further posing concerns about reliability and affordability. The research recommends that the policies on RE should integrally focus on both mini-grids and SHS to solve energy poverty issues across the board.

2.4 Conclusion

Global energy transitions date back into centuries ago and have been influenced by societal needs. The goal of the current global energy transition is to shift to cleaner and low carbon emitting energy technologies, mainly through the promotion of RE technologies. When comparing Africa to the rest of the world, its emission of greenhouse gases has been negligibly low and is equally well endowed with abundant sources of RE technologies such as wind, solar, geothermal and hydropower. It appears that the energy transition pathway for Kenya is similar to those of African countries that involves modernization and expansion of the energy sources, particularly RE (Kazimierczuk (2019). However, the determining factors are hinged on capital intensive investment in techno-economic, socio-technical and political drivers of a country towards energy transition (Cherp *et al.* 2018). This research contributes scholarly review of energy transitions in Kenya and a summary of the transition in Africa which is scarce on the global scale. Despite being endowed with abundant RE, it is not clear if the projected pipeline ambition of 100 % transition to a low carbon development pathway by 2030 is attainable for Kenya when the meta-theory postulated by Cherp *et al.* (2018) on energy transitions is applied (Government of Kenya 2018, WEF 2018). This research will fill the gap by analysing the drivers and hindrances for the transition to RE in Kenya.

As the transition to renewables is on-going, global energy poverty still abounds and the developing countries still suffer from pervasive energy poverty levels in comparison to developed countries. The energy poverty of developing countries is calculated based on availability, accessibility, affordability and reliability. Some scholars still consider Kenya as being acutely energy poor (Olang *et al.* 2018) and it's imperative to research on the perceptions of the energy sector actors in Kenya. Kenya lacks access to affordable, reliable, adequate and environmentally safe energy for cooking and lighting for all citizens as required by the Sustainable Development Goals (Masud *et al.* 2007). A win-win scenario for all sectors of the rapidly growing Kenyan economy requires that the transition to RE and energy poverty should be addressed concurrently. There is still a lacuna on research that interlinks energy transition and energy poverty, therefore this research will contribute to scholarly update on this phenomenon while focusing on the case study of Kenya.

Chapter 3. Methodology

This chapter consists of three sections. The first section discusses the research design applied. The second section explains the methods used for data sourcing and collection, comprising of the reviewed literature, sampling techniques applied and interview protocols with the stakeholders selected. The third section discusses the data analysis methods that were applied to the research for the deduction of discussions and recommendations and concluded with the limitations of the research.

3.1 Research design

This research utilizes literature review and exploratory research design to achieve the aim of the thesis which involves the understanding of energy transition and induction of the nexus between energy transition towards renewables and the energy poverty issues in Kenya.

Firstly, Mendes *et al.* (2008) support the application of literature review as a research method for the assessment and synthesis of theoretical and empirical evidence of the themes under study and in the identification of gaps. Boote and Beile (2005) adds that literature review is useful for understanding methodologies already applied in the field of study. For this research, literature review was therefore fundamental in collection of evidence based secondary data sources such as published books, articles, reports and policy documents. From the interrogation of the secondary data sources, themes on energy transition and energy poverty were developed, and gaps identified for further research and development of additional interview questions.

Secondly, qualitative research method was preferred for this research because they best answer the research questions. Hammarberg *et al.* (2016) and Gill *et al.* (2008) posit that qualitative research enables researcher to explore perspectives and experiences of individuals and institutions about how phenomena unravel and to also answer the “what’ type of questions.

There are three typologies of qualitative research — exploratory, descriptive and explanatory (Elman 2005; Yin 1994)— that can be applied, and this research chooses explanatory research as this approach allows for the investigation of causal mechanisms of particular concepts and contexts (Elman 2005; Ivankova *et al.* 2006; George and Bennet 2005).

In the application of qualitative research methods, explanatory structured and semi-structured interviews were chosen since the aim of the research was to examine what the drivers and hindrances towards the transition to RE are and to understand how the transition and energy poverty interlink in Kenya. As discussed in the literature review chapter, there has been little studies on the phenomena and its application on the study area, therefore, qualitative research allowed the researcher to understand and to seek different views from individuals and institutions. The phenomena being studied also involves social connections to natural process hence qualitative interviews were deemed appropriate. More importantly, an understanding of energy poverty requires a first-hand experience from the people impacted hence the choice to interview representatives of community-based organizations. The research sought to not only explore the perception of the respondents about the phenomena around energy transitions and energy poverty but also to understand why they think so. Further, in order to support, interrogate and contextualize the theories and data derived from the secondary data sources, experiences from energy experts and energy users in Kenya was fundamental. Therefore, in-depth interviews as a method for data collection were most likely to draw detailed information regarding the intersectionality of energy transition and energy poverty.

Moreover, structured and semi-structured interviews can be applied at multiple levels of analysis (George and Bennet 2005). Since this research was investigating evidence from secondary sources, expert opinions and user experiences on energy, it was appropriate to interview meso level respondents —government officials, private sector actors and international and national civil societies— as well as macro level actors such as community-based organizations , who are mostly impacted by daily changes in energy utilization.

3.2 Data sources and collection

3.2.1 Literature review

Prior to data collection, literature from academic and gray sources were reviewed. The review was guided by the research questions and analysis of key concepts. The two main concepts — energy transitions and energy poverty— were reviewed in detail from a wide range of sources starting from the global focus, then to regional focus and lastly on the national focus. The purpose of the literature review as captured in the research questions was to gather information on reports and studies that have already been conducted on RE transitions globally and regionally (Africa), and to further assist in contextualizing and understanding Kenya's energy transition that have been centered around the availability of RE technologies, policies and political will and social acceptance of the energy technologies. Additionally, background research was necessary in comprehending the intersectionality of energy transition studies and energy poverty within Kenya and to understand the obstacles that prevent full transition to renewables and the attainment of universal energy access. Each section of the reviewed literature endeavoured to document evidence relating to the research questions on the drivers and hindrances for the transition to renewables and to link the transition process and its impacts on energy poverty. Finally, the review of existing literature assisted in the formulation of interview questions through the identification of gaps, areas needing clarification and perceptions.

The research relied on two types of resources. Firstly, the examination of existing national and global energy policies, reports and other official government documents. Updated information and statistics on RE were mainly derived from International Energy Agency (IEA)and

International Renewable Energy Agency (IRENA) websites, while the national websites of the Ministry of Energy and the parastatals under it bore national published papers, ordinances, reports and policies, as well as grey literature. Secondly, academic literature was derived from the CEU Library through Google Scholar and other open access platforms such as Elsevier, Willey, Springier and other sources.

Literature for understanding the global context on energy transitions and energy poverty were substantial. On the other hand, there wasn't significant amount of literature on Africa and Kenya's energy transition studies and energy poverty. As transition studies require analysis of past, present and future scenarios, the outdated literature on Kenya's energy sector was unreliable and thus additional documents were needed. Literature that analyze the intersectionality of energy transition and energy poverty was very scarce both at the global level and at the national level hence the research developed a national connection between the two concepts mainly through the opinions of the research respondents.

3.2.2 Interviews

The research applied both structured and semi-structured qualitative interviews to explore the perspectives and opinions of energy actors in Kenya about RE transitions and the energy poverty issues. From the literature review conducted, a lacuna exists in exploring the relationship between energy transition and energy poverty. Due to this gap, additional knowledge via stakeholders' interviews were more likely able to assist the researcher in understanding the two concepts individually and in linking their relationship. According to Gill *et al.* (2008) and Qu & Dumay (2011), this research design therefore applied qualitative interview which is important when explaining detailed studies about a phenomenon or a topic with little documented empirical evidence. Additionally, the interviews were imperative in getting a deeper understanding of the statistical evidence derived from the secondary data sources on RE and energy poverty (Gill *et al.* 2008). Structured interviews were applied to specific groups of respondents where specific questions needed clarifications and to the respondents who had challenges with online interviews, since they were only able to answer the questions through email. On the other hand, the semi-structured interviews were administered to majority of the respondents who provided in-depth information about the different perspectives and updated reports about the research topic (Gill *et al.* 2008).

3.3 Data collection

The interview process was very detailed and time consuming as it took over one month to complete. The nascent nature of the phenomenon under research necessitated interviews with experts and users of the energy in Kenya. The first step of data collection involved the development of both the structured and semi-structured interview questions which were guided by the 3 research questions and the gaps identified while reviewing literature. The first research question sought to understand the drivers for the RE transition in Kenya, hence the interview questions were framed around the conceptual framework postulated by Cherp. *et al.* (2018) that seeks to examine the techno-economic, socio-technical and political drivers of energy transitions. The first question which intended to break the ice generally sought to understand the respondent's perception of the energy sector in Kenya. It was followed by questions on RE progress and projections, energy policies, institutional frameworks and political climate. The second research question examined the obstacles being faced in the transition to renewables and interview questions were again adopted in line with Cherp *et al.* (2018) conceptual framework. The last research question sought to evaluate the impact of the transition to renewables on energy poverty and the interview questions were formulated to answer availability, accessibility, affordability and reliability of RE technologies in Kenya.

Secondly, stakeholder mapping was done to determine the relevant institutions and people with expertise, knowledge and experience with RE and energy poverty. Due to the need of a diversified and detailed perspectives, the stakeholders were reviewed and selected from government ministries, private sector and civil societies. The stakeholders were thereafter contacted mostly via emails, LinkedIn and direct calls to determine their willingness to participate in the research.

This research applied purposive and snowball sampling to interview 21 respondents as shown in Table 1 below. The researcher used purposive sampling in mapping and interviewing energy experts and users in Kenya with the aim of finding opinions and collecting reports that fit within the themes being researched as guided by Esterberg (2002). The initial sample population was derived from networks that the researcher had maintained from previous work on climate change and RE in Kenya and from contacts identified from online searches. This sampling method is prone to researcher bias and not highly representative, but the bias was overcome with the application of open-ended questions and use of additional sampling method. Afterwards, snowballing was applied to identify and interview other experts, opinion leaders and RE users through the help of the respondents contacted or interviewed through purposive sampling (Meyer and Booker 2001).

Out of the total respondents interviewed, 5 persons represented the national government, 2 represented the county government, 5 from the private sector and 9 represented the civil society. As the key decision makers, the information from the government was beneficial in understanding the legislative processes and progress of programs pertaining to the RE sector and energy poverty in the country. The private sector and civil societies' respondents provided more information on citizen engagement on energy matters, recommendations and suggestions on collaboration that will drive the transition to renewables and tackle energy poverty. All interviews were conducted online through Zoom application and email correspondences due to travel restrictions that will be elaborated under the limitations' section. 17 interviews were conducted in English, 2 in Swahili and 2 in Luo.

Table 1: Table of interviewed stakeholders in Kenya's energy sector

Sector	**Respondent**
Government	Anonymous Ministry of Energy
Government	Anonymous KETRACO
Government	Anonymous Kenya Power and Lighting Company
Government	Eng. Mwenda Jamlick County Government of Kiambu
Government	Anonymous County Government of Homabay
Government	Anonymous Ministry of Environment and Forestry
Government	Anonymous Ministry of Environment and Forestry
Intergovernmental agency	Bianca Gichangi East Africa Alliance on Carbon Markets and Climate Finance
International NGO	Victor Gathogo SNV
International NGO	Anne Nyamabne Stockholm Environment Institute, Nairobi

Non-Governmental Organization	Eng. David Maina Njugi Clean Cooking Association of Kenya (CCAK)
CSO	Patricia Abok Anyalo Youth Group
CSO	Humprey Juma Habo Environmental Conservation Self-Help Group
CSO	Lilian Otieno Star Youth Group
Community Based Organization	Peres Akinyi Ouma Community Group lead, One Acre Fund
Community Based Organization	Mary Mwanzo Mwangaza Self-Help Group
Private sector	Eng. Dennis Kariuki CREOS Limited
Private sector	Eng. Jude Songok Energy and Automotive Solutions
Private sector	Eng. Brian Kinuthia EED Advisory Limited
Private Sector	Suzy Achieng' CAA Limited
Private Sector	Eng. Nicholas Gachie Miltec Engineering Ltd

The interviewing activity followed a similar protocol for all respondents. A formal introduction of the research was made, followed by an explanation of the research aim and objectives. The researcher then asked for consent for the conversation to be recorded for data analysis and permission sought for the respondent to either choose anonymity or allow the research to use their name in data analysis. The respondents who consented for their names to be quoted in the research, their names have been recorded and those who did not consent for security reasons, they will stay anonymous as indicated in Table 1 above. For the semi-structured interviews, critical questions relating to the topic of the study were prepared in advance to guide the flow of the interviews. The first question was a general question about the topic and depending on the response, the follow up questions were aligned and/or re-aligned to maintain the flow of the discussion. Each organization was also asked different but related questions to provide details of their organizational background and role in the RE and energy poverty sectors. The final question asked was for the respondent to add any additional opinion and questions that the researcher may have missed out and this question elicited various subtopics of interests and potential research problems that the researcher may not have considered before. The interviews were between 35-45 minutes long and ended with appreciation to the respondents for their insights and time. For the structured interviews, in addition to the interview protocol, a set of questions were prepared and sent to the respondents via email, who then answered and sent back via email (Gill *et al.* 2008).

3.4 Data analysis

Data analysis involved the inductive extraction of information from the reviewed literature and the transcribed interviews (Burnard *et al.* 2008, Pope *et al.* 2000). For the literature review, content analysis method was applied in screening and categorizing the academic articles and journals, energy reports based on the concepts of energy transition, RE and energy poverty. Further, the documents were divided into those addressing global, continental (Africa) and Kenya’s energy matters, and the themes from the literature grouped among those discussing how the transition to renewables is taking shape, the opportunities available for the transition, the challenges encountered and the implications for energy poverty.

Content analysis was also used to examine the transcribed data from the interviews. The process started by transcribing all the recorded interviews then the coded data was synthesized according to the themes similar to the ones selected in the literature review section. I applied the open coding method recommended by Strauss and Corbin (2016) to systematically group and analyses the concepts that developed into themes and to figure out how they relate to each other in the Kenyan context. The abstract concepts involved the breakdown and description of stories, events, definitions, historical inferences, actions, suggestions and culminated into the grouping them into developing patterns using selective coding (Renner & Taylor-Powell 2003; Strauss and Corbin 2016).

The themes from the two sources of data were finally combined after patterns were identified and connections established for the development of the results, discussion and recommendations (Renner & Taylor-Powell 2003). The process of data analysis applied in this research is illustrated in Figure 5 below.

For the interviews done in Swahili and Luo, the researcher translated the content into English. Being a native speaker of the two languages, the researcher was able to maintain the originality of the interviews to the best of her ability.

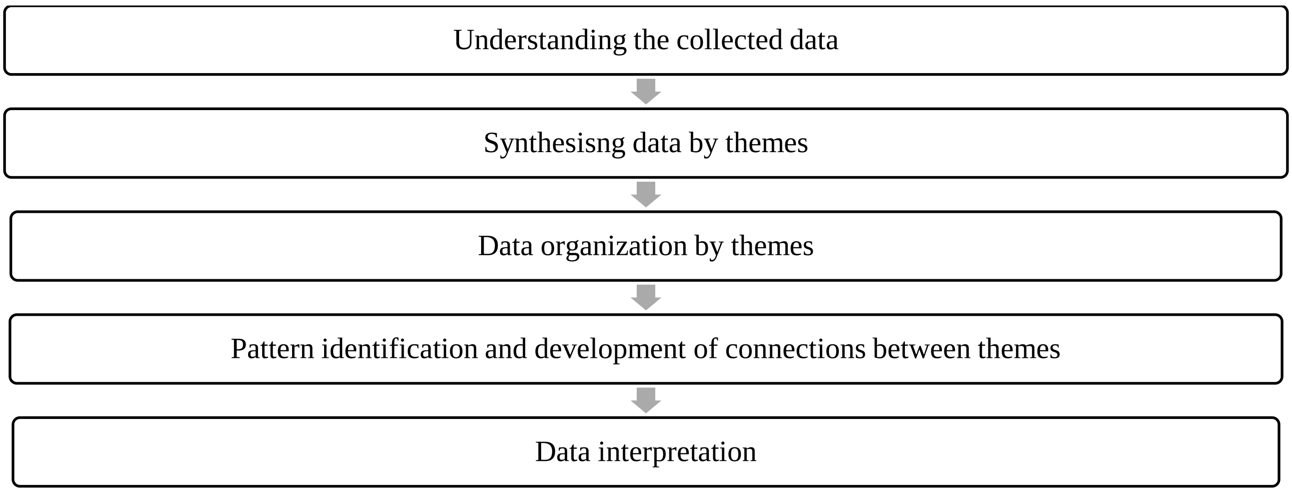

Figure 5: Data analysis process applied. Source: Renner & Taylor- Powell 2003 (with amendments)

3.5 Limitations of the research

The research took place at a time when the novel Covi-19 pandemic had hit the entire world. The field research was to take place in Kenya and as the pandemic swiftly spread, international borders were closed hence hindering travel from Hungary. Time factor became a hurdle for the accomplishment of comprehensive research, as the re-adjustment of the thesis objectives consumed a significant part of the short research period.

The research objectives had to be adjusted to allow for only online research and online participation of potential respondents. The research had a target of 40 respondents but due to challenges of internet connection and inaccessibility of emails as some of the respondents were out of office for the pandemic duration, the response rate and willingness of some of the potential respondents were low. 21 respondents were interviewed which doesn't provide a significant representation of the population for the deriving of the general position of Kenya in the interlinkage between the transition to renewables and energy poverty. The findings of these research can, therefore, be used as a baseline empirical evidence for further research on the phenomena.

While seeking reports and updates on the progress of some policies and development projects on energy poverty and status of RE, the researcher encountered confidentiality barriers as some of the respondents did not have the authority to release information official announcement and endorsement by the designated authorities.

Chapter 4. Results Analysis

The analysis of the findings indicates that the main drivers of Kenya's transition to renewables are driven by the availability of RE technologies, coupled with the push from relevant legal and institutional frameworks and socio-technical support. The hinderances for the transition to renewables are a factor of policy, institutional and systemic misalignments, limited RD & D and difficulty in changing consumer behavior and attitudes. The analysis also indicates that the transition to renewables and energy poverty are interlinked and that tackling the hindrances for energy transition solves part of the challenges of energy poverty in Kenya.

The chapter is divided into three sections. The first section focuses on findings of the drivers of the transition to renewables in Kenya. The second section focuses on the findings of the hindrances to RE transition while the third section focuses on the impact of the transition to renewables on energy poverty in Kenya.

4.1 The drivers for transition to renewable energy in Kenya

As discussed in the chapters on literature review and methodology, this section aims to analyze the application of meta-theoretical framework — techno-economic drivers, socio-technical drivers and the political drivers —postulated by Cherp *et al.* (2018) in the analysis of drivers for energy transition. The research findings apply only to the RE transitions in the context of Kenya as shown below.

4.1.1 Techno-economic drivers

Grübler (2012) assert that technological transformation is a fundamental driver of energy transition. This is supported by studies that indicate that Kenya has a vast RE untapped potential despite having enormous technologies available locally, especially from geothermal, solar, wind, biomass and hydropower (IRENA 2019b; George *et al.* 2019; Kazimierczuk 2019;

O'keefe *et al.* 1984). These studies further demonstrate that the integration of both mini-grid and grid systems for the generation and supply of RE has been a fundamental driver for RE technologies. This is explained by the traditional role that grid connections from hydroelectric power and geothermal have played in the energy sector and the recent influx of wind and solar energy (Government of Kenya 2014; IRENA 2019b). For the cooking sector, the findings from Karanja and Gasparatos (2019) imply that the main technology driving the sector is biomass, though the utilization has largely been unsustainable due to the over-reliance on traditional biomass. Innovative technologies for the cooking sector have significantly improved in the past 10 years as was noted by the Chief Executive Officer of the Clean Cooking Association of Kenya, giving hope that the transition in this sector will catch up with the targets set up in Kenya's Vision 2030.

In comparison to the findings from the literature review, similarities were noted with the responses recorded for technological transition in the lighting sector. There was consensus among all the respondents that the energy sector has made tremendous progress in transition towards more use of renewables in the national energy mix. While enumerating and explaining the drivers of the technological transition, the respondents rated the availability of local RE technologies such as geothermal, solar, wind and hydropower as a key determinant in the lighting sector. The availability of sustainable biomass was rated the highest for the cooking sector. One government sector respondent opined:

> *"If fully exploited, geothermal energy alone can drive the energy needs for Kenya for several years."*

The statement was supported by a private sector actor who added that:

"The potential for geothermal energy is enormous, but the government and investors shouldn't overlook the under exploited but massive potential of wind and solar energy in revolutionizing and hastening the transition efforts."

Further, both grid and mini-grid technologies have been pivotal in the transition process, though historically, the priority system for energy transmission in Kenya was grid systems (Government of Kenya 2014; Kazimierczuk (2019). The integration of mini-grids and off-grid technologies increased substantially from 2013 as one private sector responded observed:

Between 1963 to 2013 (50 years), the total connections were 2 Million. This figure tripled between 2013 and 2018 which recorded 6 Million connections, mainly due to the influx of mini grids into the national energy installation.

On the other hand, some respondents argue for the prioritization of the grid technologies only in the transition process. The respondents based their argument on the challenges of mini-grid expansion experienced in Kenya ranging from limited technical expertise, economic unviability, inflexibility of wattage expansion when demand surges and other technical challenges of mini grids. The respondents further suggested the use of mini grids as a supplement for the grid technologies, instead of prioritizing both systems at a go.

4.1.2 Political drivers (legal and regulatory frameworks)

a. Policy directives

Political regimes determine the energy policy priorities of Kenya and how institutions mandated with their delivery respond to the policy processes. Majority of the respondents cited conducive legal and regulatory frameworks and institutions for the promotion of RE since late 1990s as a key driver while 4 respondents were oblivious about the governments' policies for the promotion of RE but they have benefitted from some of the interventions available and implementation of programs from both state and non-state actors. Further, the enactment of the Energy Act of 2019 was fronted by majority of the respondents as a huge progress in ensuring that RE programs are implemented and enforced. The respondents think that the non-renewal of Power Purchase Agreements (PPAs) for thermal plants already operational — as enshrined in the Energy Act 2019 —has reduced the investment in non-renewables and will halt their future generation and contribution to the energy mix.

Energy transitions result into prioritization of particular energy sources by different countries as embedded in their policy directives. An evaluation of the Kenya Energy Policy 2018 and Energy Act 2019 did not provide priority RE technologies but rather elucidated the actions needed for the exploitation of the full potential of all the technologies (Energy Policy 2018; The Energy Act 2019). The respondents opined that if RE technologies had been prioritized over fossil fuels for future energy needs that also conforms to the development trajectory of the country. The prioritization of RE technologies over non-renewable sources is mainly due to the abundance of local technologies in the country. While ranking Kenya's priority sources of RE technologies, both from policy and personal perspectives, 7 respondents enumerated both geothermal and solar energy, 11 thought that solar energy takes the lead, while 11 preferred geothermal energy as a reliable provider of a stable energy future. Wind energy was equally ranked highly while majority of the respondents agreed on the importance of hydropower but mentioned its unreliability. The comparative availability informed the responses availability of these technologies and the economic investments that have been made to harness their potential. In comparison to reports from IEA (2019) and IRENA (2019Bb), geothermal, solar and wind are arguably key sources of future energy needs for Kenya.

Reports and policy documents finds policy goals and mentions of a transition to low carbon development pathway by 2030 in the Kenya Vision 2030 and in the Green Economy Strategy and Implementation Plan (GESIP), National Climate Change Action Plan (NCCAP 2013-2017, 2018-2022), emission abatement ambitions in Kenya's NDC (MENR 2018) , RE development strategies in the Energy Act and Energy Policy (The Energy Act 2019) and a presidential decree for a 100% transition to RE by 2020 published by WEF (WEF 2018).

b. Institutional frameworks

Egging & Tomasgard (2018) and Kazimierczuk (2019) notes that Kenya has a robust and extensive energy institutional framework. To ensure implementation, enforcement and compliance, 14 respondents mentioned the transformation of Kenya Rural Electrification Authority to Rural Electrification and Renewable Energy Corporation (REREC) as a requisite institutional entrenchment of RE. REREC's vision (George *et al.* 2019; REREC 2020) of being a "*green energy driven nation*" gives hope to the respondents that RE projects in the pipeline, especially in the marginalized rural regions are attainable as a result of the institutionalization of the sector. In alignment with the studies done by George *et al.* (2019), the research found out that there are a plethora of institutions working in tandem with the Ministry of Energy in supporting RE as illustrated in table 1 below:

Table 2: Key energy institutions in Kenya and their main functions. Source (websites of each institution with amendments of function done by the author)

Key Institution	**Function**
Ministry of Energy (MOE)	Energy policy development and creation of an enabling environment for the operationalization of the energy sector
Rural Electrification and Renewable Energy Commission (REREC)	Mandated to provide energy solutions through rural electrification and renewable/green energy for all
Energy Regulations Commission (ERC)	Regulation of the energy sector through licensing, tariff setting, coordination, reporting and monitoring

Energy Tribunal	Arbitration of disputes in the energy sector set up under the Energy Act of 2019
Kenya Electricity Generating Company (KenGen)	Leading electricity generation company in Kenya covering RE sources from geothermal., hydropower, geothermal and wind
Kenya Power and Lighting Company (KPLC)	Leading off-taker of power generated and transmitted in Kenya and with the mandate of ensuring delivery of cost-effective, reliable and quality power to consumers.
Kenya Electricity Transmission Company (KETRACO)	Leading designer, planner, owner, operator and provider of maintenance of grid national and regional electricity transmission and connections
Geothermal Development Corporation (GDC)	Ensure the development of geothermal resources in Kenya through surface exploration and drilling
Independent Power Producers (IPPS)	Independent private investors who generate power either on a large scale or small scale. For RE, they apply the FiTs policy
Consumers	Consumption of the RE produced and supplied

c. Market liberalization

Within the last 8 years (2013-2020), the respondents have observed an influx of programs supported by both the state and non-state actors (IPPs, CSOs, Private Sector and development partners) in the promotion of RE technologies. The respondents mentioned some of the most recent programs include the Last Mile connection (IEA 2019), the KOSSAP and the Lake Turkana Wind project (LWTP 2019; Kazimierczuk 2019) which addresses universal grid access, solar energy installation in off grid and marginalized regions and large-scale wind power generation respectively. The Ministry of Energy mostly funds these programs with support from development partners. The interview responses enabled the inclusion of the KOSSAP which the literature review failed to capture.

The respondents tie the influx of RE programs with liberalization of the energy market through policy interventions (Egging & Tomasgard 2018). One of the policies that have liberalized the market flow is the FiTs. The government sector respondents argued in favor of FiTs that has resulted in lower prices of energy in the markets. On the other hand, some private sector respondents opined that the FiTs policy is yet to be implemented hence not a crucial driver for the sector. In contrast, another section of the private sector respondents was optimistic about the policy's ability to revolutionize the RE sector. One respondent from the private sector explained that the implementation and monitoring of the FiTs were too ambiguous for prospective investors and that the quoted tariffs over-estimated their actual market prices. Two respondents from the private sector further suggested that the government should consider fast-tracking the implementation of the net-metering system in the Energy Act of 2019 for further cost reduction and promotion of public-private partnerships. The private sector respondents also posited that aside from the challenges of implementation of the FiTs system, the policies provide a very favorable environment for investments by IPPs. The studies reviewed hardly captured reports and discussions about the integral role of energy tariffs in Kenya, but majority of the respondents brought it out as a key driver of the RE sector development.

According to some respondents, the introduction of subsidies, incentives and tax exemptions for RE technologies and equipment equally play an essential role in promoting investments in the sector. Investors have taken advantage of the conducive economic environment to bankroll RE programs across the country. Reports from (Government of Kenya 2014; Government of Kenya 2014; Kazimierczuk 2019; Karanja and Gasparatos 2019; IEA 2019) illustrate the progressive development of energy policies in Kenya and the role and benefits of the incentives as elucidated by the respondents.

4.1.3 Socio-technical drivers

Respondents talked about the perceived benefits of RE technologies to the environment, economic growth and human health are other important drivers for the exponential diffusion. These benefits have been relayed through concerted public awareness campaigns, word of mouth and fast penetration of social media networks throughout the country as explained by some civil society and private sector respondents. A government sector respondent added that the open and receptive public-private partnership enables all stakeholders to work together for faster and efficient information dissemination.

Additionally, the diffusion of the RE technologies introduced through the various programs is as a result of affordable payment models that have been introduced to Kenya's energy market as mentioned by the respondents from all sectors. The PAYG model that has been adopted by most of the solar service providers was noted to have enabled the fast diffusion of solar energy in Kenya, and particularly to the low and middle-income households who were previously not able to access clean energy. In confirmation of the observation of the respondents, George *et al.* (2019) and Abdullah *et al.* (2011) extensively discuss the PAYG model applied in Kenya and lauded it as a success in comparison to other countries that have tried to domesticate the policy but without as much success as compared to Kenya. The PAYG model in Kenya allows SHS buyers to pay a small amount of money for the initial instalment and offers a monthly or daily payment plan for the clearances of the balance. The payment is made through mobile money apps such as MPESA which is highly accessible in most parts of the country. The lengthened payment plan enables buyers with lower incomes to afford the purchases, which otherwise, would only be attainable for wealthier consumers. Peres Ouma narrates her experience:

> *"I bought my SHS which has 3 bulbs in 2017 at Ksh 8,200 and I was given 8-months payment period. After the initial instalment, I paid the balance at Ksh 50 per day. Without this payment plan, I couldn't have afforded the total cost."*

4.1.4 Drivers not exploited maximumly

Concerns were raised by the respondents and particularly stressed by the civil society actors about the low focus on drivers for transition in the cooking sector. More emphasis has been put on the lighting sector which has institutionalized regulations for the attraction of investments and funding, and this is confirmed in the studies done by Masud *et al.* (2007). For the attainment of a full transition, both sectors need to be prioritized and 8 respondents suggested that policies for clean cooking need to be expedited and awareness campaigns escalated. Concerns were also raised for the transportation sector as e-mobility is a key driver for the transition to full RE and all the respondents mentioned that Kenya is yet to have a concrete plan for the transition from fossil-fuel based vehicles to bioenergy and electric vehicles.

A summary of the drivers and indicators for the transition to RE is indicated in Table 2 below:

Table 3: Drivers and indicators for the transition to RE in Kenya. Source; Author

Drivers for the transition to renewables	**Indicator**	**Impression**
Techno-economic drivers	- Abundance of RE technologies e.g. geothermal, wind, solar, hydropower and biomass	- A fundamental indicator needed for the expansion and modernization of techno-economic indicators - Potential not maximized

Political drivers (legal and regulatory frameworks)	- Institutions such as Ministry of Energy, REREC, Geothermal Development Corporation, KETRACO, KPLC, KenGen, EPRA - Policies such as the Energy Act 2019, Climate Change Act 2016, Kenya Vision 2030, GESIP, National Climate Change Action Plan (2018-2022), Kenya National Determined Contribution (NDC) - RE programs e.g. Kenya Off-Grid Solar Access Project (KOSAP), Last Mile Connection, Big 4 Agenda, Lake Turkana Wind Program (LKWP) - Market liberalization - Non-renewal of PPAs for thermal plants	- Kenya has the required institutions needed to promote RE for the lighting sector. - Robust policies are available for promoting RE technologies. - Institutionalization of e-mobility and cooking sector as key drivers of full transition - The RE market flow is liberal - Fossil fuels might be driven out if the PPAs are not renewed
Socio-technical drivers	- The influx of mini-grid and off-grid RE especially solar and wind - Increased national installation of grid electricity and increased access to electricity in the marginalized areas - Willingness to Pay (WTP) for new RE technologies - Innovation and adoption of clean cooking technologies - Perceived and known benefits to human health, economic growth and the environment	- Market liberalization has eased diverse technological diffusion and promoted social acceptance due to lower costs and availability of options - Innovative solutions are and should be highly adaptable in the local market and responsive to consumer needs. - The health and environment benefits are as important as the economic benefits of RE

4.2 Hindrances for the renewable energy transition in Kenya

Energy transition processes are complex and present slow rates of change (Grübler 2012). Transition processes require enormous investments in technologies and societal preferences which are often met with resistance to change and inadequacy of government and social structures to deal with the proposed changes in energy systems. Therefore, despite the noticeable progress made in the transition to complete utilization of RE in Kenya, the respondents noted several challenges that will delay the policy and program goals and ambitions as shown below.

4.2.1 Institutional and systemic challenges

Olang *et al.* (2018) and Egging & Tomasgard (2018) acknowledged the presence of extensive institutional frameworks in Kenya's energy sector as illustrated in table 1 above and noted some of the challenges that have been corroborated by the respondents as discussed herein. As noted by George *et al.* (2019) and confirmed by some respondents from all the sectors interviewed, the energy institutions have historically placed greater emphasis on grid systems expansion and the allocation has not been equitable. The grid distribution inequality has left certain regions like the Northern Frontier unconnected for decades. On the other hand, some respondents claim that the returns on investments made by institutions in setting up mini-grid and off-grid systems are so low thus discouraging institutional investments in such systems. The critics further claim that mini grids should only be used to support central grid systems due to their limited capacity and flexibility challenges when it comes to wattage expansion when energy demand increases.

All the respondents mentioned challenges in the implementation and enforcement of energy regulations and changes in political regimes. The private sector and civil society respondents cited inefficiencies and onerous government bureaucratic processes as a scare for investors and a cause of delay in initiating RE projects. The private sector actors further noted the overlapping roles of the institutions working in the energy sector that makes paperwork processes cumbersome and tiring. A respondent from the private sector mentioned about the process of making approvals for a project which might involve shuttling between different offices, thus prompting the need for corruption and kickbacks for the processes to be expedited. The respondent recommends the need for synergy and transparent protocols. Another respondent from the government observed;

> *"Kenya is a continental leader when it comes to the formulation of policies on energy, environment and climate change but the implementation and enforcement remains largely undone. Additionally, since our political regimes are very fickle, we can only hope that successive government regimes will not reverse the gains made until now."*

At the time of writing this thesis, the respondents mentioned that the national budget for the year 2020/21 was under final review and there were proposals by the National Treasury to remove the tax emption from RE technologies and to increase the VAT levy on RE. The Tax Law Amendment Act of 2020 and Finance Bill of 2020 all have mentions of these proposals and effected changes. All the respondents were against this proposal citing that it will make energy more inaccessible and unaffordable and this presents a further research area on how the changes if effected, will impact on the sector.

4.2.2 Policy gaps

Additionally, the lack of policies supporting clean cooking and e-mobility has resulted in the lag in implementation of programs focusing on these sectors as stressed by respondents from the civil society and private sector. This component was an additional finding from the respondents that were not captured in the literature review. A respondent who works in the clean cooking sector remarked:

"The Bioenergy strategy and the Clean Cooking Action Plan have been on the pipeline for long and it will be fundamental that the policy formulation process be hastened. Availability of clean cooking policies will give the government responsibility of delivery and enables other stakeholders to hold the government accountable in service delivery"

A strongly suggested driver for the transition to renewables are the FiTs and net-metering policies. However, some respondents noted that being an emerging policy in Kenya, the technical expertise for designing a country-specific policy was inadequate, hence the slow implementation challenges being experienced and the reluctance in adoption of the policy by some IPPs and even government institutions mandated with its regulation.

4.2.3 Funding

Financial implications present a major hindrance for the renewable sector of Kenya. Majority of the respondents opined that the leading financier of the energy sector in Kenya is the Ministry of Energy but through significant assistance from development partners and international financial corporations such as the World Bank, African Development Bank, GIZ, SNV, among others. High initial capital and investment costs for the installation of RE technologies was mentioned by most of the respondents as a key hindrance which has resulted into over-reliance on international financial assistance to supplement the national budget. Different scholars (Masud *et al.* 2007; George *et al.* 2019; Abdullah *et al.* (2011) both globally and locally support the assertion that funding, particularly in developing countries present sustainability challenges to projects on RE which are dependent on intensive capital injections.

Majority of Kenyans still live in rural areas and have lower incomes. The proportion of urban poor is significantly higher as well, hence the transition to cleaner energy sources might not be easily attainable. The respondents talked about the low levels of household income as a hindrance for transition in households. As supported by the findings of Olang *et al.* (2018), one Solar Housing System (SHS) user from a Community-Based Organization (CBO) quipped:

> *"My house has 4 rooms but the SHS I have, has two lanterns only and charging system for my phone. To light the other rooms, I supplement with kerosene lamps or leave some rooms under darkness. I cannot buy a better SHS as my income is very low and I have to prioritize other household needs such as food and education for my children."*

Respondents from the government sector cited the high financial bearing on land acquisition as a hindrance for expeditious scale-up of RE programs. Large tracts of land are required for setting up RE large-scale infrastructure and The Energy Act stipulates way leaves for such projects and the compensation for displacements emanating from these activities (The Energy Act 2019).

4.2.4 Low Research, Development and Dissemination (RD & D)

Respondents particularly from the private sector and civil society decried the low investments in Research, Development and Dissemination (RD & D) in RE as another major impediment for transition processes. Studies done by Masud *et al.* (2007); Government of Kenya (2018) and Gubler (2012) assert that the transition to RE is very capital intensive, especially in the acquisition of the initial capital for the instalment of RE technologies. The government sector respondents supported the need for comprehensive RD & D, while citing the limited technical capacity and expertise for the new technologies, FiTs and net-metering policies that have been introduced in the market in the last few years. One government respondent mentioned that:

"Kenya has trained several technicians on RE grid connection but not as much on mini-grids for solar and wind energy. There are so many mini-grids that need maintenance and installation, but we are short of man-power hence, you will come across a lot of abandoned power plants or several needing maintenances."

The respondents across all sectors mentioned technological challenges associated with RE such as storage, intermittency, transmission costs and they further added that these challenges could be solved by investment in RD & D and these mentions are confirmed in the studies carried out by Olang *et al.* (2019) and Kazimierczuk (2019. Likewise, 14 respondents believe that fossil fuels still play a major role in the energy mix of the county hence a complete transition is not foreseeable by 2030 unless radical changes are made expeditiously. On the other hand, 7 respondents believe that the transition to 100 % renewables is possible in Kenya and might be attainable by or around 2030. This necessitates further RD & D on what happens in the absentia of fossil fuels or if any country can in the first place runs its economy while completely devoid of fossil fuels.

4.2.5 Behavioral and attitudinal changes

George *et al.* (2019) and Kazimierczuk (2019) report that there has been a significant shift towards the use of RE by consumers in Kenya in the past 8 years. Additionally, more large-scale investments are being made by the government and IPPs on RE than on non-RE and the studies imply that it is being influenced by the global shifts to climate change mitigation discourses. For the consumers, some respondents talked about the low awareness about alternatives available in RE technologies while others talked about skepticism associated with cultural leanings and preferences in energy utilization as the reasons for low diffusion for RE in Kenya. Particular communities still attach strong attachments to three-stone biomass cookstoves that present challenges in the adoption and shift to modernized cookstoves.

A respondent from the Clean Cooking Alliance of Kenya chimed in with a common myth from the communities;

> *"A great wife must be able to cook on three-stone cookstoves and food cooked on the three-stone cookstoves tastes better than food cooked on gas cookers or on charcoal jikos."*

Without changing this belief, resistance to technological changes will remain the norm and the communities will remain outliers of national energy transition priorities.

One respondent from the community-based organizations faulted the nature of awareness campaigns which are majorly concentrated in urban areas while the majority who need sensitization live in the rural areas. She also believes that the low diffusion in the rural areas which is tied to cultural preferences for energy is because the communities are hardly involved in designing alternative solutions to their problems and opt to use the locally available but unsustainable energy sources that they are used. The innovative alternative ideas at times have very complex technological designs that are too complex for inhabitants of some rural communities and neither do they meet the needs of these communities.

4.3 The impact of transition to renewable energy on energy poverty in Kenya

From the results of the first research question, there was consensus that the enormous strides have been made in the transition to RE in Kenya, but this question on energy poverty elicited different reactions as discussed in the sections below. Further, the reviewed literature section deduced that the main energy poverty challenges in Kenya are a factor of accessibility, affordability and reliability and this will form the basis of the themes for discussing the results of both methodologies.

4.3.1 Accessibility

Two respondent from the government expressed confidence that Kenya is almost at 100% in the access to RE—since RE technologies are currently more available and with high connection and transmission rates as compared to the 1990s levels — due to the extensive infrastructure that has been laid throughout the country as a result of programs like the Last Mile Connection and KOSSAP. One respondent from KETRACO mentioned that the generation of energy was comprised of 80 % RE by 2019 and suggested that:

> *"Travel by road or air at night to see how well-lit Kenya currently is"*

On the other hand, majority of the respondents believe that despite the availability and the developments in RE, Kenya is still acutely energy poor when all parameters of energy poverty are taken into consideration. The high production and transmission costs hinder the expansion of connection lines to certain regions that are very far off from the central production regions and to the consumers with access to grid connections, the utility bills are way beyond the reach of certain consumers. In the words of a respondent;

> *"As a resident of a rural area, we still do not have access to the grid connections by KPLC in my locality. I've heard of the Last Mile Connection under the current government's agenda and I can only hope that my region also gets connected to the system"*

In the comparison of energy sectors, most respondents prefer to term the access as improved mainly for the lighting sector and calls for expeditious action on clean cooking technologies while 1 respondent is of the opinion that the access levels have greatly improved, though not as fast as the rate of transition to renewables.

Similarly, studies done on Kenya's energy poverty differ on the acuteness. Olang *et al.* (2018) and (Masud *et al.* 2007) imply that the energy poverty levels are still acute when all parameters are considered, especially in the review of energy for cooking and for mobility. On the other hand, IEA (2018); George *et al.* (2019); Karanja and Gasparatos (2019) and Kazimierczuk (2019) imply that it is no longer acute by citing the rapid increase in lighting access levels to 75 % of the population and the progressive developments in clean cooking technologies.

4.3.2 Affordability

The proposition from the studies done (IEA 2019; IRENA 2019b; Masud *et al.* 2007) is that since the RE technologies are still relatively new in Kenya's market, the high initial capital investment costs are transferred to end users hence increasing the prices of consumption. In the long run, the energy prices are expected due to economies of scale. IEA (2019) records that the exploitation of solar and wind energy began to rapidly rise around 2009 hence it will take a while before the market prices are regularized. George *et al.* (2019) and Kazimierczuk (2019) corroborates the IEA records by reporting that solar and wind energy are more affordable in the long-run and majority of the respondents opined that the cost of energy has also significantly reduced in Kenya, in comparison to 1990 and early 2000s levels, but this does not directly translate to affordability for all residents. All the respondents also acknowledged that the rates for energy poverty associated with lighting have significantly reduced while those associated with cooking are reduced but still comparatively higher than those of the former (Karanja and Gasparatos (2019). Nonetheless, one respondent assessed the changes in lighting:

> *"My household uses both grid connection from KPLC and personal installed SHS. The electricity bill had gone down considerably, and I can comfortably manage the monthly payments"*

Contrarily, some respondents added despite the overall national cost reductions in the last couple of years, the grid transmission costs considerable increases the burden of bill payment to the consumers, especially in need to ensure equitable distribution throughout the country.

A respondent from the civil society opined:

> *"If the electricity bills were affordable to all Kenyans, we would not be having the #SwitchOffKPLC that has been trending on social media for a couple of years, neither would we be having the civil suits against the company"*

Comparatively, the cost of clean cooking technologies was argued to be either high or low depending on the location, income levels and choice of fuel type. For the urban and rural, majority of the middle income and high-income earners consider clean cooking technologies to be affordable while both the urban and rural poor consider clean cooking technologies to be beyond their reach hence resort to unsustainable options.

Lastly, all respondents believe that the energy poverty levels were significantly higher in the rural areas— particularly in the marginalized northern frontier counties— than those in the urban areas. This implies that more infrastructure and programs that will increase the affordability need to be scaled-up in rural areas.

4.3.3 Reliability

Reliability of energy systems in Kenya is measured by the availability of storage technology that reduces intermittency, diversification of energy producers and suppliers and the installation of standard technologies. Some respondents opined that mini-grids and off-grids still need much expertise for RD &D that should increase the efficiency of the systems, reduce intermittency, and make them more accessible to the consumers. Market liberalization has also brought forward challenges of importation of sub-standard RE equipment and technologies that reduce the durability of the end products, increases the frequency of repairs and reduces the consumers' trust on the technologies. A respondent from the private sector observed that:

> *"Most of the RE equipment are sourced from China and dealers import all kinds of materials. Kenya Bureau of Standards is faulted with not conducting thorough due diligence and inspection hence the market is currently infiltrated by sub-standard, cheaper alternatives."*

On the other hand, decades of investment in grid systems has ensured that the installations strive to meet the market standards (Government of Kenya 2014;). The key reliability challenge noted by the respondents was on frequent blackouts and shortages in national production occasioned by seasonality of weather conditions.

Overall, energy poverty has reduced significantly over the last 8 years (2013-2020) associate the changes to increased connectivity and accessibility to both off-grid and grid RE options, affordability of RE in the long-term for both household and commercial users, higher quality of life and improved rural economies and social acceptability of RE technologies across the country. On the other hand, the respondents who believe that the country is still acutely energy poor and/or has made some progress but still experiencing major hindrance, mentioned challenges with RD & D, transmission, monopoly of the sector by KPLC, the unreliability of some RE technologies such as intermittency of solar and wind, infiltration of sub-standard RE products especially the SHS, capacity building and awareness creation on benefits of RE to the economy and human welfare and gaps in policy processes (Masud *et al.* 2007; Kazimierczuk 2019; IEA 2019; Government of Kenya 2018).

4.4 Summary of findings

This chapter dealt with data presentation analysis of findings from the themes developed under each of the research questions. In analyzing the drivers of renewable transition in Kenya, it emerged from the literature review and from the responses that the ready availability of RE technologies plays a dominant factor. Kenya's policy and regulatory framework were also mentioned as a boost in attracting investments into the RE sector, particularly for RE for lighting. The respondents cited the need for policies on clean cooking and e-mobility as a prerequisite for significant transition. Socio-technical perspective of energy transitions also plays a fundamental role in Kenya's transition journey and has resulted in the high innovation and diffusion of RE technologies in the last 8 years (2013-2020). This gives hope for most of the respondents that if the gaps identified are acted upon expeditiously, then the ambitious targets for a transition to a low carbon development pathway are attainable by around the year 2030.

The second research question sought to understand the hindrances for an effective transition to RE in Kenya. From the discussion with the respondents and the deductions of the reviewed literature, the main theme was the ineffectiveness of policy implementation and inefficiency of the regulatory authorities under the Ministry of Energy. Secondly, financial costs of the transition to renewables, both for the investors and consumers have slowed down the desired progress of the RE programs. As the technologies evolve rapidly, continuous RD & D and capacity building of consumers ought to be sustained but this has not been the case as noted from the responses. Fossil fuels still play a role in the energy mix of Kenya and the responses mentioned their acknowledgement in the national policies. A future without fossil fuels seemed unlikely for some respondents while others still maintained hope and belief that owing to the drivers available, fossil fuels can be phased out from the national energy mix.

The third research question focused on assessing how the transition to renewables is impacting on energy poverty in Kenya. Across the board, the respondents observed that the local availability of RE technologies has increased access to consumers, with exponential diffusion of technologies recorded in the last 8 years. The influx of mini-grids pointed to a fundamental supplementary role to the previously monopolized on-grid system that wasn't equitably distributed throughout the country. Rural areas are still lagging in comparison to the urban areas, but progress noted, nonetheless. The lag in rural areas was attributed to behavioural and attitudinal challenges associated with reliance and cultural leanings on specific energy types that take a long time in influencing societal changes. Further, the lag is associated with inequitable distribution of national energy resources. The main challenge deduced from the responses was on the affordability of the RE technologies both to the investors and the consumers. Reliability challenges were also pointed out but at the same time, appreciation was given owing to the gap on accessibility that the RE technologies have filled. In overall, there were significant variations in the perceptions of respondents on the rate of access to, availability and reliability of RE technologies in Kenya.

This analysis indicates that Kenya has adequate techno-economic drivers, which needs the support of the political drivers and enhancement of socio-technical drivers for the energy transition to be attained in completion. More fundamentally, energy poverty ought to be an integral component and priority when evaluating the progress of energy transitions in Kenya.

Chapter 5. Discussion and recommendations

5.1 Discussion

The results of the research indicate the fundamentality of the interlinkage of the drivers and hindrances of RE transition and energy poverty. The patterns portrayed by the drivers of energy transitions in Kenya depict scale-up and modernization of technological solutions, but with some level of challenges on implementation and enforcement of the transition programs which have spilt over onto energy poverty reduction efforts. The hindrances for the transition are a factor of the government's incapacity and societal resistance to respond to the transition within the timelines expected for the transition to be complete. The hindrances of the transition process further decelerate energy poverty alleviation processes by increasing the inaccessibility, unaffordability and unreliability of RE technologies.

This section will therefore, analyze the context of the research by discussing these key findings. The section is divided into three parts, with each section providing an interpretation of the research questions as answered by the reviewed literature and the qualitative interviews. From the discussion, recommendations will be suggested, and areas of further research identified as will be elucidated in the final sections of the chapter.

5.1.1 The drivers for transition to renewable energy in Kenya

To meet the objective of the first research question, the energy transition meta-theoretical framework postulated by Cherp *et al.* (2018) was applied. The application of the framework showed that, Kenya's energy sector is largely driven by techno-economic factors, coupled with socio-technical and political drivers.

The study of the techno-economic drivers of energy transition is confirmed to be unique in Kenya in that the transition history portrays a RE technological modernization and expansion rather than a shift from fossil fuels to RE that is seen in developed countries as was posited by Kazimierczuk (2019). The techno-economic drivers in Kenya are determined by availability of RE technology and the capacity to convert the technology into useful energy. As of 2019, the energy mix of Kenya was composed of 70 % RE and 30 % non-renewables and this is credited with the large RE technology resource endowment and expansion, ranging from geothermal, solar, wind and hydropower for lighting and biomass for cooking (IEA 2018).

Government of Kenya (2018) ranks biomass as the highest source of energy in Kenya especially for the cooking sector. The main form of biomass utilized is wood fuel, but the modernization of cookstoves, promotion of biogas and bioenergy has been prioritized by the government in the recent years in a bid to promote sustainability of the biomass technology.

Hydropower has been the main source of energy for lighting in the country and is tapped from several dams spread across the county in regions around the five major basins (IEA 2019). However, the sector is highly vulnerable to the impacts of climate change, and as droughts and flooding become more common in Kenya (Droogers *et al.* 2009), the government has put in place strategies to diversify the RE sector.

For the future drivers, geothermal is fronted as one of the most reliable and clean grid energy technology favourable for the transition and IRENA (2019b) and IEA (2019) classify Kenya as the largest geothermal producer in Africa and the 9th largest global producer, with a total production potential of 10,000 MW. The wind energy potential is also high and suggested as an energy future due to high wind speed and the favourable topography of Kenya, especially in the northern, central and coastal regions of Kenya (Kazimierczuk 2019; O'keefe *et al.* 1984). Historically, wind energy was not a priority energy source for Kenya. However, from 2009, there have a drastic rise in the investment and production of onshore wind energy and key programs currently running are the Lake Turkana Wind Power Plant with a production capacity of 310 MW and the commissioning of IPPs with a total capacity of 210 MW (Kazimierczuk 2019; LTWP 2019). Just like wind energy, George *et al.* (2019) and Abdullah *et al.* (2011) support that solar technology presents a viable and rapidly expanding future driver for RE production and consumption due to the country's location in the tropics which has longer sunlight hours annually and insolation of 4-6kWh/m. With the implementation of the government's program KOSSAP and other mini-grids and SHS from IPPs spread across the country, the statistics of solar energy technologies are expected to rise significantly.

Results of data analysis reveal that the key political drivers of the transition to renewables in Kenya are a factor of policy and legal frameworks, institutional frameworks and market liberalization efforts. The Energy Act of 2019 provides anchorage for RE technological expansion and modernization, validates energy institutions for the formulation, implementation and enforcement of RE regulations and provides incentives, tax exemptions and subsidies that have liberalized energy market flows. Additionally, Kenya's Vision 2030 provides a strategic roadmap and driver for the transition of the rapidly growing Kenya low-middle class economy into a low carbon development pathway, which necessitates the production and supply of RE and clean energy. Supporting the realization of Kenya's Vision 2030 goal are the climate change policies such as the Climate Change Act, National Climate Change Action Plan (2013-2017, 2018-2022), Green Economy Strategy and Implementation Plan 2016-2030 and Kenya's NDC. In synergy with other energy institutions recorded in the research, the Rural Electrification and Renewable Energy Corporation (REREC) will play an integral role in ensuring renewable/green energy solutions are available for all consumers in the country (George *et al.* 2019).

Emerging from the research findings, the FiTs policy and net-metering systems are requisite drivers for the expansion of RE technologies in Kenya and in conformity with best practices globally. Kenya's FiT framework includes allowances for wind power, biomass, small hydro, solar, and geothermal and biogas. Expedition of their implementation will provide incentives for investors and IPPSs to set-up RE technologies in Kenya.

The research places a significant role in Kenya's socio-technical energy transition drivers associated with emerging technologies such as wind and solar energy. As Abdullah *et al.* (2011) noted, the diffusion of solar energy has increased significantly in the Kenyan market due to the introduction of consumer-driven strategies such as the PAYG model provided by various solar system providers, that allows for flexibility in the payment of the high cost of acquisition of solar panels/systems. Additionally, the research respondents lauded the installation of mini-grid solar systems in marginalized, remote regions without access to grid energy systems as an important driver in ensuring that both decentralized and centralized systems drive the transition process and that availability and access to RE technologies are ramped in all corners of the country. Lastly, the respondents perceive that health, economic and environmental benefits of RE to the consumers have driven the rapid diffusion of clean energy in the country rapidly since 2009. Abdullah *et al.* (2011) qualify this perception by reporting that majority of Kenyans are willing to pay for new RE technologies based on the valuation of the technologies on their long-term economic well-being, health and environmental benefits. The researcher assessed that more awareness and capacity building need to be done to ensure that the information about the need to transition to RE is disseminated to all energy users and synergies need to be enhanced among the policymakers, civil societies and the private sector.

5.1.2 Hindrances to the transition to RE in Kenya

Historically, the grid system has been given more priority in the expansion of energy systems in Kenya and as George *et al.* (2019) note, this entrenches the marginalization of rural off-grid communities where the transmission costs would not make economic sense for their connection to the main grid. The need to connect the entire country to the grid would also take decades to be attainable and at even higher costs to the production and transmission companies and a resultant higher utility bills for the consumers. This provides a strong case and need for expeditious installation of mini-grid systems which are easier to install in both highly accessible areas and especially in remote regions. However, respondents who criticized mini-grids claim that they have low return-on-investments and discourages prioritization of them due to the high capital investment costs associated with mini-grid installation. Since both systems have their weaknesses, the research assessed that a mix of both systems should be a priority for the government to maximize the strengths and to mitigate the weaknesses.

Despite the abundance of RE technologies in the country, their production and consumption are heavily linked to high investment in RD & D. As new and improved technologies are innovated and introduced to the markets, constant capacity building and training of experts are fundamental in ensuring that the installation, maintenance and information dissemination is possible. In Kenya, RD & D has been focused on traditional sources of energy such as hydropower and geothermal. On the other hand, little has been done to empower the solar, biomass and wind technology sector experts to ensure optimum cycle from generation to consumption. Additionally, research needs to be expanded on the technological challenges associated with lack of storage for emerging technologies and the intermittency challenges of solar and wind energy. Cumulatively, these factors discourage both investment and consumption of these technologies and the continuous reliance on grid systems which are touted by the respondents to be more stable and reliable due to several years of dedicated RD & D and investments.

The national statistics of poverty levels in Kenya indicate that a significant proportion of the residents live below the national poverty line and majority are based in the rural areas and in slum areas of urban regions. From the findings, it was evident that low income makes cleaner RE unaffordable for the poor population and this is evidenced by the campaigns and lawsuits targeted at the national electricity supplier, KPLC, that seeks to ensure utility cost reduction of the utility bills for grid connections. On the other hand, Abduallah *et al.* (2011) make a case for a contingency valuation plan that has been embraced by residents under the PAYG model for mini-grid and off-grid SHS, but analysis of the system from the perspective of some respondents indicate that in as much as rapid diffusion, majority of the poor Kenya still struggle to pay the upfront costs for the SHS.

A holistic transition to renewables requires prioritization of all sectors utilizing energy and the low focus on cooking and e-mobility presents a challenge to the sector goals and targets. The lighting sector has made tremendous progress in terms of availability, accessibility, affordability and reliability due to extensive policy and institutional frameworks which support program implementation. For the attainment of the 2030 goals on Low Emission Development for all sectors and the realization of the right to energy access enshrined in the Energy Act 2019, access to clean cooking needs to rise significantly from the current 25 % (IEA 2018) and the e-mobility sector needs to hasten the formulation of supportive policies and the introduction of e-mobility vehicles and other transport options.

The energy policy processes are also not well aligned, and this has led to overlaps, confusion and duplication of policy roles by the state institutions. An emerging impact of these policy gaps are cases of delays in roll-out RE projects, corruption and resistance to embrace and implement new policy ideas such as for the FiTs and net-metering system. Further, an assessment of the policies reveals similarities and differences in priorities. Policies on climate change reveal the need for a future devoid of fossil fuels while the Energy Act 2019 still acknowledges the role of fossil fuels in the energy mix of Kenya. Confusion therefore emanates on what the energy future of Kenya will be like, with some respondents having hope of a fossil fuel future while other respondents opined that a fossil-fuel is crucial for a rapidly growing economy like Kenya.

72 % of the Kenyan population live in rural areas (World Bank 2019) and majority of them still demonstrates strong attachment to cultural practices associated with energy access and consumption are still recorded to be high especially for biomass. Rural households in Kenya still predominantly use three-stone cookstoves which rely on enormous amounts of wood fuel and causes respiratory health problems to the users. The belief that meals prepared on three-stone cookstoves and the societal reverence of women who use this technology as better wives/homemakers presents a challenge for transition to cleaner and efficient RE technologies for cooking. However, as the respondents noted and as supported by studies done by Karanja and Gasparatos (2019) and IEA (2019), these beliefs are not factual and it is imperative that the households are adequately sensitized about alternatives and these alternative technologies are well designed to meet the needs of households and communities and the distribution of these technologies done equitably across the country. Without changes in the culture and behaviour of the communities and adequate technological expansion, it is very likely that consumption of unsuitable biomass will persist beyond 2030.

5.1.3 Impact of the RE transition on energy poverty

Energy poverty in Kenya presents itself mainly through availability, accessibility, affordability and reliability challenges that Sovacool (2012) defined for developing countries. Since Kenya has enormous RE sources, the challenge of availability on a national scale has been reduced. This research supports the assertion that local availability of RE technologies provides an impetus for the ease of modernization and expansion of a renewables-based energy sector. On the other hand, the accessibility to the readily available RE resources has been hampered due to the inequitable historical distribution of the grid and mini-grid systems, high transmission costs to off-grid regions and the systemic institutional challenges that did not prioritize socio-economic development of remote regions. As the research found out, the high capital investment required for RE technologies result in high transmission costs for grid systems and high installation costs for mini-grids, which consequently increase the costs of energy. Further, the government has invested in energy storage for grid systems but still faces challenges with reliability as blackouts are a common occurrence. However, reliability challenges are more ubiquitous in mini-grids systems from solar and wind technologies that are faced by weather seasonality, storage, and intermittency and low technical expertise for installation, repair, and maintenance (Olang *et al.* 2018). Therefore, as the global and national discourses continuously advocate for the transition to renewables, it is imperative that challenges related to RE are expeditiously addressed in order to increase the confidence of the government, investors and consumers in them.

5.2 Recommendations

The generalizability of this thesis might be limited due to the number of samples interviewed and researcher's bias, however, the findings proved to be universally applicable. These findings can therefore be used by policymakers, NGOs, private sector and scholars. The key recommendations emanating from this research are:

a. In order to attain a holistic energy transition, Kenya's policy processes, investments and programs need to put as equal amount of emphasis on the reduction of energy poverty and the transition to RE.

b. Additional emphasis and commitments need to be made on RE for the clean cooking sector and the transport sector for the attainment of the Kenya Vision 2030 goals and climate mitigation goals committed to in the Kenya NDC and the Kenya NCCAP 2018-2022.
c. For the attainment of universal access to energy, reliable connection and transmission technologies need to be increased and utility costs should be affordable for all.
d. The research recommends detailed consultations on appropriate and sustainable energy taxation policy direction by all relevant stakeholders to ensure that the low carbon development goals are met. Evidently, the tax exemption on RE technologies has greatly incentivized investments in the sector. As proposed in the on-going national budget 2020/21 and tax bill 2020, removal of the exemptions and increment in the VAT tax on RE technologies would significantly increase the costs to both the service providers and the consumers yet the energy poverty levels are still comparatively high. Without financial and economic incentive, the utilization of RE will be slower.
e. The private sector, in collaboration with other relevant stakeholders need to develop more innovative, low cost technologies that respond to the energy needs of the residents of Kenya which promote uptake of RE. Income disparities signify that low-income earners cannot exclusively use RE technologies.
f. Momentum on capacity building and awareness creation on RE needs to be sustained to increase diffusion of RE technologies and to shift the attitudes and behaviours of the consumers.

5.3 Areas of further research

Although Kenya's RE sector has received considerable attention, the author was unable to find scholarly articles or studies that analyzes the drivers and hindrances for the transition to renewables in the context of analyzing all the techno-economic, socio-technical and political frameworks. Additionally, scholarly articles interlinking the transition to renewables and the impacts on energy poverty in Kenya were not found hence this research presents a novel background research on this phenomenon. Further, the energy transition and energy poverty studies in Africa differ from those of developed countries and comparatively, research on Africa is insufficient. This research recommends that further scholarly research needs to be done to showcase more empirical information, particularly in Africa where energy transition and energy poverty has been insufficiently studied.

This research reviewed all the three meta-theories postulated by Cherp *et al.* (2018) in the analysis of energy transition in Kenya. For a more detailed understanding of Kenya's energy transition and development of conclusive scenarios, more research needs to be done on each of the meta-theories that was applied in this research. Additionally, more research needs to be done on the application of the framework on each RE technology in Kenya.

The expansion and modernization of the RE system is largely driven by market liberalization policies and the proposals to remove the tax exemptions and increase VAT for RE technologies and equipment the Tax Law Amendment Act 2020 will introduce new dynamics into the Kenya energy transition process. Further research can be done to evaluate what the impact of such proposals and their enactment may mean for the RE transition pathway.

Chapter 6. Conclusion

Energy is at the center of all human needs and as the world outlook on the environment and climate change evolve, the energy needs also change. In response to the impacts of climate change associated with the industrial revolution, energy transition and discourses in developed countries have shifted to the promotion of low carbon emitting energy technologies. On the other hand, the energy transition for developed countries is currently influenced more by the need to modernize and expand their RE systems as their emissions are lower in comparison to those of developed nations and their socio-economic development needs require substantial energy input. Despite being gradual, historical analyses confirm that energy transitions have occurred and therefore the quest to modernize and expand RE systems by African countries is feasible.

As a rapidly developing economy and with a rapidly growing population, the energy needs for Kenya's economic sector and the population is projected to grow equally quickly. This economic development for Kenya is embodied on a low carbon transition pathway which gives preference for RE. It can be concluded that in order to meet the growing energy demands, congruence between the techno-economic and political drivers are needed with the socio-technical drivers for an effective and just transition to be possible and integral. This research reveals that Kenya have more availability and production of RE technologies —geothermal, hydropower, biomass, wind and solar—than non-renewable energy sources, and this gives the country a comparative advantage in meeting the techno-economic drivers of energy transition. The RE resource abundance gives hope for some stakeholders that 100 % transition is possible in Kenya, but only with the support of legislative and policy frameworks, coupled with societal attitudinal and behavioral changes to facilitate the transition to RE. From a political drivers' perspective, the extensive and robust policy and institutional frameworks provide the requisite anchorage of RE in the energy mix and has highly boosted the exploration of the techno-economic drivers. The incentives provided by institutional and policy frameworks have also worked to drive social acceptance of RE technologies upwards, in addition to the known and perceived benefits of RE.

The transition to RE in Kenya has been met by several hindrances. The transition process places more emphasis on the lighting sector than on the cooking sector and mobility sector, hence the transition is not viewed as integrated. To meet the visionary transition policy targets, all the energy sector stakeholders' need to realign different components of the energy sector and to re-direct considerable efforts towards ensuring that policies and programs supporting the e-mobility and cooking sector are formulated expeditiously and implemented. Equally, the findings indicate that despite formulating several policies supportive of RE and set-up of institutions for the lighting sector, their implementation and enforcement has been inadequate, which necessitates the evaluation of policy and program failures and success. Further, confusion stems from policies that still acknowledge the role of fossil fuels in the running of Kenya's economy and which compounds the pessimism of some respondents that the transition to 100 % low carbon development pathway might not be attainable by 2030. Clarity is therefore fundamental in ensuring that the energy future of Kenya is certain, in order to unpack the alignment of RE programs towards a low carbon development pathway and to review the feasibility of the Kenya Vision 2030 target.

On the technological expansion and modernization front, the research concludes that there needs to be a mix of both grid and mini-grid systems, with more prioritization of Kenya's energy futures such as geothermal, solar, wind and sustainable biomass. The RE technological expansion and modernization is further reliant on continuous RD & D and financial investment which was concluded to be inadequate in meeting the speed of energy transition. The centrality of RD &D requires that the government in collaboration with all stakeholders increase RE funding and investment in order to achieve consumer driven innovative technologies and expand the capacity of the experts to deal with the changes in modern energy systems. Another major challenge on the socio-technical front is associated with attitudinal and behavioral changes that inhibit the transition to cleaner RE. The research identified low awareness of consumers about the alternatives of non-renewables and unsustainable RE (biomass), innovative solutions that do not meet community needs and cultural beliefs on energy use as the main barriers for the diffusion of RE technology. Sustainable momentum on awareness creation and capacity building is recommended to demonstrate the alternatives offered by RE, and to enable the consumers shift their attitudes and behavior towards the need for RE transitions.

As the transition towards RE is rapidly expanding and modernizing, impacts on energy poverty present a mixed signal of hope and areas of improvement. The RE resource abundance provides hope that universal access is attainable, through integrated energy needs, and equitable distribution mechanisms should be designed and implemented. As accessibility is improved, the cost of energy needs to be reevaluated to ensure that not only the middle-class and the wealthy are able to afford cleaner energy as 35 % of the population live below the poverty line. More investment in RD & D should be facilitated to ensure that the RE technologies are reliable and innovate enough to meet the localized needs of Kenyans. Centering accessibility, availability, affordability and reliability challenges in the energy transition in Kenya will ensure that the fundamental role of holistic changes in energy systems are successfully triggered.

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