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Dynamics of Electricity Transmission Infrastructure and Implications on Development in Kenya

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Abstract

The general objective of this study was to identify the most innovative cost – effective ways of financing and developing electricity transmission infrastructure in Kenya. The study adopted an inductive research approach. to come up with relevant themes. Using a thematic analysis, searches were carried out in key infrastructure databases. Eleven studies met the selection criteria and were used to identify four key themes that formed the basis of this study namely: smartphone technology, mini grids, government policy and public private partnerships. The study established that the adoption of smart technology and mini grids led to a reduction in losses because a considerable amount of electricity transmission related costs were recovered by the service providers. The study also found out that the current licensing procedures in Kenya favored national grid electrification and not decentralized electricity transmission. Finally, concerning available financing options, the study established that the Kenyan Government benefited from reduced maintenance and operation costs through the adoption of public private partnerships infrastructure financing model. Use of secondary information in the study was one limitation. Primary data research could have been more beneficial because interviews would have been used to collect qualitative data. Another limitation of the study was the sample size used to produce the study findings. The study's key findings were generated from eleven pieces of secondary information sources. This could be criticized for being small scope. The derived categorization of major cost-effective themes is of high relevance to planners of energy transmission investments, where understanding the available viable financing options is vital. The findings can thus be applied when establishing sound and innovative cost-effective ways of financing and developing electricity transmission infrastructure investments. The article will be of benefit to financiers, potential investors, scholars and regulators in the energy sector to assess the creditworthiness, firm's efficiency in managing borrowed funds, use the study findings as a basis for further research and inform the general public the extent of value for money achieved by using the financing models supported by this study respectively.

Key Words: Kenya, cost-effective, electricity, financing, infrastructure, transmission, electricity

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1. Introduction

The traditional non-renewable energy sources such as natural gas, oil and coal supply a vast majority of the globe's electricity demand. However, these sources have been criticized for intense greenhouse gas emissions which pollute the environment. Renewable sources such as wind, solar photovoltaic, geothermal, hydroelectric and biomass have become attractive alternative sources of energy due to their indefinite supply, low carbon emissions, economic benefits and price stability in the energy market. It is however important to note that renewable energy sources also have their shortcomings such as, base load electricity demand, intermittent supply of energy and high initial costs (Vandaele and Porter, 2015). Insufficient energy supply presents a formidable challenge to African development. Poverty levels in the continent attributed to inadequate energy supply is said to afflict close to 620 million people in Africa. This situation has not only suppressed expansion of economic opportunities in Africa, but it has also created health risks to majority of poor who depend on the low-cost alternative sources of energy such as wood fuel (IEA, 2014). In the absence of secure and reliable access to electricity, households and businesses cannot operate effectively. This reduces the quality of life and restricts the flow of human capital.

In the past three decades, Powanga and Giner-Reichl (2019) noted that the energy sector in Africa was inefficient. Majority of the people approximated at slightly over 600 million particularly in rural areas have no access to electricity. They still rely on firewood to cook and have not embraced new technologies such as cookstove programs that are aimed at reducing health hazards and sometimes deaths associated with firewood smoke. The study further revealed that Africa had significant potential to generate electricity from its untapped renewable energy sources. Powanga and Giner-Reichl (2019) further noted that Africa countries could take advantage of their energy infrastructure infancy to institute efficient energy policies to increase energy access through deployment of low carbon power systems aimed at mitigating the negative effects of climate change. The study specifically recommended that countries such as China who have shown interest in investment in the energy sector in the continent and any other developed country in the world could take advantage of this potential to collaborate with any African country with renewable energy potential to develop cost-effective and sustainable energy infrastructure investments.

According to Musau, Ighobor and Kuwonu (2017), Africa needs approximately $93 billion every year to cater for its infrastructural needs. This translates to approximately 15% of the continent's Gross Domestic Product. Thus, most cash strapped African countries have turned to Public Private Partnerships to bridge this gap so that they can deliver more efficient and cost-effective infrastructure projects. Kenya, for instance, needs between $4 billion and $5 billion per year to finance her infrastructure projects. The Lake Turkana Wind Power Project is a classic example of a project that has been successfully executed through Public Private Partnerships arrangement. Tanzania and Ghana need up to $8 billion and $ 1.5 billion annually to meet their infrastructural financing shortfalls. Even South Africa, which has been touted as a model economy for Public Private Partnerships in Africa, is facing infrastructure budget shortfalls. The country needs between $4.5 billion to $8 billion annual budget to bridge this gap.

Section 1 presented the background of the study, section 2 highlighted the problem statement of the study. Section 3 reviewed in detail the literature about the specific objectives being

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investigated in the study. Section 4 discussed the methodology used in the study. Section 5 presented results and findings, while section 6 gave the conclusion, recommendation and discussion of the study.

2. Statement of the Problem

According to ERC (2015), Kenya needs between 18-23 billion USD by 2020 to achieve its power sector targets. Although an estimated 3-5.5 billion USD has already been secured, a budget deficit of between 14-18 billion USD is yet to be met. In addition, KETRACO is currently seeking funds to finance 4,200-kilometer distance stretch. This is in addition to ~4,150 km of existing lines and ~4,500 km under construction. ERC (2015) further established that Kenya projects 2,600-3,600 MW peak demand by the year 2020 due to proposed large industrial projects for example Dongo Kundu free trade port, Athi River and the Naivasha dry port. The Kenyan government also plans to connect 5 million new households and approximately 16,000 public Institutions through the Last Mile Connectivity Programme. Other Vision 2030 key flagship projects under the energy sector which require electrification include: rapid transit system for Nairobi, standard gauge railway from Mombasa to Nairobi to Malaba, LAPSET projects (resort cities, oil pipeline, port terminal and petrochemical industries). Others include: Konza techno city and special economic zones. Despite of the above mentioned financial constraints to meet project cost, World Bank (2018) in its report highlighted the following challenges as having negative impact on project implementation. This includes escalated costs for wayleaves compensation, contractor's claims as a result of the government not meeting some of its contractual obligations such as provision of right of way, delayed payments of contractor invoices, bureaucratic processes and government taxes. This posed a knowledge gap worth investigating. This study therefore is intended to address this concern by identifying the most innovative cost – effective ways of financing and developing electricity transmission infrastructure in Kenya.

3. Literature Review

3.2 Effect of Technology on the Financing and Development of Electricity Transmission Infrastructure

3.2.1 Wireless Power Transmission

Wireless power transmission involves transmission of electric power from the source to the destination without interconnecting wires. Wireless transmission is crucial in circumstances where transmission through interconnected wires is hazardous, inconvenient, or just not possible. The concept of wireless power transmission especially in the energy sector lays more emphasis on efficiency. Some of the common forms of wireless power transmission may be through use of direct induction, followed by resonant magnetic induction. Other methods include use of radio waves for instance, microwaves or beam light technology. Wireless power transmission technology is applicable in circumstances where conventional ways of transmitting energy are not practicable such as long-range communications (Sadiku, Nelatury and Musa, 2018).

Siddiqui, Nagani and Ali (2015) argued that if wireless power transmission technology is adopted, it can facilitate interconnection of electricity generating plants on a global scale by eliminating the existing towers, sub stations and high-tension power transmission line cables. The technology offers flexibility in terms of freedom of choice of receivers and transmitters including the mobile ones. By eliminating physical transmission of electricity by use of cables, wireless power transmission technology drastically reduces the cost of power transmission. This has a direct effect on electricity cost chargeable to the final consumer. The other advantage of the wireless power technology system is that it is possible to transmit electricity to places where there is no electric wire connectivity. In addition, the technology ensures that there are negligible energy losses during transmission; hence, this method of power transmission is more efficient than the wired transmission system. Power will always be available at the rectenna so long as the system is operating. Besides, the issue of power failure due to faulty cables and short circuits would never exist in wireless power transmission systems. Finally, the problem of power theft would not be possible at all. It is however important to note that wireless power transmission technology has two major disadvantages. Firstly, initial investment cost for its implementation is very high and secondly, microwave technology used in the system tend to interfere with other communication systems (Mahmood *et al.*, 2014).

3.3 Effect of Decentralization through mini grids on the Financing and Development of Electricity Transmission Infrastructure

According to Contejean and Verin (2017), mini grid may be defined as a form of electricity network supplying electricity to a given community. It may be connected to a country's national grid or it may just be island operated. The term could also be defined to mean an integrated energy infrastructure with energy resources and loads whose functions include energy generation, storage, conversion, measure, control and management. Initially, mini grid debut had low penetration in Sub Saharan Africa due to high energy generation costs. Recent reports, if they are anything to go by, are giving a totally different scenario that costs are declining, with further decreases being projected.

In Nigeria for example, Azimoh and Mbohwa (2019) found out that using renewable energy, levelized costs of a mini grid are expected to drop to the range of between "USD 0.30 per kilowatt-hour (kWh) and USD 0.57/kWh by the year 2025, to a range of between USD 0.19/kWh and USD 0.35/kWh by the year 2035. Considering that these costs are currently in the range of between USD 0.47/kWh and USD 0.92/kWh, this is confirmation that indeed that they are on the declining trend. The study further established that mini-grid development in Nigeria was still at its infancy stage and a lot needs to be done in terms of increasing electricity access.

Within the Southern African region for many years now, electricity access has been expanded by member states' efforts to extend their national grids. In Seychelles for example, near universal electricity coverage has been achieved thanks to the mini grids through the national grid. Mini grids are small-scale power generators which can generate as little power as 10kW or as much power as 10MW. It can provide services of the same quality as the national grid but to a limited number of customers in one concentrated area. Once operational, a mini grid does not have to connected to the national grid for it to serve its purpose. Micro grids are the smaller version of mini grids. They can generate and transmit energy as little as between 1- and 10-kW capacity. Both mini and micro grids are valuable complements to grid-based energy electricity transmission, especially in areas where grid extension is financially or technically not viable. To achieve universal access to electricity in Africa, the International Energy Agency estimates that close to 60% of the additional energy requirements should come from off-grid solutions. The Agency further claims that of the 315 million people in rural Africa who are expected to have access to electricity by the year 2040, close to 80 million people will be served by off grid systems while close to 140 million will use mini grids. Preliminary analysis indicates that by 2030, close to 59% of rural electricity demand in the entire Southern Africa region would be met through decentralized generation of electricity (IRENA, 2019).

In Uganda, the Kampala administration recognizes that off-grid technologies are the way to go in as far cost-effective transmission of electricity to the rural areas is concerned. Since majority of Ugandan rural population is dispersed, it is not economically viable to extend the national grid. Uganda's rural population is approximately 75% of the country's total population. Moving forward, off-grid power transmission technologies are likely to play a crucial role in transmitting electricity to the rural areas. Currently, 4.9% of the Ugandan households' electricity demand is met by electricity supplies from solar photovoltaic systems. However, by 20130, it is estimated that close to 33% of households will receive off-grid electricity (Dalberg, 2017). Although policy support off-grid electricity transmission is popular in the country, there is skepticism about the economic viability of mini-grids. Besides, lack of financial incentives to drive off-grid uptake remain a challenge to policy makers.

3.4 Effect of Various Financing Models on the Financing and Development of Electricity Transmission Infrastructure

3.4.1 Angola Model

In May 2015, China took a bold move to launch the AIIB in a bid to address the global infrastructure deficit created by unwillingness by the traditional donors to continue financing infrastructure projects in developing countries. The United States, Japan and other developed countries viewed this move by China as a challenge to the way existing international financial institutions such as the World Bank and the International Monetary Fund manage their affairs especially in as far as infrastructure financing to developing countries is concerned. It is worth noting that before AIIB was launched, China had offered developing countries in Latin America, Southeast Asia and Africa infrastructural financing. This support was mainly being offered on concessional basis and repayment was to be secured at least partially in kind through access to the borrowing countries' raw materials such as gas, oil or minerals such as copper by the lender. This form of Chinese support differed significantly from the kind of support offered by the traditional donors. China usually offers her trading partners a mix of concessional loans, export credits and grants.

3.4.2 Build-Operate-Transfer (BOT)

According to Yang, Nisar and Prabhakar (2017), BOT model is a private sector initiative whereby a project company is established to design, finance, construct and operate a facility for a concession period after which, the facility is transferred to the government. The sponsors of the project will arrange the financing of the project to its realization through equity and debt financing. In BOT form of partnership, design, construction and operational costs are borne by the client. The principal on the other hand is not exposed to any direct cost risk except the likelihood that the project may not meet the expectations of its customers or that the concession agreement is not satisfactory (Akbiyikli and Eaton, 2003).

3.4.3 Build-Own-Operate-Transfer (BOOT)

According to Bashiri et al., (2017), Build-Own-Operate-Transfer is a model whereby a public authority or agency enters into an agreement with a private firm commonly known as concessionaire to Design Build, Own and Operate a specific infrastructure project such as water, transport or a power plant within a given concession period say 15-25 years. On expiry of the concession period, the ownership of the project is transferred to the public entity through a single organization commonly known as BOOT provider or consortium. Income earned by the BOOT provider may take the form of a fixed annual fee or flat rate measured in terms of quantity supplied multiplied by a given unit rate or may take the form of "Take-or-pay" arrangement that is basically two-part tariffs expressed in a different manner. The main objective of BOOT model of financing infrastructure projects is to create jobs for the citizenry in a host country by reducing government's role in building and operating capital-intensive projects. By so doing, the government will be promoting technological innovation by the citizenry.

3.4.4 Build-Own-Operate (BOO)

Under the BOO model, the private sector designs, builds and finances the infrastructure. The private sector proceeds to construct, own, operate and finally maintains that project over the concession period. Thus, most of the risks associated related to planning, design, construction and operation of the project are borne by the private partner. Later, the public sector partner in the BOO agreement will 'purchase' the goods and services produced by the project as per agreed terms and conditions. This model is commonly used in developing telecommunication, power and social infrastructure for instance wastewater treatment facilities (Sambrani, 2014).

3.5 Effect of Private Finance Initiatives on the Financing and Development of Electricity Transmission Infrastructure

3.5.1 Design-Build-Finance-Operate (DBFO)

In DBFO contracts, Akbiyikli and Eaton (2003), argued that the private sector provides assets, arranges for debt financing from financial institutions and ensure that the balance of the funding requirements needed for the on-going operations of the project and asset maintenance services be met through equity financing. However, on completion of the project and when services are provided, the public sector pays for that. The banks pay the private sector on completion of the project whereas the capital charge payable by the public sector over the contract period will be used to remunerate the equity and to repay the banks. DBFO is basically an output focused contract model that sets out a project's functional specifications. The public sector specifies the requirements, that is, what is expected. It is the private sector's responsibility to determine and decide on the best way to be adopted to meet the set specifications. This arrangement will therefore compel the private sector to be innovate enough in designing and coming up with solutions to meet the client's output specifications.

A DBFO contract is a long-term contract between a government agency commonly referred to as the public sector and a contracting vehicle commonly known as a Special Purpose Vehicle (SPV). The SPV will design and build the asset or project, provide finance and provides operation and maintenance services. The SPV will enter into a primary contract with the public sector and is responsible for the provision of assets and services over the contract period. The SPV will then engage a construction contractor to build the asset or project at a fixed price contract. The SPV will also engage an operation and maintenance contractor to provide the services (Akbiyikli and Eaton, 2003).

Once the back-to-back contracts with the construction contractor are established, the SPV will determine its funding requirements. Generally, debt will constitute not less than 90% of the SPV's funding requirements while the balance should be met through equity financing by the SPV shareholders. The public should not make any up-front payments when the asset is being constructed. All the design and build expenses should be borne by the private sector through debt and equity financing. The financial institution responsible for financing the project will make monthly payments in respect of certified work to the works contractor in line with the financial agreement between the SPV and the financiers. The loans advanced to the SPV will be used to make these payments. The public sector will only start payments to the private sector once it is satisfied with the performance of the services as specified in the Output Specification. The total cost to the public sector in respect of the DBFO contract is equal to the present value of these contract payments (Akbiyikli, Dikmen and Eaton, 2011).

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In Britain, Shaoul, Stafford and Stapleton (2006) conducted a study to clarify government claim that DBFO projects were cost-effective and that the Value for Money (VFM) for such projects would be higher over the contract's life than conventional procurement. The study findings revealed that the Highways Agency paid three times more than then initial construction costs and close to 30% of the total contract cost estimated at £6bn refuting claims that private finance was cost-effective for the government in the long run. The arrangement proved costly for the government because more than an estimated budget of £590m for the construction of the project was paid by the Highways Agency. Hence, the government should have opted for conventional procurement rather than getting into DBFO arrangement that proved costly in the long run. To answer the question regarding a claim that DBFO financing option would yield better VFM results over the contract period than conventional procurement, the study findings revealed that; firstly, based on the volume of traffic on highways which has been rising, the payment mechanism introduced additional cost burden for the public sector; secondly, DBFO proved more costly than expected, thus the marginal cost advantage that was expected was eroded. Lastly, the cost of risk transfer increased.

3.5.2 Joint Ventures

According to Saha and Chattopadhyay (2015), Joint Venture finance arrangement entails a situation whereby the public sector provides the Private Finance Initiative contractor with a subsidy aimed at reflecting the social benefits of the project that are not necessarily reflected in the cash flow. In typical Joint Venture arrangements, the public entity does not contribute more than half of the total capital funding requirements. Profit made is shared between the public and private sectors based on the ratio of capital contributed by each one of them. The revenue comes principally from third parties. For a project to be considered for a joint venture financing model, it must pass the cost-benefit analysis test. It is however important to note that a joint venture would not be financially viable if is funded by private finance only excluding public finance.

Some classic examples of joint ventures which have worked in the recent past include the French Chinese private-public joint venture named Alcatel Shanghai Bell. The other relates to the Chinese engagement with some African countries such as Zimbabwe, Zambia, Gabon and the Democratic Republic of Congo to mine minerals such as copper, iron ore, and bauxite (Foster *et al.*, 2009).

4. Methodology

4.1 Research Approach

The study adopted an inductive research approach. In this approach, the researcher primarily used detailed readings of raw data to come up with themes. Inductive research approach was ideal for this study because it attempted to condense extensive literature on the innovative cost-effective ways of financing and developing electricity transmission infrastructure in Kenya into a brief and summarized format.

4.2 Data Collection

The criteria for inclusion was used to identify the appropriate secondary sources of data used in the study. All secondary sources that were used as references were subjected to an additional collection criterion to ensure that they have been peer reviewed to justify their authenticity. Samples were selected based on their relevance to the topic under review. Each sample was thoroughly analyzed, and the key themes contained therein were aligned accordingly. In this research, four key themes were then interpreted to formulate findings based on the study's research questions. The themes were: smart technology, mini grids, government policies and private public partnerships. Finally, the key findings were interpreted in relation to the relevant literature that was reviewed. These findings were presented in the discussion chapter of the dissertation.

4.3 Search Terms

Relevant search terms such as 'PDF Journal on effect of technology, decentralization and various financing models on financing and development of electricity transmission in the World', 'PDF Journal on effect of technology, decentralization and various financing models on financing and development of electricity transmission in Africa'', and 'PDF Journal on effect of technology, decentralization and various financing models on financing and development of electricity transmission in Kenya" was entered in the search engines to filter and find the most appropriate and relevant information for the research article.

4.4 Research Ethics

Ethical considerations are crucial in any research writing process. To achieve this, journal articles and reports that have been reviewed were used. This guaranteed the validity of the information used. Since this is a research project, ethical approval was necessary. Thus, secondary research was appropriate because the information used was from ethically approved sources.

5. Results and Findings

5.1 Introduction

Four broad themes emerged from the thematic analysis of the sampled secondary information sources. These themes were then used to generate key findings to be examined further in the discussion chapter.

5.2 Effect of Technology on Financing and Development of Electricity Transmission Infrastructure

5.2.1 Smart Technology

A study was conducted to assess the relationship between adoption of technology and financial performance of the Kenya Power and Lighting Company's Embu branch. Specifically, the study sought to determine the effect use of adoption of smart meter technology; adoption of billing technology and adoption of electronic payment system on firm performance. Using a sample size of 253 out of a targeted population 600 customers, the study revealed that adoption of smart meter technology had a significant positive relationship with firm performance.

Key Finding Two

Adoption of smart meter technology significantly influences firm performance due to a reduction in costs which includes electricity transmission costs.

5.3 Effect of Decentralization on Financing and Development of Electricity Transmission Infrastructure

5.3.1 Mini Grids

Although the benefits of mini grids are disputed, they can be used to transmit electricity to the rural areas that are far from the national grid network. Changes were observed in two trading centres which were not electrified previously. In one of the trading centres, 13.5kWp solar photovoltaic mini grid scheme was constructed. The study revealed that after electrification, the trading centre recorded increased number of business activity and income among the people around the centre. Comparing income levels of people leaving in the surrounding, the study showed that income levels of those people leaving around the electrified centre improved than their counterparts in the surrounding areas with no electricity. Interview with respondents showed improvement in service provision by the health centre and local school. The co-operative started to run the mini-grid decided to set its own kWh tariff with the aim of recovering at least 70% of its initial investment interest-free and generally cover all its operating costs. The study showed that the tariff that was finally agreed upon was higher than the national grid tariff. This would be difficult to attain if the mini grid was not run for the interest of the local community. The study concluded that mini grid had a positive influence over background development, managed to recover some of initial investment cost and charged a higher tariff than the national rate.

Key Finding

The use of mini grids is cost-effective way that has been used to recover electricity transmission project's initial investment cost.

5.3.2 Government Policies

Taylor, Turner, Willette and Uawithya (2015), identified lack of access to electricity as one of the key development issues. The geographical distance locations and high capital costs required for large scale grid connections leave gap in the socio-economic development of those in need of energy power. The de-centralized renewable energy focuses on productive power mini grids to offer solution to identified gap. However, the study established that a country like Kenya has limited potential to anchor tenant de-centralized solution model due to unfavorable regulatory conditions. Government policies primarily support national grid electrification, which ultimately hinders the scale of de-centralized solutions.

Key Finding

Currently, there are no procedures which are specific to mini- grids in Kenya. The current licensing procedures for example are not suitable for small mini –grid projects. Government policies primarily support national grid electrification, which ultimately hinders the scale of de-centralized solutions.

5.4 Effect of Various Financing Models on Financing and Development of Electricity Transmission Infrastructure

5.4.1 Public Private Partnerships

The Public Private Partnership arrangement undertaken by the government to finance infrastructure was informed by the need to fast track the timely and speedy completion of these projects. This arrangement does not only ensure that the Kenyan taxpayer gets value for money through cross-transfer of knowledge, but also ensures that there is exchange of skills and expertise between the private and public sectors. In addition, public private partnerships enable local investors participate in the delivery of infrastructure projects through partnerships with foreign investors. The partnership also encourages innovation in the delivery of public services and effective utilization of public assets (Farquharson *et al.*, 2011).

Ngahu, Muturi, Ngumi and Kwasira (2018), studied the relationship between project viability and project financing through public private partnerships. The study established a positive relationship between the variables. The study further established that private public partnerships are based on mutual benefit of both the public and private investors. Government benefits from reduced maintenance and operation costs whereas the private sector benefits from popularity associated with working with the public sector which consequently will result in higher market share for the private sector.

Key Finding
Government benefits from reduced maintenance and operation costs through the adoption of public private partnerships.

6. Discussion

6.1 Introduction

This section will discuss the four key findings which have emerged from the four themes mentioned in section 4 and will be contextualized with the literature reviewed in section 2 of this research. The key findings may be consistent or inconsistent with the research findings of similar previous studies. This section will focus on each theme mentioned in the results section and will discuss it with reference to the key findings.

6.2 Effect of Technology on the Financing and Development of Electricity Transmission Infrastructure

6.2.1 Smart Technology

The first theme on the effect of technology as an innovative cost-effective way of financing and developing electricity transmission infrastructure involved adoption of smart technology. The key finding in this category argues that technology use had a significant positive relationship with development of electricity transmission infrastructure in Kenya (Mulli & Wanyoike, 2015; Orina & Luketero, 2018). This agrees with Mohammed et al., (2010) quote in the literature review which stipulates that people do not need copper wires, cables or pipes to receive power. Power can be transmitted like a cell phone call in real time wherever and whenever through wireless power transmission technology.

With wireless power transmission technology being adopted, there will be no need whatsoever of high-tension power transmission line cables, sub stations or towers to transmit electricity from the generating stations to the consumers. This move will drastically lower the cost of electricity transmission and distribution. Consequently, the cost of energy to the final consumer will also reduce. Power could be transmitted to places where under normal circumstances, wired transmission is not possible such as islands. Power losses associated with wireless power transmission is negligible; hence, the method is more efficient than wired transmission system. Power is always available at the rectenna any time the wireless power technology is operating. Power failure as a result of short circuiting and faulty cables and power theft would never exist in the transmission (Mohammed, Ramasamy and Shanmuganantham, 2010).
The greatest disadvantage with this technology however relates to the high initial cost outlay needed to implement it. The system also tends to interfere with existing telecommunication microwaves. Yasir & Haque (2013) also provide evidence in support of this key finding. The study

argues that by completely avoiding the use of substations, transmission line cables and opting for the cheaper components of transmitter and receivers, the adoption of witricity or wireless electricity technology will be less costly.

6.3 Effect of Decentralization on Financing and Development of Electricity Transmission Infrastructure

6.3.1 Mini Grids

The first theme regarding influence of decentralization on the financing and development of electricity transmission infrastructure was about use of mini grids. This theme's key finding was that use of mini grids was cost-effective in as far as the financing and development of electricity transmission infrastructure was concerned (Bahaj *et al.*, 2019). This is consistent with Majumder (n.d.) study in Bangladesh. Optimization strategies presented in this study could be developed into a tool to find out the most cost-effective way of designing solar mini grids. This could be replicated in other countries after certain parameters that suit those countries have been adjusted. When a plant's capacity is optimized, the project implementing agency will incur minimum initial costs possible while giving access to more people.

6.3.2 Government Policy

The second theme regarding influence of decentralization on the financing and development of electricity transmission infrastructure was about government policies. This theme's key finding was that exogenous variables chosen by planners and the penetration rate had a significant effect on the average electricity connection cost than factors such as demand per household, inter-household distance, and proximity to the national grid. Moner-Girona et al., (2018) research provides better understanding of the cost structures of hybrid mini-grid projects in Africa. The review revealed significant lack of transparency and inconsistency in hybrid mini-grid costs. Multi-dimensional cost analysis of social and environmental impacts from the study highlight that hybrid mini grids offer a unique opportunity to create a standardized framework for quantifying costs, this can support decision-making processes for designing viable business models. The research findings show that there is a strong need to minimize the data quality gap between current business model and that of successfully implemented hybrid mini-grids electrification projects. This gap could be mitigated through studying the issues that influence mini-grid costs (both hardware and software).

6.4 Effect of Various Financing Options on Financing and Development of Electricity Transmission Infrastructure

6.4.1 Public Private Partnerships

The only theme under the relationship between various financing options and financing and development of electricity transmission infrastructure was the effect of public private partnerships on electricity transmission. This theme's key finding was that Government benefits from reduced maintenance and operation costs through the adoption of public private partnerships (Ngahu *et al.*, 2018). This is supported by the quote in the literature by Yang, Nisar and Prabhakar (2017), who argued that BOT model is a private sector initiative whereby a project company is established to design, finance, construct and operate a facility for a concession period after which, the facility is transferred to the government. The sponsors of the project will arrange the financing of the project to its realization through equity and debt financing. In BOT form of partnership, design, construction and operational costs are borne by the client. The principal on the other hand is not exposed to any direct cost risk except the likelihood that the project may not meet the expectations of its customers or that the concession agreement is not satisfactory.

The other quote in the literature review in support of the theme's key finding is the study by Bashiri et al., (2017). The study described one of the public private partnership models commonly known as Build-Own-Operate-Transfer (BOOT) as a model whereby a public authority or agency enters into an agreement with a private firm commonly known as concessionaire to Design Build, Own and Operate a specific infrastructure project such as water, transport or a power plant within a given concession period say 15-25 years. On expiry of the concession period, the ownership of the project is transferred to the public entity through a single organization commonly known as BOOT provider or consortium. Income earned by the BOOT provider may take the form of a fixed annual fee or flat rate measured in terms of quantity supplied multiplied by a given unit rate or may take the form of "Take-or-pay" arrangement that is basically two part tariffs expressed in a different manner. The main objective of BOOT model of financing infrastructure projects is to create jobs for the citizenry in a host country by reducing government's role in building and operating capital-intensive projects. By so doing, the government will be promoting technological innovation by the citizenry.

The theme's key finding however disagrees with Akbiyikli and Eaton (2003) quote in the literature review concerning DBFO contracts. The private sector provides assets, arranges for debt financing from financial institutions and ensure that the balance of the funding requirements needed for the on-going operations of the project and asset maintenance services be met through equity financing. However, on completion of the project and when services are provided, the public sector pays for that. The banks pay the private sector on completion of the project whereas the capital charge payable by the public sector over the contract period will be used to remunerate the equity and to repay the banks. DBFO is basically an output focused contract model that sets out a project's functional specifications. The public sector specifies the requirements, that is, what is expected. It is the private sector's responsibility to determine and decide on the best way to be adopted to meet the set specifications. This arrangement will therefore compel the private sector to be innovate enough in designing and coming up with solutions to meet the client's output specifications.

A DBFO contract is a long-term contract between a government agency commonly referred to as the public sector and a contracting vehicle commonly known as a Special Purpose Vehicle (SPV). The SPV will design and build the asset or project, provide finance and provides operation and maintenance services. The SPV will enter into a primary contract with the public sector and is responsible for the provision of assets and services over the contract period. The SPV will then engage a construction contractor to build the asset or project at a fixed price contract. The SPV will also engage an operation and maintenance contractor to provide the services (Akbiyikli & Eaton, 2003).

Once the back-to-back contracts with the construction contractor are established, Akbiyikli et al., (2011) argued that the SPV will determine its funding requirements. Generally, debt will constitute not less than 90% of the SPV's funding requirements while the balance should be met through equity financing by the SPV shareholders. The public should not make any up-front payments when the asset is being constructed. All the design and build expenses should be borne by the private sector through debt and equity financing. The financial institution responsible for financing the project will make monthly payments in respect of certified work to the works contractor in line with the financial agreement between the SPV and the financiers. The loans advanced to the SPV will be used to make these payments. The public sector will only start payments to the private sector once it is satisfied with the performance of the services as specified in the Output Specification. The total cost to the public sector in respect of the DBFO contract is equal to the present value of these contract payments.

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6.4 Conclusions

As regards technology, the study established that smart technology significantly influences the recovery of electricity transmission costs. Concerning mini grids, the study concluded that they can be used to recover electricity transmission project's initial investment cost. Concerning government policy, the study established that exogenous variables chosen by planners and the penetration rate had a significant effect on the average electricity connection cost than factors such as demand per household, inter-household distance, and proximity to the national grid. Finally, concerning the relationship between public private partnerships and financing and development of electricity transmission infrastructure, the study showed that Government benefits from reduced maintenance and operation costs through the adoption of public private partnerships.

In summary, this study has confirmed that there are various innovative cost-effective ways that can be adopted in the financing and development of electricity transmission infrastructure including: technological factors such as smart technology and wireless power technology; decentralization factors such as mini grids and various government policies; and various financing options such as public private partnerships. Generally, this research provides a framework for an in-depth analysis of innovative cost-effective ways associated with electricity transmission.

6.5 Recommendations

Based on our findings and discussions on Innovative cost – effective ways of financing and developing electricity transmission infrastructure in Kenya, a set of implementation recommendations were developed to help the power sector achieve its goals. The study further proposes below interventions that will help delivery 2,000+ MW in generation, 2.5+ million off-grid connections and strengthening of the whole system.

6.5.1 Effect of Technology on Financing and Development of Electricity Transmission Infrastructure

Since smart technology proved cost-effective, it is recommended that; The energy sector in Kenya should review both its technical and operational standards to ensure that smart technologies are adopted and implemented in the entire electricity grid management system of generation, transmission and distribution. Secondly, the energy sector should improve on its metering system since metering plays a crucial role in the determination of sales volumes and losses that may arise due to under billing.

6.5.2 Effect of Decentralization on Financing and Development of Electricity Transmission Infrastructure

The study established that there were no procedures which were specific to mini- grids. Licensing procedures for electricity generation, transmission and distribution have been designed mainly for large power projects. It is therefore recommended that;

i. Adopt private model approach where private developers are responsible for the generation and distribution of electricity be adopted. This approach would fill the gap left by government due to budget deficits in achieving universal access to electricity.
ii. The government should provide policy and regulatory design and reform assistance based on global best practice.
iii. Develop and support initiatives to finance the 14-18 billion USD gap to achieve generation, transmission, distribution, and off-grid electrification targets.

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6.5.3 Effect of Various Financing Models on Financing and Development of Electricity Transmission Infrastructure

i. Financing through syndicated loans from several local banks, which have been successful in other sectors in Africa. For Example, Standard Bank, in conjunction with four Kenyan banks, pooled resources to fund Safaricom, a telecommunications firm in Kenya. The same model can be used for the energy sector.
ii. To pursue Build, Own, Transfer (BOT**)** model on key transmission lines to bring in private capital and skills
iii. Enhance internal revenue generation and further explore sourcing of projects finance using EPC+ Financing and Public-Private Partnerships (PPPs) approaches
iv. Facilitate and/or provide feasibility, pilot, and project (equity and debt) financing
v. Provide critical transaction advisory, technical assistance, market information, and PPA process support for 800+ MW of renewable projects.
vi. Support distribution system loss reduction and operational efficiency through integrated planning, investment mobilization and technical assistance
vii. Continue to drive grid management support and capacity building to enable grid adoption of intermittent renewable energy projects
viii. Develop critical go-to capability for community engagement and land-related challenges
ix. Use of innovative financial instruments such as infrastructure bonds, municipal bonds, pension funds and investing in technological upgrades to lower the costs.
x. Endeavour to engage the project affected persons (PAPs) in a harmonious manner in order to timely acquire wayleaves and eliminate project stoppages and costs overruns.

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