# THE UTILIZATION OF INFORMAL FINANCING TO ACCELERATE OFF-GRID ENERGY ADOPTION IN KENYA'S RURAL AREAS

by
Jefferson Choti

A capstone submitted to Johns Hopkins University in conformity with the requirements for the degree of Master of Science in Energy Policy and Climate

Baltimore, Maryland
May 2020

**ABSTRACT**

The research paper provides a literature review and analysis on the role of informal financing in the adoption of renewable off-grid technologies and the electrification of Kenya's rural areas. The country is facing a growing demand for electricity and the national grid is not meeting the demands of every region in the country. On the country level, close to 40% of the population do not have access to electricity, as of 2015. In the rural region, the electricity access is much lower with only about 13% of the population having electricity, as of 2015. Kenya has been making tremendous effort in growing the connection rate, as the economy continues to grow as the needs of the population also increase. In 2018, the Government of Kenya introduced the Kenya National Electrification Strategy to accelerate the national electricity access to 100% by 2022. New innovations in the informal financial sector have increasingly enabled rural dwellers to access affordable capital to invest in renewable and other off-grid technologies. The utilization of mobile-based technologies has accelerated economic development of the country and the ability for many rural dwellers to enhance their standard of living. These innovations are giving users the ability to obtain loans, save money, transfer and receive payments, and pay for products and services. The integration of informal financing and off-grid technology innovations is proving to be a tremendous opportunity and mechanism for rural dwellers to gain access to electricity that allows suppliers to be reliably paid, and help the country reach the goal of 100% electrification.

# CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# INTRODUCTION

It is estimated that 1.3 billion people out of 7.3 billion in the world lacked access to electricity in 2015 (Linderman, 2015), but it steadily decreasing. According to the World Bank, 86.8% of the world had access to electricity in 2015 and 88.9 had access in 2017 (data.worldbank.org). Sub-Saharan Africa is home to a large percentage of the population without electricity access. Approximately 600 million people, which estimates to nearly seven out of ten people, are living without electricity in sub-Saharan Africa (Linderman, 2015), About 36% of Kenya's population of over 50 million (as of 2018) do not have access to electricity (World Bank, 2020). Electricity serves a crucial purpose in improving the economic and social conditions. The Government of Kenya has been making significant efforts to electrify the entire country, through improved policies and collaborations of private-public partnerships. Innovations in financial services serve a critical role in helping drive the electrification process forward.

Kenya is the most developed economy in East Africa (Kiplagat, 2011). It has seen continuous high-level of investment, near to billions of dollars, in renewable energy programs over the recent years (NewClimate Institute, 2019). Even though funds for energy innovations have increasingly contributed to the rapid economic growth of Kenya in recent years, the financing services for rural dwellers have been limited and this has led to the development of alternative and more flexible financing methods, outside of the regulated financial structure. These alternative financing methods can be classified as informal financing schemes, which is a form of financial services that takes place outside of the traditional financial intermediary structures between savers and borrowers, such as banking institutions. Since formal financing requirements, such as stable address and income verifications, have made it difficult of rural

dwellers to gain access to financial services from local banks, many of them have relied upon informal financing. These informal financing schemes include loans from employers, moneylenders, shop credits, savings associations, and other non-institutional financiers.

This capstone research reviews and analyses how informal financing is being harnessed to benefit the clean energy revolution in rural areas of Kenya. The research addresses the question: *To what extent is informal financing promoting and increasing electrification in the rural areas of Kenya, as compared to the formal (regulated) financing services*? In the rural region, informal financing is bridging the divide between institutional financial services and the informal livelihood of Kenyans. For many of these participants, it may be practical not only to have an alternative but perhaps the only method of accessing capital which often include mobile money, interpersonal borrowing from relatives and friends, community investment funds, and loan services by local shops.

Other recent studies such as Formal and informal institutions' lending policies and access to credit by small-scale enterprises in Kenya: An empirical assessment by Rosemary Atieno (2001) and Does the Informal Sector in Kenya Have Financial Potential to Sustainable Prepay for Health Care? Implications for Financing Universal Health Coverage in Low-Income Settings by Vincent Okungu (2019) have looked at the role of informal financing and credit policies on market-based enterprises and healthcare systems, respectively. These studies have found that informal financing has been very effective in low-income markets such as the rural areas of Kenya.

This research study differs by focusing on (1) how informal financing services, specifically mobile money, are utilized in the electric sector to drive electricity access in the rural areas and (2) synthesize available literature to assess the penetration of renewable technologies on the

rural areas of Kenya. This research will examine how informal financing market providers can reach the 37.5 million rural dwellers, who make up 73% of Kenya's population as of 2018 (World Bank, 2018), to harness the affordable opportunities in renewable energy services, whether it is through short term liquidity and/or money management.

Rural dwellers, commonly farmers, find it difficult to access formal financing due to banking requirements and regulations. With the limitations of formal institutional financial services, the informal financing sector has undergone immense growth in popularity amongst vast regions alongside the increasing penetration of decentralized energy generation. Additionally, the increasing focus on digital innovations, like the Internet of Things, are leading energy providers to reevaluate the core structures of traditional energy business models to expand services to rural areas.

The research set out in this report is intended to provide a substantive review and analysis that explores the financing opportunities available to support off-grid renewable generation and discusses the costs of the procuring renewable technology, such as the utilization of energy storage and distributed generation. The research aims to provide insightful and informative insights, based on available literature and data publications, that will serve as a resource for renewable energy adoption strategies aimed at the electrification of the rural areas of Kenya.

To achieve this, the capstone research will

(1) document recent progress in rural electrification and suggest strategies to increase rate off-grid electrification, including use of different technologies at different scales. The appropriate strategy for rural electrification using off-grid technology require assessment of the existing energy infrastructure and financial systems infrastructures.

(2) synthesize the available data resources to provide an analysis and summary on the advantages of using informal financing to support the roadmap to rural electrification.

(3) further look at the cost structures for small-scale hydropower plants, bio-diesel generators, solar photovoltaic, and wind power systems as feasible options when identifying affordability and sustainability in the long-term. It will look at how it may vary with the scale of generation capacity.

(4) summarize key findings including identifying the key challenges of energy access in Kenya for the next 10 years and conclude with ideas and recommendations.

The rest of this capstone research paper is structured as follows. Section 2, as part of the market research, we discuss formal versus informal financing mechanisms and provide a synopsis of the electricity sector in Kenya. In Section 3, the paper introduces the research design and methods. Section 4 presents the market analysis on the off-grid renewable technologies and the financing systems. Section 5 concludes the research with a summary of the findings.

# MARKET RESEARCH AND LITERATURE REVIEW

## *Section 1: Formal financing vs. informal financing methods in Kenya and their impact in urban vs. rural areas*

This section is divided into three main topics: (1) formal financing methods, (2) informal financing methods, and (3) the topographical mapping of financial services in Kenya.

**Formal Financing Methods in Kenya:** The formal system of financing is licensed by a central banking system. It includes commercial, retail, development banks, and specialized non-bank financial institutions, such as rural banks, post banks, savings and loan companies. The

principal clients include large businesses, governments, large rural enterprises, salaried employees, small and medium enterprises.

Formal financing institutions tend to favor large scale clienteles who meet stringent loan conditions. These institutions have complex requirements that are beyond that understanding of rural populations and low-income savers. The transaction costs are relatively high, but interest rates are low. Financial institutions like KCB Bank Kenya Limited (KCB) (ke.kcbgroup.com), offer these loans where the minimum loan provided is 100 shillings ($1 USD) and the maximum being 100,000 shillings ($1,000 USD). The interest rate is about 4.08% per month with a payable period of up to 3 months, since the loan amounts are small. To obtain these types of formal loans, there are some stringent requirements that can be difficult for rural dwellers. These requirements include certified ID or Passport, Kenya Revenue Authority number (used by the national government to track taxable incomes), latest pay slips (latest 3 months), proof of residency documents, a letter from the employer, and bank account statements.

Other banks offer higher maximum amounts that extend the payable period up to 72 months but imposes additional requirements. For banks that offer longer payment period, the eligibility requirements also include a minimum gross salary. For example, Standard Chartered (www.sc.com/ke), which offers a maximum of 7,000,000 shillings ($70,000) and 6 months to 72 months in payment periods, require a minimum gross salary of 40,000 shillings ($400) per month. These requirements hinder many rural inhabitants from accessing loans in the formal banking systems. They become factors in the transaction costs, along with the “hidden fees”. The hidden fees include arrangement fees (2.5% of the loan amount), credit life + retrenchment insurance cover, and other charges & fees that may be applicable.

Another factor to the transaction costs for formal banking is physical barriers. Banks like KCB do not find it feasible to establish full-service branches in remote places where there is limited population density. In some instances, there is no electricity access to power banks that may decide open branches in remote areas.

**Informal Financing Methods in Kenya:** Unlike formal financing institutions, informal financing systems are not licensed by a central banking system. These informal systems include savings collectors, savings and credit associations, and moneylenders. The common clients include low-income and self-employed. The simplicity of the informal schemes is attractive to these clients. The transaction costs are low, and the repayment fees are high.

M-Shwari, a loan service offered by Kenya's leading telecommunication company, Safaricom, has the highest popularity. M-Shwari is a paperless mobile money service that enables people to open and operate a savings account through the mobile phone, without filling out any forms. The mobile money service offers loans, as a micro-credit product that comes with the savings account. The interest rate is 7.5% per month, with a minimum credit of 100 shillings ($1.00 USD) and a maximum loan of 50,000 shillings ($10,000 USD) with a repayment period of one month. In order for a person to qualify, they will need to be an M-PESA subscriber of 6 months (which a great majority of the population are), have a M-Shwari savings account, and actively using the Safaricom as a telecommunication service provider. These requirements are very simple and most rural dwellers are prequalified.

The informal financial system in Kenya became well developed, after the creation of mobile money. Mobile money is a technology that permits people to spend, receive, and store money using a mobile phone. Mobile-based financial services, such as M-PESA, have enabled many people in the rural areas to perform financial transactions through mobile phone account.

M-Pesa, one of the most common mobile money services, provides people with person-to-person (P2P) transfers and withdrawals, payment options, connections to formal banking, and credit access. M-Pesa, with the launch of M-Shwari, created direct access to formal banking loan services. M-Pesa uses a cellular phone to transmit monetary transactions through telecommunication lines.

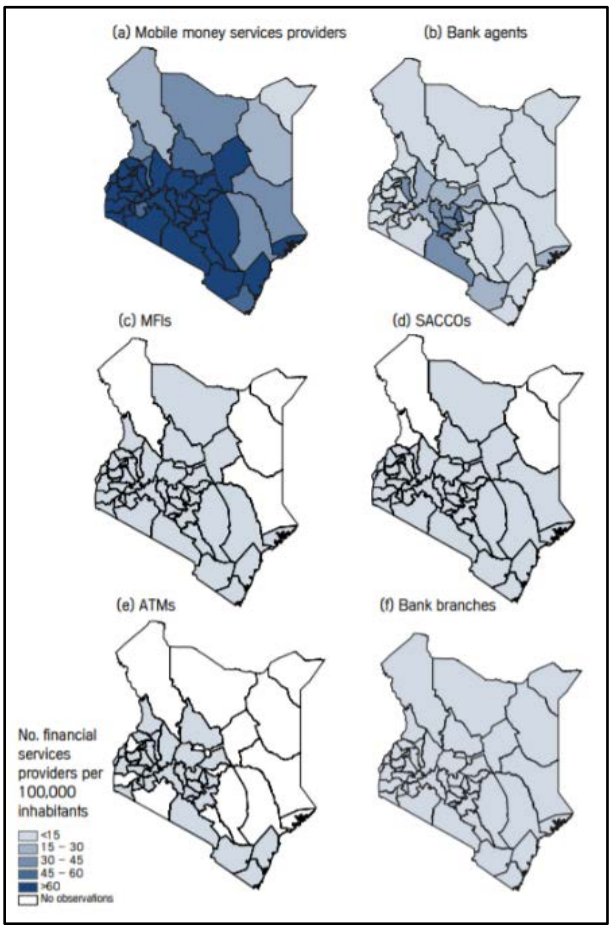
**Access to financial services in different parts of Kenya – rural versus urban areas:** The country of Kenya is located on the eastern part of Africa. Figure 1 displays the map of Africa and Kenya. Kenya is divided into 8 regions (Nyanza, Western, Rift Valley, Nairobi, Coast, Central, Eastern, North Eastern). The two major bodies of water bordering the country include Indian Ocean, on the eastern side, and Lake Victoria, located on the western side. The capital city is Nairobi, which is considered urban. The rural areas are mainly found on the northern half of the country, southeastern, and far west.

**Figure 1. Map of Kenya, Africa**


Source: https://www.bugbog.com/maps

Financial services sector in Kenya has saturated with many providers. They range from formal banking providers to informal communal networks. Figure 2 shows a 6 heat maps showing individual financial services and how they are scattered across the country. The areas closest to the capital city have the highest concentration of financial services.

**Figure 2. Mapping of the financial services providers**

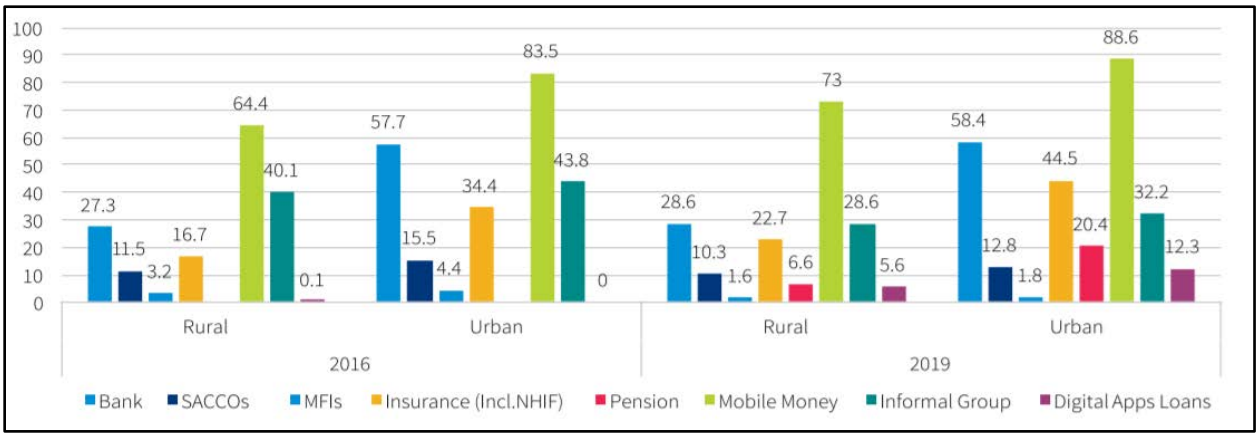



Source: (Barboni, 2015)

The figure 2 shows a locational mapping of all the financial services across the country. It is categorized as (a) mobile money services providers, (b) bank agents, (c) MFIs (which are microfinance institutions), (d) SACCOs (which are savings and credit cooperatives), (e) ATMs, and (f) bank branches. Mobile money services, which is part of the informal financial

systems, has penetrated many areas across the country. This is not the case for ATMs and bank branches, which are commonly found in more urbanized areas. The number of bank agents has been increasing over the years, in conjunction with growth in mobile money services.

**Figure 3. Level of financial access by residence (%)**




Source: (FinAccess, 2019)

The level of financial access, particularly for mobile money providers, have been increasing over the years. As shown on Figure 3, mobile money service providers have been reaching the highest percentage of rural residence with 73%, as of 2019, which is up from 64.4% in 2016. They are followed by banks, which are contracted entities that perform banking functions in remote regions for formal financial institutions, at 28.6% in 2019.

The proportion of Kenya's population with access to formal and informal financial services rose to 83 percent from 2016 to 2019, in connection with mobile technological advancements (Reuters, 2019). The adoption of mobile money services, one form of informal financing, has led to double-digit growth in monetary valued transactions in Kenya. In a country of a little over 50 million people, over 30 million are active users of mobile money transfer services

(Safaricom, 2019). Part of the growth has been facilitated by the partnerships with PayPal, Google, Western Union, and AliExpress, which are resulting in 34% of all remittances coming from outside of the country going through M-Pesa (Safaricom, 2019). Remittances can be classified as money transfers relating to gifts or payments for products or services. In a 2013 report by FSD Kenya, about 10% of all adults conducted a mobile money transfer daily and a little over 30% conducted money transfers weekly (Central Bank of Kenya, 2013). The Central Bank of Kenya data for 2018 shows that mobile money transactions reached nearly $40 billion dollars, which is roughly a 10% increase from 2017.

The mobile money services have gained significance in the agriculture business, as these technologies serve as the popular medium for monetary exchange. According to United Nations Food and Agriculture Organization, about 80% of the population in Kenya perform agricultural related activities as a form of livelihood (Kenyan Agricultural Research Institute, 2012). The utilization of informal financing, such as M-PESA, is proving to be the most efficient and affordable method of supporting off-grid energy adoption in the rural region. Due to the ease of business with informal financing methods, off-grid energy providers are finding it to be more economical to integrate off-grid energy solutions with mobile money services, as the primary payment services.

### *Section 2: Electrification in Kenya*

Financial services continue to spur the economy upwards to support the population growth, but the high cost of electricity and lack of electricity access for many rural dwellers is still hindering that progress. According to the most recent data on Global Petrol Prices, the price of electricity was $0.225/kWh in September 2019, whereas it is averaging close to $0.12/kWh in the U.S (GlobalPetrolPrices, 2020). The cost of energy on a $/kWh basis in Kenya is nearly

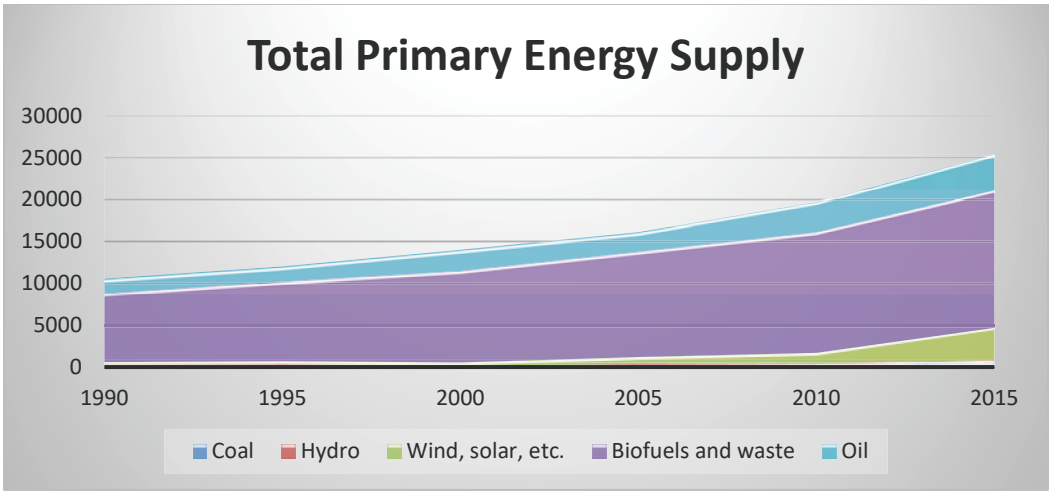
double that of more advanced and developed nation. The higher cost of energy might be due to the major use of diesel-fired power plants and the low customer base to which the costs are socialized to. As a result of the high energy prices, it is hard for an average rural dweller in Kenya to afford consistent energy from the grid without sacrificing other essential goods and services though this is mitigated considerably because of electricity usage (kWh) for those that gain access.

International development institutions are introducing off-grid technologies at different scales, like mini-grids, stand-alone solar systems, and solar water pumps in the rural areas of Kenya to help provide affordable energy for the long-term. The renewable energy capacity in the continent of Africa had increased by 40% from 2015 to 2016, reaching close to 900 MW, and out of which 25.3MW of the installed capacity in 2016 was in Kenya (NewClimate Institute, 2019).

The appropriate strategy for rural electrification by using off-grid technology requires a clear assessment of the existing energy infrastructure and financial systems infrastructures. Part of the research utilizes the available data resources to provide analysis and insights on the advantages, as well as potential barriers, of using alternative financing methods to support the roadmap to rural electrification. Additionally, the research will highlight the prevailing cost structures for small-scale hydropower plants, bio-diesel generators, solar photovoltaic, and wind power systems as feasible options when identifying affordable and sustainable solutions for the long-term.

In Kenya, energy supply is provided by biofuels and waster, coal, renewables, hydro, and oil. Biofuels and waste are the dominant source of energy. Figure 4 shows the energy source mix trending upwards over time.

**Figure 4. Energy Supply Power in Kenya, 1990 – 2015, (ktoe Units)**




Source: IEA Kenya Dataset (2020)

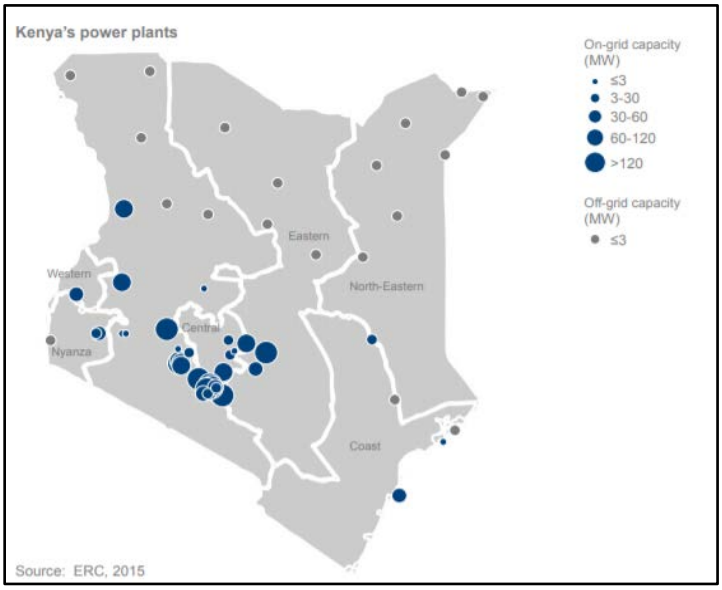
In 2015, Kenya's power generation was 593MW in geothermal, 827MW in hydro, 26MW in wind, 751MW in fuel oil, 38MW in biomass, and 60 gas turbine (PowerAfrica, 2015), leading to a total of 2,295MW of capacity from 42 grid-connected power plants. Figure 4 shows the dominance of biofuels and waste on the energy supply growth from 1990 to 2015. PowerAfrica report states that an additional 11.5MW in 19 off-grid stations are installed in the rural areas. According Kenya Power and Lighting Company annual report of 2018, Kenya's installed energy capacity is 2,351 MW in 2018, which includes on-grid capacity and off-grid stations, and peak demand is 1,802 MW connected to the grid. Kenya is among the largest geothermal power producers globally (REN21, 2016), with capacity reaching over 630 MW in 2019 (KPLC, 2019). The geothermal power provides nearly a third of Kenya's energy needs. The Government of Kenya is making tremendous effort in driving the generation capacity up, resulting from increased investments.

Kenya Power and Lighting Company, in 2018, reported that the energy mix for geothermal sources was 47%, while hydro and conventional thermal plants generated 30.1% and 20.6%,

respectively (KPLC, 2018). The total geothermal generation was reported at 5,053 GWh and hydro generation was 3,224 GWh, and solar generation was less than 1% of the power generation capacity that was connected to the grid.

Figure 5 shows the spread of on-grid and off-grid capacity across the nation. Significant presence for on-grid capacity development is showing around the Central province, which has more urban areas of the country that includes Nairobi. The off-grid capacity, as shown in the figure, is scattered to the rural areas.

**Figure 5. Kenya's energy capacity (MW) split by on-grid and off-grid**




Source: Kenya's Energy Regulatory Commission 2015.

As of 2019, the existing off-grid electrification in Kenya is largely dominated by the small-scale stand-alone Photovoltaic system at about 99% (Moner-Girona, 2019), in terms of number of systems, even though diesel has a largest percentage in installed capacity. The available sources of energy in the rural energy include mini-grids, battery-operation, kerosene lighting, and petrol/diesel-powered generators.

According to the World Bank, the population of the country in 2018 was recorded to be 51.393 million, with 73% of the population living in the rural areas. The population has steadily increased since 2005 for both urban and rural areas. Table 1 shows the growth comparison for 2005 to 2014. The population density for rural region made a significant increase with 50.3 people/square mile, which is an increase from 39.3 people/square mile in 2005.

**Table 1. Population Growth, 2005 and 2014.**

| **Categories** | **Unit** | **2005** | **2014** |
|---|---|---|---|
| Demographics | | | |
| Population | Million | 35.3 | 44.9 |
| Growth in Population | Average (Annual) | 3.0% | 3.0% |
| Rural - Population | Million | 28.2 | 34.4 |
| Growth in Rural Population | Average (Annual) | 2.0% | 2.0% |
| National – Population Density | People per sq. ml | 39.3 | 50.3 |

Source: World Bank Development Indicators (2016)

**Table 2. Kenya Electrification Growth: 2005 and 2014.**

| **Electricity Sector** | **Unit** | **2005** | **2014** |
|---|---|---|---|
| Electricity connection rate | % of population | 20.4 | 36.0 |
| Urban | | 70.2 | 68.4 |
| Rural | | 6.6 | 12.6 |
| Electrification growth rate | Percentage change in population (%) with a connection, (5-year compound rate) | 8.1% | 12.3% |
| Population with electricity connection | Thousands | 7,208.6 | 16,150.9 |
| Urban | | 5,341.3 | 11,813.0 |
| Rural | | 1,867.3 | 4,337.9 |
| Electrical power consumption | kWh/person/year | 130.2 | 166.7 |
| | kWh/person with an electricity connection/year | 638.5 | 463.2 |
| Customers served by the grid | Thousands | 599 | 2,482 |

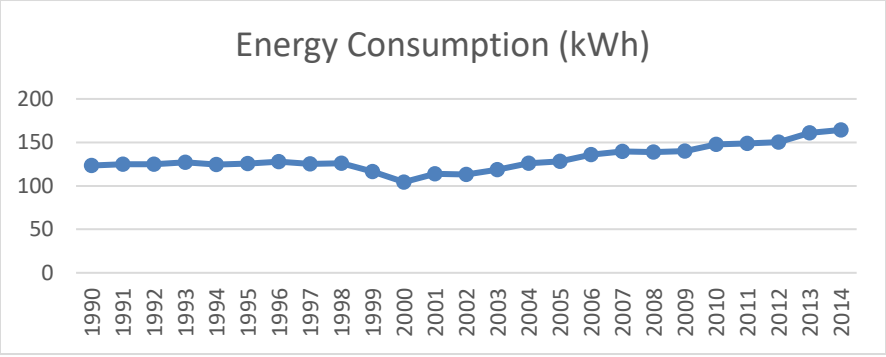
Source: KPLC Annual Reports (2005 & 2015)

Table 2. shows significant growth in electrification. Electrification in the rural region grew by about 132% from 2005 to 2014. In 2015, the Last Mile Connectivity Project by KPLC,

financed by the African Development Bank, World Bank, and other international financing institutions, was launched to increase connectivity in the rural areas, by offering subsidies for grid extensions. In phase one of the project, over 200,000 customers were connected (KPLC, 2018). The project will undergo 4 phases whereby millions of customers will be connected to the grid.

The cost of energy for a typical residential customer who is connected to the grid, as of November 2018, is 10 shillings ($0.10) per kWh, which does not vary with location. It is subsidized for customers in the Last Mile Connectivity Project. A similar customer, with solar only, can expect to see 6 shillings ($0.06) per kWh as the cost of energy. The unreliability in the energy supply infrastructure supplements the high energy costs for connecting to the grid. Many companies in the country lose nearly 10% of the production due to outages (Taneja, 2017). The current conditions have led the national policy to prioritize sustainable, affordable, and reliable domestic energy, as the overall energy consumption of the country continues to increase, as shown in Figure 6.

**Figure 6. Electricity Power Consumption in Kenya (kWh per capita per year)**




Data based on OECD/IEA 2014.

The electricity consumption per capita in Kenya is relatively small compared to the rest of the world. In countries like Italy and Belgium, the electricity consumption per capita per year

is about 5,000kWh and 8,900kWh, respectively (World Bank, 2020). Many countries in Europe, such as Italy, have energy consumption per capita that ranges between 4,000kWh to 7,000kWh. Households in many parts of Kenya do not have many energy consuming appliances that are common in more developed nations, such as washing machines, dryers and multiple refrigeration systems.

According to the World Bank, a little over 60% of the population in Kenya have access to electricity. Data from the Department of Economic and Social Affairs United Nations suggest that only 16% of the population in the rural areas in Kenya had access to electricity, in 2015. The government of Kenya has been working diligently to grow rural electrification by 40% by 2024 (Ministry of Foreign Affairs, 2019). The efforts can be seen through the increasing targets to achieve higher penetration rates for electricity access.

**Table 3. Electricity Access and Population in Kenya**

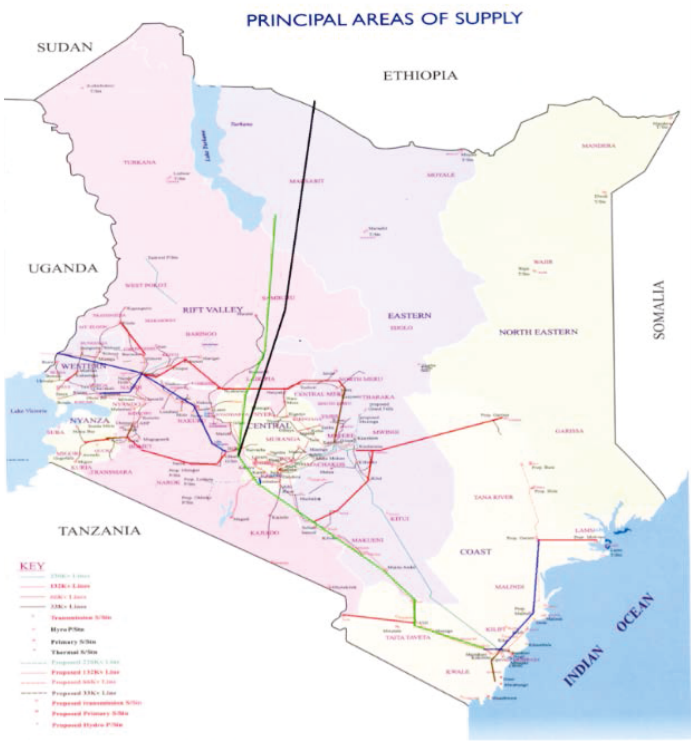
| | Electrification | | Population | |
|---|---|---|---|---|
| | Achieved Access (%, 2015) | National Target (%, 2020) | # of Households (thousands, 2005) | # of Households (thousands, 2015) |
| Urban | 78 | 100 | 2853 | 4577 |
| Rural | 16 | 32 | 3999 | 4262 |
| Total | 42 | 67 | 6851 | 8839 |

Source: Energy Regulatory Commission, 2013; European Development Partners, 2015; Department of Economic and Social Affairs United Nations, 2018.

The data in table 3 provides the electricity access targets and population dynamics from available data. The targets for 2020 were set at 100% for urban areas and 32% for rural areas, leading to a combined 67% national target. The electrification process has been greatly successful in the urban areas, as shown in Figure 7. Majority of transmission and distribution lines are in or within the Central province. However, the country's energy potential is enormous, especially in renewable energy. The utilization of solar and wind energy can help reach the regions where the feasibility for electricity grid access remains deem.

The figure 7 shows the transmission network on the map of Kenya, highlighting most current available mapping of the transmission lines. The regions with the high population are Central, Rift Valley, Western, and Nyanza province. Many regions with less dense population have little to no electricity access, which can be seen on the northern part of the map. The solid lines show the current transmission network, with lines ranging from 33kVv to 220kV. The dotted lines are the proposed transmission lines for future consideration, as 2019. In Kenya, the electricity is produced at 11kV to 15kV, then it is stepped up at the transmission substations to 220kV or 132kV to be transported on the transmission lines. It is then stepped down to different levels of 66kV, 33kV, and 11kV for distribution to various size consumers. KPLC is the national system operator overseeing these transmission and distribution lines.

**Figure 7. Map of the transmission lines in Kenya**




Source: https://renewableenergy.go.ke

In Figure 7, the single solid line that goes up north is the existing transmission line that serves the northern regions. As shown, there is limited grid access for many regions that reside far away from that transmission line. This poses a crucial need for adequate off-grid capacity for the remote areas, which also requires appropriate financial services to make them affordable.

## RESEARCH DESIGN AND METHODS

Many studies have been done to study the potential opportunities available in the renewable energy space for developing nations (for example Review on the integration of photovoltaic renewable energy in developing countries- Special attention to the Lebanese case by J. Khoury (2016) and Renewable Energy and Energy Efficiency in Developing Countries by UNEP (2017), have demonstrated tremendous promise in the expansion of renewable energy in developing markets). The results show that for renewable energy providers to be successful, they must customize their product offerings to meet the needs of each specific region. This research paper conceptualized the data published by financial institutions, academic scholars, national agencies and energy companies to analyze the value of informal financing on promoting or increasing energy access to the rural areas, as compared to the formal financing services.

To achieve the stated objectives, the methodology relied on performing literature review of case studies, scientific publications, such as World Bank data available online, and governmental policy implementations of the last 10 years and looking forward to the next 10 years. In performing this research, I also utilized my personal knowledge of Kenya's financial services and energy utility services, coupled with peer reviewed and other studies conducted by experts on these areas.

## MARKET ANALYSIS

### *Section 1: Off-Grid Market Analysis*

In the Kenya's Vision 2030 development program, the Kenyan government established a target of ensuring 100% of the population has electricity access by 2022. Given the targets in the table 3, it is likely that the target of 100% will be reached by 2020. In 2018, about 75% of the population in Kenya had access to electricity (IEA, 2019); IEA recorded that a little over 95% for the urban areas and 66% of the rural areas.

Two of the key agencies have been tasked with electrifying the rural areas include Rural Electricity Authority and Kenya's Ministry of Energy. The Rural Electricity Authority is the main organization tasked with accelerating the access to electricity in the rural areas. In conjunction with the Kenyan Ministry of Energy, Rural Electricity Authority developed a comprehensive plan called Rural Electrification Master Plan which provided a framework of connecting as many rural customers to electricity as possible. The Kenyan Ministry of Energy oversees the development and implementation of energy regulations for the energy sector participants and to provide energy security and ensure efficiency in the utilization of energy.

The off-grid generation market has seen a significant increase in focus over the recent years. The regulatory provisions for off-grid generation have been substantially developed by the key agencies. Some of the notable provisions that have been introduced include guidelines on various levels of capacity. On-site power generation projects of up to 1MW are receiving quicker approval process and projects below 3MW are not required to have generation permits (ECA et al., 2015). Energy policies, that reduce the cost of energy by providing subsidies, are having positive impacts on the rural dwellers. In connection with access to informal financing,

many households are beginning to acquire off-grid generation at affordable rates. The prominent off-grid generation options include:

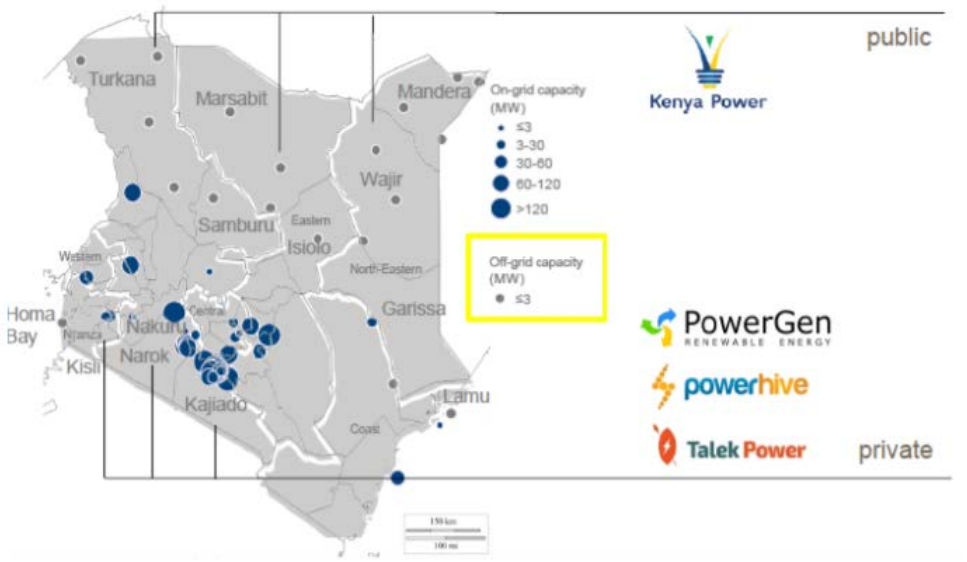
**Mini-grids:** [ranging from 1kW to 2MW] consists of a combination of generating technologies, such as hybrid wind-diesel generator, hybrid PV-diesel generator, small hydro power, solar-PV mini grid, wind power mini grid, and diesel generator mini grid. All the combinations consist of either a wind turbine, photovoltaic panels, and/or diesel generator. These mini grids can be either publicly owned or privately owned.

The two mini-grid schemes in Kenya are public models and micro-grid models. The public models scale from as low as 100kW to 2MW, which are predominately diesel generation (NewClimate Institute, 2019). The newest of the existing pubic mini grids has an installed capacity of 184kW, serving 34 connections (June 2018). The oldest public mini grid in Kenya has an installed capacity of 3,485kW, serving 9,528 connections. The public mini grids are publicly funded to keep the cost of electricity low, at 0.44$/kWh on average (ECA, 2014), in operating costs that excluding the capital costs, for the operators. The micro-grid models are very small scale with 1 to 20kW generation capacity, mainly using solar as the fuel source. The micro-grids operate on private sector funding and are vertically integrated model. Both mini-grid schemes use pre-paid metering technologies to ensure revenue is secured from the consumers.

The privately owned mini grids tend to be smaller; the PV component of the system often has a size range of 2kWp and 15kWp (World Bank, 2017), with an aggregated installed capacity lower than 100kW. In Kenya, the main operators for privately owned mini grids are PowerGen, SteamaCo, and Powerhive. A little over 20 of the private mini grids are serving between one thousand to twenty-five hundred consumer homes, with 500kW in aggregated

capacity (World Bank, 2017). These types of mini grids will be important contributors to the future growth in electrification. The community mini grids are operated by communities with their own management committees (World Bank, 2017). The payment collection is done on a door-to-door basis, whereby a representative of the community mini grid management visits members to collect amounts due. There is a great opportunity available for mobile money applications and remote monitoring of operations.

**Figure 8. Map of Kenya's mini grid stations (Public and Private)**




Source: World Bank (2017)

Mini grids were first introduced in the 1980s as part of the government's plan to reduce the cost of electricity in the rural areas. Currently, these mini grids have been modernized to run on solar and wind power, and some are exclusively powered by renewable energy generation (AHK Kenya, 2016). The operating companies that dominate the mini grid market in Kenya are KPLC, Powerhive, Talek, PowerGen, and RVE.Sol. The public mini grids are owned by the Rural Electrification and Renewable Energy Corporation (REREC) and operated by KPLC.

These mini grid systems come in various small sizes to fit the needs of the communities. As shown in Figure 8, the public and private mini grid stations have a few key operators; Kenya Power, PowerGen, Powerhive and Talek Power. These systems serve about 80 to a little over 4,000 households and vary from nearly 200kW to 3,400kW of installed capacity and are scattered all over the country. The aggregated generation capacity for the installed private mini grids are around 0.5MW, with most of them having PV panels (NewClimate Institute, 2019). Most of the households that utilize these mini grids have a monthly demand of 200W to 400W (World Bank, 2017). Many of the current mini grids in Kenya are power by diesel, as shown in Table 4, but as the costs for renewable technology decreases, renewable-power mini-grids are becoming more cost-effective.

**Table 4. Installed public mini grids in Kenya**

| County (Locality) | Commissioning date | Number of connections (June 2016) | Installed capacity (kW) (October 2018) |
|---|---|---|---|
| Garissa (Daadab) | 2016 | 4,800 | 784 (diesel) |
| Homa Bay (Mfangano) | 2009 | 3,000 | 650 (diesel)<br>10 (solar, 2013) |
| Isiolo (Merti) | 2007 | 1,485 | 250 (diesel<br>10 (solar, 2011) |
| Lamu (Faza) | 2017 | 2,010 | 1,370 (diesel) |
| Lamu (Kiunga) | 2017 | 350 | 260 (diesel) |
| Mandera (Elwak) | 2009 | 1,700 | 740 (diesel)<br>50 (solar, 2012) |
| Mandera (Mandera) | 1979 | 8,000 | 3,130 (diesel)<br>330 (solar, 2013) |
| Mandera (Rhamu) | 2013 | 400 | 520 (diesel)<br>50 (solar) |
| Mandera (Takaba) | 2013 | 500 | 320 (diesel)<br>50 (solar) |
| Marsabit (Laisamis) | 2016 | 160 | 264 (diesel)<br>80 (solar) |
| Marsabit (Marsabit) | 1977 | 8,200 | 2,900 (diesel)<br>500 (wind, 2011) |
| Marsabit (North Horr) | 2016 | 160 | 184 (diesel) |
| Tana River (Hola) | 2007 | 1,300 | 800 (diesel)<br>60 (solar, 2012) |
| Samburu (Baragoi) | 2009 | 473 | 240 (diesel) |
| Turkana (Lodwar) | 1976 | 9,598 | 3,425 (diesel)<br>60 (solar, 2012) |
| Turkana (Lokichoggio) | 2010 | 350 | 1,050 (diesel) |
| Turkana (Lokitaung) | 2018 | 34 | 184 (diesel) |
| Turkana (Lokori) | 2016 | 150 | 184 (diesel |
| Wajir (Eldas) | 2013 | 342 | 184 (diesel)<br>30 (solar) |
| Wajir (Habaswein) | 2007 | 1,180 | 1,160 (diesel)<br>50 (wind, 2012)<br>30 (solar, 2012) |
| Wajir (Wajir) | 1982 | 12,055 | 4,200 (diesel) |

Source: New Climate Institute, 2019. "The role of renewable energy mini-grids in Kenya's electricity sector.

Table 4 shows most of the public mini grids currently operating in Kenya, as of October 2018. Many of the connections are in small towns and villages. The aggregated installed capacity is about 24.1MW, with 50% of the total installed capacity being solar-connected mini grids. Although the number of mini grids is growing, they are still a small amount of capacity relative to the total system capacity. It is more than likely that the number of solar-connected mini grids will grow, due to technological advancements and affordability. The REREC is in the process of adding 25 additional mini grids (NewClimate Institute, 2019).

The payments are collected from mini-grid energy users in two ways. One way is through the process of meter reading, where a representative reads the meter at the premise and sends a bill (method is known as which is known as post-paid). The other payment method, which utilizes mobile money, is whereby the customer pre-pays through M-Pesa for the energy to be used.

**Solar Home Systems**: Kenya is also home to one of the most advanced pay-as-you-go solar home system (SHS) firms for photovoltaic mini grid development, whereby more than 700,00 households own a system and with potential for 1.96 million more in the near future (NewClimate Institute, 2019). This system ranges in generation capacity, from a few Watts to more than 2kW, though common size is 10W. The market leaders for these systems are M-KOPA and BBOXX. Figure 9 shows a standard M-KOPA system. The financing arrangement for the smallest M-KOPA system is 2,999 shillings ($29.99) for down payment and 50 shillings ($0.50) per day for 420 days (Zarembka, 2020).

**Figure 9. A M-KOPA System**

Source: cleantechnica.com

The SHS products come ready to use and all the necessary accessories are available in the packaging. Table 5 shows the pricing of a sample of M-KOPA and BBOXX SHS systems. The 60W M-KOPA system appears to be cheaper in terms of total cost per watt even though it has the largest capacity. This is due to the financing periods varying between products, as shown in the table.

**Table 5. Cost of Solar Home System per User.**

| Company | Product | Payment Terms | Total Cost | Total Cost per Watt |
|---|---|---|---|---|
| M-KOPA | 8W system | $0.50/day for 420 days, with $29.99 upfront deposit. | $240 | $30 |
| | 60W system | $1.35/day for 660 days, with $79.99 upfront deposit. | $896.49 | $14.94 |
| BBOXX | 15W system | $9 per month for 36 months, with $9 upfront deposit | $336 | $22.4 |
| | 50W system | $21 per month for 36 months, with $21 upfront deposit | $761 | $15.22 |

Sources: M-kopa.com, 2020. World Resources Institute, 2016.

According to the World Resource Institute, the M-KOPA 8W system comes with four 1W LED lights, 2 charging cables, 1 LED flashlight, 1 control unit with battery, and 1 radio. The BBOXX 15W system comes with four 1W LED lights plus 1 radio. The BBOXX 50W system comes with four 1W LED light plus radio and 19-inch LED TV. M-Kopa has various options that include 24-inch and 32-inch TVs, smart phones, and small 100L Fridge (M-Kopa, 2020). The prices seem high on per watt basis, but they are calculated by factoring the length of the financing period with added default risks and related provisions. Because the systems can in many price levels, the rural dwellers find them to be affordable. They can upgrade as their needs grow.

The national government, with the aid of World Bank, have embarked on a project called the Kenya Off-Grid Solar Access Project (K-OSAP), which has a mission of increasing electricity access in underserved regions (Kenya Power and REA, 2017) by introducing mini grids and SHS technologies. The Rural Electrification and Renewable Energy Corporation (REREC), in charge of electrification of the rural communities, is currently developing mini grids that are coupled with PV and diesel generation, backed by battery storage. In 2019, Kenya established the 2019 Energy Act, whereby the Renewable Energy Feed-in-Tariff System was revised in support of the local distributed generation technologies (Government of Kenya, 2019).

KPLC estimates average consumption for users with mini grids to be 121 kWh/month/user, which is nearly 10 times the average use in rural Kenya. Studies show it ranges between 80 to 106 kWh/month/user (Economic Consulting Associates, 2014). In the village, energy demand is estimated to be between 35 to 62 kWh/month/user for owners of mini grids. (Carbon Africa

Limited et al., 2015). Urban households consume 50 percent more electricity than rural households (S. Fobi et al., 2018).

Projects that provide solar PV systems to low-income householders often deploy smaller systems that are affordable by households but cannot power more than a few light bulbs and a radio. In recent years, the providers of SHS have increased the sizes of PV systems, which now include larger power items such as TVs. Mini-grid systems have larger capacity and can serve 50 or even 100 households at a time. (U. Deichmann et al., 2011). Table 6 provides capital and operating and maintenance expenses, and lifetime of technologies.

**Table 6. Cost of Kenya's Popular Off-grid Technologies**

| **Technology** | **Size** | **Investment [$]** | **Cost of Investment ($/kW)** | **O&M** | **Lifetime** |
|---|---|---|---|---|---|
| Diesel Generator | 23 kW | $13,800 | $600/kW | 0.35 USD/hr. | 15,000 hours |
| Wind Turbine | 54 kW | $15,300 | $238/kW | 3% | 20 years |
| PV | 1 kW | $1,200 | $1,200/kW | 1% | 20 years |
| Battery | 1 kWh | $450 | - | 1% | 2,300 kWh |
| Inverter | 1 kW | $600 | - | - | 15 years |
| Installation Costs (PV) | 1 kW | $150 | - | - | - |

Source: African Solar Designs (2018), Fortis Wind Energy (2018), and Moner-Girona et al. (2018)

The capital cost of installing a wind turbine is still the highest with $15,000, based on the available data shown on the table above. Diesel generation is the next most expensive investment at $13,800 per unit. The other technologies have the lowest capacity but may be more affordable in the long-term. Table 7 shows the expected cost for energy with a standard Feed-in tariff. Off-grid solar has the highest rate per kWh and given that it has lifetime of 20

years, it will be a good investment for the long-term. Off-grid PV will be work best if it is coupled with battery storage.

**Table 7. Feed-in-Tariff for renewable projects in Kenya**

| Technology | Project Size (MW) | Standard Feed-in-Tariff ($/kWh) |
|---|---|---|
| Wind | 0.5-10 | 0.11 |
| | 10.1-50 | |
| Hydro | 0.5 | 0.105 |
| | 10 | 0.0825 |
| | 10.1-20 | |
| Biomass | 0.5-10 | 0.10 |
| | 10.1-40 | |
| Biogas | 0.2-10 | 0.10 |
| Solar (Grid) | 0.5-10 | 0.12 |
| | 10.1-40 | |
| Solar (Off-grid) | 0.5-10 | .20 |
| Geothermal | 35-70 | 0.088 |

Source: Ministry of Energy and Petroleum, 2014

The role of PV and battery storage is growing. Solar generation systems, with built-in battery storage, are being promoted across the rural areas by off-grid market developers. These developers are teaming up with micro-credit financing organizations to enable consumers to quickly acquire and own these systems on credit. Battery storage systems performs a vital role in integrating renewable energy generation systems, by enabling operators to dispatch energy at different times of the day or night. Globally, the costs for battery storage are steadily declining as resources are becoming available for building capacity and innovating on current technologies. This leads to lower costs of financing and maintenance and operation for renewable generation with battery storage in the rural markets in Kenya.

### *Section 2: Financing Options Analysis*

In Kenya, the financial sector services have experienced technological innovations as well, to focus on the inclusion of the rural populations as the demand for electrification increases. An example of the innovation is the mobile telephone money transfer services that allow mobile phone users to make financial transactions and transfers across the globe with convenience and at low cost, in the form of mobile money. Mobile money is a technology that permits people to spend, receive, and store money using a mobile phone. Safaricom, Kenya's major phone company with 80% of the market (Jack et al., 2014), provides the mobile payment services called M-Pesa, which uses a cellular phone to transmit monetary transactions through telecommunication platforms.

M-Pesa was first brought into the market in 2007. As the most popular mobile money service in East Africa, it provides people with P2P transfers and withdrawals, payment options, connections to formal banking, and credit access. In recent years, millions of Kenyans are using M-Pesa to send remittances, make merchant payments, short-term savings, without need and use of bank accounts. Using an active SIM card, to establish the telecommunication signal, an M-Pesa user can load money by visiting one of Safaricom's agent stores and exchange monetary currency for e-money that is deposited into their account. Thereafter, the user can transfer the money to anyone who has an M-Pesa account. The operation is done at a very low cost, in a secure and convenient manner. It has contributed significantly to the financial inclusion, where the poorest individuals at any remote region can perform financial transactions. Airtel Kenya, Telkom Kenya Ltd, and Equitel also operate mobile money services in Kenya. Safaricom's M-Pesa is the market leader with approximately 30 million users, followed by Airtel with about 4 million users (CNBC AFRICA, 2020). Table 8 shows the

typical cost structure for transactions with M-Pesa service. The charges tier upwards starting from $5 transactions.

**Table 8. Transaction Costs for M-Pesa (User to User fees)**

| Min ($) | Max ($) | M-PESA Charges |
|---|---|---|
| 0.01 | 0.49 | Free |
| 0.50 | 1.00 | Free |
| 1.01 | 5.00 | Free |
| 5.01 | 10.00 | Free |
| 10.01 | 15.00 | 0.26 |
| 15.01 | 25.00 | 0.41 |
| 25.01 | 35.00 | 0.56 |

Source: www.safaricom.co.ke (2020)

Informal lending practices flourish in Kenya as a result of adverse polices and regional conditions. Much of the Kenyan population live in regions that are isolated, where banks are scarce. As a result, Kenyan cultural values have a strong emphasis on communal connections and informal financing. In promoting greater energy access in rural areas, off-grid providers must take into consideration the great opportunity offered through informal financing. In Kenya, many service providers have identified alternative forms of payments that are proving to be successful, such as mobile money system. The off-grid energy providers are predominantly using mobile money system to conduct payments.

Many people in rural areas have low incomes, which are often unpredictable. This has driven the need for an alternative payment scheme known as “Pay-as-you-go” (PAYG). PAYG, as a business model, is gaining traction in Kenya’s energy services, such as financing for SHS and mini grids. It allows energy users to prepay for consumption of energy in real-time. The installation of smart meters allows off-grid providers to control the consumption of electricity and the recovery of costs from customers with variable income. With the

combination of M-Pesa and PAYG, off-grid providers are benefiting from the convenience and simplicity of obtaining revenues for energy services rendered in real-time, and the ease of transactions is growing the customer base.

Kopo Kopo is an operator of mobile money payments received through M-Pesa and other platforms of monetary exchange. It performs data analytics to determine the likelihood that an individual will pay or default on their loans. It is an excellent service that could be utilized to bring down the cost of financing for customers and provide useful data to off-grid system operators.

Smart grid technology is a significant component of the electrification process for mini grids, SHS, and other off-grid technologies. A smart meter provides a two-way communication mechanism as well as data gathering capabilities, which are used in real time to record consumption. The smart meter system allows remote mobile-based payments. For example, energy users who have a phone, an M-Pesa accounting, and an account with the energy provider (such as PowerGen), can utilize the service. The account holder is asked to pay a flat rate of 18 Kenyan Shillings (KSh) or 0.18 USD for every kWh of electricity used. At the start of each month, the account holder pays a flat fee of 222 KSh ($2.22). After the first payment, the user can PAYG or wait till the meter runs out.

High cost of grid extensions in rural areas is concerning – it comes with troubles of electricity reliability – that is why mini grids are more benevolent. It allows electricity access to go into less densely populated areas with cost-effectiveness and with application to many sources of energy. It also allows the rural areas to “leapfrog” into the modern era of smart distributed generation technology.

## DISCUSSION AND CONCLUSION

The research reveals that the deployment of off-grid technologies, such as mini grids and solar energy, is being aided by using mobile money and other informal financing schemes in connecting customers with electricity services providers or systems. This has helped increase the electrification rates. The research also shows that more people can access capital to finance the procurement of small off-grid systems through the mobile-money systems or to pay for the use of electricity from micro grids. The variations in types of off-grid technologies have allowed different income levels to obtain energy production, subject to financial constraints. PAYG is very effective in eliminating the lag between services rendered and the revenue collection for use of electricity from micro grids.

With a growing economy and a national government committed to driving energy sustainable age, Kenya presents a promising future in renewable connectivity throughout the rural areas. The commitment set forth in Kenya Vision 2030 plan shows that improved policies and regulations, investments in proven technologies, coupled with public participation, can and will drive the expansion of electricity access to the rural areas.

The market analysis shows that the success of renewable energy depends on the collaboration between the Government of Kenya and the private institutional players in both the financial sector and energy sector. The innovations in informal financial services provides an efficient and more flexible and affordable path towards the adoption of off-grid technologies for rural dwellers. As more off-grid energy companies demonstrate an ability to innovate their products and services to reach populations in the most remote locations, Kenya will eventually reach 100% electricity access rates.

The success of informal financing is being witnessed globally. On April 2020, Reuters published an article in The New York Times reporting that Visa and Safaricom, the telecom operator of M-Pesa, have entered a deal to connect M-Pesa users with Visa's 61 million merchants (Reuters, 2020).

# CITATIONS


AHK Kenya (2016) EE-INSELNETZE IN KENIA. Available at: http://www.kenia.ahk.de/uploads/media/Zielmarkt_EE_Inselnetze_Kenia_2016.pdf.

Central Bank of Kenya & FSD Kenya. (2013). FinAccess National Survey 2013: Profiling developments in financial access and usage in Kenya. Nairobi, Kenya: FSD Kenya.

CNBC AFRICA. 2020. "M-Pesa has completely changed Kenyans' access to financial services, this is how…" Available at: https://www.cnbcafrica.com/news/east-africa/2019/04/03/m-pesa-has-completely-changed-kenyans-access-to-financial-services-this-is-how/

ECA, TTA and Access Energy. 2014. *Final Report: Kenya Off-Grid Power Supply*. Retrieved from: http://www.eca-uk.com/wp-content/uploads/2016/10/ECA-Kenya-Minigrid-Report.pdf

FinAccess. 2019 *FinAccess Household Survey*. Retrieved from: https://s3-eu-central-1.amazonaws.com/fsd-circle/wp-content/uploads/2020/02/06095110/2019-FinAccess_Household_SurveyReport_FIN_Web.pdf

FSD Kenya. *2016 Annual Report*. Accessed from: https://s3-eu-central-1.amazonaws.com/fsd-circle/wp-content/uploads/2017/06/05112253/17-07-05-FSD-Annual-report-final-web-version.pdf

Germidis et al. (1991) Financial Systems and Development: What Role for the Formal and Informal Financial Sectors? Paris: OECD Development Centre. Published Book.

Global petrol prices 2019. http://www.globalpetrolprices.com/ (accessed April 20, 2019).

Government of Kenya (2019). The 2019 Energy Act, Kenya Gazette Supplement No.29. Retrieved from: https://www.epra.go.ke/download/the-energy-act-2019/

IEA (2019), SDG7: Data and Projections, IEA, Paris. Accessed on: https://www.iea.org/reports/sdg7-data-and-projections

J. K. Kiplagat, R. Z. Wang, T. X. Li, "Renewable energy in Kenya: Resource potential and status of exploitation", Renew. Sustain. Energy Rev., vol. 15, no. 6, pp. 2960-2973, 2011.

Jack, W., and Suri, T. 2014. Risk Sharing and Transactions Costs: Evidence from Kenya's Mobile Money Revolution. *The American Economic Review*, 104(1), 183-223

Kenyan Agricultural Research Institute. 2012. "Policy Responses to Food Crisis in Kenya". Available: http://www.foodsecurityportal.org/kenya/food-security-report-prepared-kenya-agricultural-research-institute

Kenya Power and REA (2017) Kenya Off-Grid Solar Access Project: *Environmental & Social Management Framework.*

Kiplagat, J.K., Wang, R.Z., Li, T.X., (2011). *Renewable energy in Kenya: Resource potential and status of exploitation*. Available at: https://www.sciencedirect.com/science/article/pii/S1364032111001262

KPLC. 2016. *Annual Report and Financial Statement: 2015-2016*. Kenya Power and Lighting Company *(KPLC), 2016*, [online] Available: http://www.kplc.co.ke/AR2016/KPLC%202016%20Annual%20Report%20Unload.ndf

Linderman, Todd. 2015. Washington Post Article. "1.3 Billion Are Living in the Dark". Retrieved from: https://www.washingtonpost.com/graphics/world/world-without-power/

M-Kopa Website (2020). http://www.m-kopa.com/products/

Ministry of Foreign Affairs. *Final Energy report Kenya*. Available: https://www.rvo.nl/sites/default/files/2019/01/Final-Energy-report-Kenya.pdf

Moner-Girona, Magda, et al. 2019. "Decentralized rural electrification in Kenya: Speeding up universal energy access". Available: https://www.sciencedirect.com/science/article/pii/S0973082619300845

NewClimate Institute. Ambition to Action (2019). "The role of renewable energy mini-grids in Kenya's electricity sector." Available at: https://newclimate.org/2019/11/12/the-role-of-renewable-energy-mini-grids-in-kenyas-electricity-sector/

Newell, Peter, Phillips, Jon. (2016). *Neoliberal energy transitions in the South: Kenyan experiences*. Available at: https://reader.elsevier.com/reader/sd/pii/S0016718516301646

Reuters, (2020). The New York Times. Visa Gives Kenya's Safaricom 'Missing Link' for Global Payments. Obtained from: https://www.nytimes.com/reuters/2020/04/30/technology/30reuters-kenya-safaricom-visa.html

Olaofe, Z.O., "Review of energy systems deployment and development of offshore wind energy resource map at the coastal regions of Africa (2018)." Sourced from: https://www.sciencedirect.com/science/article/pii/S0360544218314828

PowerAfrica (2015). Development of Kenya's Power Sector: 2015-2020. Obtained from: https://www.usaid.gov/sites/default/files/documents/1860/Kenya_Power_Sector_report.pdf

Reuters. 2019. "M-Pesa helps drive up Kenyans' access to financial services – study". Available: https://www.reuters.com/article/kenya-banking/m-pesa-helps-drive-up-kenyans-access-to-financial-services-study-idUSL8N21L2HK

REN21. 2016. "Renewables 2016 Global Status Report. Paris", REN21 Secretariat.

S. Fobi, V. Deshpande, et al. A longitudinal Study of electricity consumption growth in Kenya, Energy Policy 123 (2018) 569-578, https://doi.org/10.1916/j.enpol.2018.08.065.

Safaricom. *2019 Safaricom Annual Report and Financial Statements*. [online] Available: https://www.safaricom.co.ke/images/Downloads/Safaricom_Annual_Report_2019.pdf

Shaw, Lucy, Tilleard, Matt, and Davies, Gabriel. (2018). *More people than ever now have electricity in Africa, but 600 million are still in the dark*. Available at: https://qz.com/africa/1265780/how-many-people-have-electricity-in-africa/

Taneja, Jay. 2017. "Measuring Electricity Reliability in Kenya". Available: http://blogs.umass.edu/jtaneja/files/2017/05/outages.pdf

The Kenya Power and Lighting Company Limited-KPLC. (2018). *KPLC Annual Report and Financial Statements 2017/2018*. Kenya.

Vodafone. 2020. Company Website: M-Pesa. Available at: https://www.vodafone.com/what-we-do/services/m-pesa

World Bank (2017). "MINI GRIDS IN KENYA: A Case Study of a Market at a Turning Point." Obtained from: http://documents.worldbank.org/curated/en/792001512392701402/pdf/ESM-cKenyaMiniGridsCaseStudyConfEd-PUBLIC.pdf

World Bank (2018). Data Set: Rural Population. Obtained from: https://data.worldbank.org/indicator/sp.rur.totl.zs

World Bank (2020). Sustainable Energy for All (SE4ALL) database. Available at: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=KE

World Resources Institute (2016). "Stimulating Pay-as-you-go Energy Access in Kenya and Tanzania: The Role of Development Finance. Accessed from: https://www.gogla.org/sites/default/files/recource_docs/stimulating_pay-as-you-go_energy_access_in_kenya_and_tanzania_the_role_of_development_finance.pdf

Zarembka, David. 2019. "Off-Grid Solar In Kenya". Available at: https://cleantechnica.com/2019/04/27/off-grid-solar-in-kenya/

APPENDIX

M-PESA Charges and Rates 2020/2021:

| Min (Kshs) | Max (Kshs) | Transfer to other M-PESA Users | Transfer to Unregistered Users | Withdraw From M-PESA Agent |
|---|---|---|---|---|
| 1 | 49 | Free | N/A | N/A |
| 50 | 100 | Free | N/A | 10 |
| 101 | 500 | 11 | 45 | 27 |
| 501 | 1,000 | 15 | 49 | 28 |
| 1,001 | 1,500 | 26 | 59 | 28 |
| 1,501 | 2,500 | 41 | 74 | 28 |
| 2,501 | 3,500 | 56 | 112 | 50 |
| 3,501 | 5,000 | 61 | 135 | 67 |
| 5,001 | 7,500 | 77 | 166 | 84 |
| 7,501 | 10,000 | 87 | 205 | 112 |
| 10,001 | 15,000 | 97 | 265 | 162 |
| 15,001 | 20,000 | 102 | 288 | 180 |
| 20,001 | 35,000 | 105 | 309 | 191 |
| 35,001 | 50,000 | 105 | N/A | 270 |
| 50,001 | 70,000 | 105 | N/A | 300 |

**Safaricom Mpesa Withdrawal Charges and Rates for ATM 2020/2021**

| MPESA TRANSACTION RANGE (KSH) | | |
|---|---|---|
| Min (Ksh) | Max (Ksh) | Mpesa Charges |
| 200 | 2,500 | 34 |
| 2,501 | 5,000 | 67 |
| 5001 | 10,000 | 112 |
| 10,001 | 20,000 | 197 |

**Other Safaricom M-PESA Transaction Charges and Rates for the Year 2020/2021**

| Mpesa Transaction | Mpesa Charges (Ksh) |
|---|---|
| Change M-PESA PIN | 22 |
| All Deposits | FREE |
| Register for M-PESA | FREE |
| Buy Airtime | FREE |
| Check M-PESA Balance | 1 |

(Source: https://www.mpesacharges.com/mpesa-charges/)

CURRICULUM VITAE

Jefferson Choti will be completing the Master of Science in Energy Policy and Climate program at the Johns Hopkins University. Mr. Choti's academic focus has been on renewable energy technologies, policy frameworks, and energy finance.

Born in Kenya, Mr. Choti migrated to the United States at the age of 10. He attended high school in Silver Spring, MD. He graduated at the University of Maryland, Baltimore County with a Bachelor of Science in Financial Economics.

Mr. Choti is a Rate and Business Consultant at the National Rural Utilities Cooperative Finance Corporation (NRUCFC or CFC). Jefferson specializes in delivering pricing and regulatory solutions, with knowledge of state and federal regulatory policies, to CFC electric cooperatives and internal stakeholders. Jefferson is responsible for developing revenue requirements, conducting cost-of-service studies, formulating/updating rate designs and regulatory research to assist cooperative members across the country make informed decisions that meet the needs of their stakeholders.

Prior to joining CFC, Jefferson was a Rate and Business Analyst with Baltimore Gas and Electric (BGE), where he specialized in developing gas and electric rate designs, cost of service models and writing witness testimony used before the Maryland Public Service Commission during rate case proceedings. He has also conducted routine filings for pricing adjustments and demand response programs, relating to BGE's electricity and natural gas service, for approval in PSC's administrative hearings.