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Off-grid Private Sector Minigrids in Kenya

Identifying the current challenges and barriers of minigrid developers and a look at the role of public private partnerships

by

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Abstract

The Republic of Kenya aims to reach universal access to electricity by 2022. However, rural areas lag behind in electricity gains due to the complexity of rural consumers and the cost of extending the national grid. Renewable energy minigrids have been presented as a viable solution to off-grid rural electrification. However, there is a lack of documentation surrounding the experiences and knowledge of the Kenyan minigrid sector. This thesis takes an innovation systems approach to uncover the barriers and challenges that private minigrid developers are facing. Additionally, a look at the role of institutions and networks is given to explore how PPPs can help overcome these barriers. A qualitative approach is used with a case study methodology. 12 semi-structured interviews were conducted with various actors in the minigrid sector during a 16 field trip in April, 2019. The results showed that the diffusion of minigrids is hindered by regulatory issues, lack of access to funding and business model complexity. PPPs were argued as being an effective tool to mitigate some barriers but that other barriers could use further PPP model development.

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List of Acronyms

DFI: Development Finance Institution

KwH: Kilowatts per hour

MW: Megawatt

NGO: Non-governmental Organization

PPA: Power Purchase Agreement

PPP: Public Private Partnership

PU: Productive Use (of energy)

REA: Rural Electrification Authority

SDG: Sustainable Development Goal

1 Introduction

1.1 Background

Every year, the World Bank releases a report on the state of electricity access throughout the World. And every night, approximately 600 million people are plunged into darkness without access to electricity (Troost, Musango & Brent, 2018). Sub-Saharan Africa contains the largest swath of people that lack access to electricity (World Bank, 2018). However, some countries, particularly in East Africa, have shown enormous improvements in electricity access in the last 25 years. Currently, Kenya has an electrification rate at 56 percent (or 75 percent when including off-grid solutions) which is quite an improvement considering the 1990 rate of a mere 3.3 percent (World Bank, 2018). However, only 39.3 percent of rural households in Kenya have access to electricity, while urban households have a substantially higher access rate at 77.6 percent (World Bank, 2018). In the East African context, these numbers are quite impressive. Kenya's 56 percent rate is the leader in the region as neighboring countries have significantly lower rates. Rwanda, for example, has a rate of just under 30 percent and Tanzania at 32.8 percent (World Bank, 2018). These numbers show two things; first, access to grid-connected electricity has improved drastically since the 1990's in East Africa. Second, that there is still much room for improvement and especially so in the rural electrification and off-grid context.

Rural electrification improvement has more than one major barrier. In the World Bank's (2017) report titled *The State of Electricity 2017*, a major challenge is stated as getting rural areas connected to the "main-grid" of a country. The financial cost to extend linkages from the main grid to sparsely populated areas is usually not financially viable. As a result, there has been immense interest in the use of renewable energy, such as wind power, solar and hydro, to create decentralized energy generation in rural areas (World Bank, 2018; Kenya Miniwind, 2018; Schmidt, Blum & Wakeling, 2013). These solutions, called minigrids, can with careful planning and consumption forecasting, be set-up at a relatively low cost in comparison to extending the national grid (Kenya Miniwind, 2018; World Bank, 2018) and can provide electricity that is often more reliable than the national grid for villages and households in rural areas (World Bank, 2018, Schmidt et al, 2013). The use of decentralized solutions in Kenya such as minigrids is nothing new; the first notable minigrid in Kenya dates back to 1988, where Kenya's national utility installed diesel generators in a rural northern county (EED Advisory, 2018). However, the difference in Kenya today lies in promoting sustainable energy generation using renewable energy technologies to help reach the UN's Sustainable Development Goals (SDG 7: access to clean and affordable energy) and the trend of an increasing number of private minigrid developers entering the Kenyan market (TFE Consulting, 2017).

A minigrid is defined by the World Bank (Asmus and Wilson, 2017) as:

"Isolated, small-scale distribution networks typically operating below 11 kilovolts (kV) that provide power to a localized group of customers and produce electricity from small generators, potentially coupled with an energy storage system."

In other words, a minigrid provides substantial energy generation capabilities to a target group of customers nearby. It is important to note that a minigrid does not have to be connected to the main grid and therefore can operate in 'island mode,' i.e. operating as a decentralized entity (Asmus and Wilson, 2017). In the rural sub-Saharan African context, reaching universal energy access will not be possible by extending the national grid to cover all areas as the economics behind doing this would prove too costly for governments to afford. For context, the 'main grid', or 'national grid', is defined as:

"*A network made of high-voltage power lines, gas pipelines, interconnectors and storage facilities that together enables the distribution of electricity*." (Davies, 2017).

In Kenya, there are numerous private companies that are creating impactful solutions in off-grid areas to further energy access, helping to reach SDG 7. The government of Kenya aims to reach universal energy access by 2022, however it is unclear as to how big a role minigrids will play in these efforts. Although minigrids have been promoted as a viable solution, diffusion of specifically private sector projects has not been

1.2 Research Problem

In both the academic community and East African energy sector, there is still a debate as to whether private minigrids are a viable solution for the energy needs of all rural and off-grid customers (EED Advisory, 2018; Lee, Miguel & Wolfram, 2016). However, what is clear is that demand for electricity is constantly growing in sub-Saharan Africa and in Kenya, while it is becoming clear that main-grid extension is not viable to all areas considering inadequate government spending (EEP Africa, 2018); Pedersen, 2016. Therefore, minigrids are receiving growing hype from both the academic community and development practitioners (Pedersen, 2016).

The private minigrid sector's entrance is rather recent in Kenya, and most minigrid development in the country has historically been implemented by the public sector (EED Advisory, 2018; Nikiriki & Ustun, 2016). However, there is still the perception that the Kenyan public sector expects the private sector to deal with traditionally unprofitable segments, like the off-grid areas (Pedersen, 2016). Kenya Power, the national utility, is perceived as not being equipped or not completely willing to single-handedly deal with this type of customer base, much like traditional banks in the country were unequipped to deal with low-income and rural customers. Private sector innovations, like the mobile-money service M-PESA, provided better business models to this customer segment. In part, that is

why private developers of minigrids may be able to better serve the energy needs of rural customers (Sovacool, 2013), as opposed to the national utility, Kenya Power. However, there have been a slew of problems identified in minigrid-related literature that are under researched or have been neglected. First, the role of investments is a contentious issue and one that has received moderate attention from the academic community (Troost, Musango & Brent, 2018; Pedersen, 2016; Williams, Jaramillio, Taneja & Ustun, 2015; Schmidt, Blum & Wakeling, 2013). Sources of investment are primarily grants from the public sector and development finance institutions (DFIs). Coupled with a limited amount of funding and investment from the public sector in developing countries, increasing private sector investment has been identified as being an important building block in the continuous development of the minigrid sector, going forward (Donastorg, Renukappa and Suresh, 2017; Pedersen, 2016). However, the regulatory environment in many sub-Saharan African countries, among other challenges, pose as significant barriers to increasing participation from the private sector (Castalia and Ecoligo, 2017; EEP Africa, 2018)

Various frameworks and ideas have been put forward in academic literature and in publications from industry players and development organizations. However, there is a lack of literature that takes into account the perspectives of the private sector minigrid developers themselves (Pedersen, 2016). Researchers Schäfer, Kebir and Neumann (2011) state that various decentralized energy solutions have been implemented many times over in developing nations in the past 30 years, however, the problem lies with the transfer of experiences and knowledge between these projects. The authors conclude that there is a greater need for 'systematic transfers' of experiences. This is especially true in the sub-Saharan African context (Schnitzer, Lounsbury, Carvallo, Deshmukh, Apt & Kammen, 2014). In Kenya, however, there is a lack of research into the complete private minigrid ecosystem (EED Advisory, 2018). Schnitzer et al (2014) argue that there is a research need to better understand what current trends look like in the African context. They state that in the Asian context, like in India and Bangladesh, documentation of minigrid processes and experiences is considerably better researched. Additionally, Pedersen (2016) mentions the variance in business models and policies found in the off-grid context as opposed to on-grid urban and peri-urban minigrids. And from that, the minigrid research becomes more segregated into off-grid and on-grid contexts, which may mean that one perspective is not always relevant for the other. Furthermore, the author argues that a research approach for analyzing private-sector minigrids, as this thesis does, would be to apply an innovation system framework where the private minigrid is seen as a socio-technical innovation; a special focus should be on the processes of minigrid developers and their networks. Considering the recommendations of the authors cited in this paragraph (Schäfer et al, 2011; Schnitzer et al, 2014; Pedersen, 2016), there seems to be a research gap related to the aspect of knowledge-sharing and of the networks of the minigrid ecosystem in both the sub-Saharan African context and in Kenya specifically. Therefore, this thesis will attempt to fill this research gap by applying a special focus on the role that networks may play in overcoming the contextual challenges of Kenyan off-grid minigrid developers. Using an innovation system lens as the framework for this thesis, public-private partnerships will be used for analyzing how networks could potentially play a role in overcoming barriers to the diffusion of minigrids.

1.3 Aim and Objectives

The aim of this research is to discuss how access to funding can be improved for minigrid developers in an off-grid context. This analysis will be framed through the lens of *Innovation Systems* which is comprised of; technology and knowledge; networks and actors; institutions (Malerba, 2005). Specifically, the focus will be put on how the role of networks within this innovation system can be used to overcome barriers in funding and other barriers for the private minigrid sector. The analysis aims to uncover the current barriers to the diffusion of minigrids in the Kenyan context and to discuss how networks, in the form of public private partnerships, can be utilized to overcome minigrid-related challenges such as access to funding.

Understanding the current challenges and barriers may be useful in stimulating further research into possible solutions or policy adjustments. The expected outcome is intended to be relevant for three parties: 1) private sector minigrid developers that are not presently active in Kenya but are interested in entering the market, 2) public sector actors and policy-makers that could benefit from the private sector's opinions, 3) actors within the research and academic community, as this thesis aims to provide an updated view of the Kenyan minigrid sector through an innovation system lens.

1.4 Research Questions

RQ 1: What are the current challenges and barriers inhibiting diffusion of private sector minigrid development in the off-grid Kenyan context?

RQ 2: What do existing PPP models look like for off-grid minigrids in Kenya?

RQ 3: How could PPPs help in overcoming the barriers that off-grid minigrids face in Kenya?

1.5 Outline of the Thesis

The remainder of this thesis will follow with a literature review and introduction of the theoretical framework. The literature review will focus on existing literature that introduces the Kenyan electrification context as well as literature pertaining to the challenges and barriers that minigrid developers face in developing nations. The theoretical framework will introduce innovation systems, diffusion theory and PPPs in the developing country context.

The method section will present the approach applied in more detail and will discuss the collection and analysis of the primary data. Additionally, limitations to the method and study will be examined.

The findings section will present the structured primary data collected in this thesis in accordance to the research questions. The discussion section will attempt to interpret, compare and contrast the findings to the literature review and to the theoretical framework.

The conclusion will follow with a brief summary of the main contributions of this study, in tandem with potential future avenues for research.

2 Literature Review

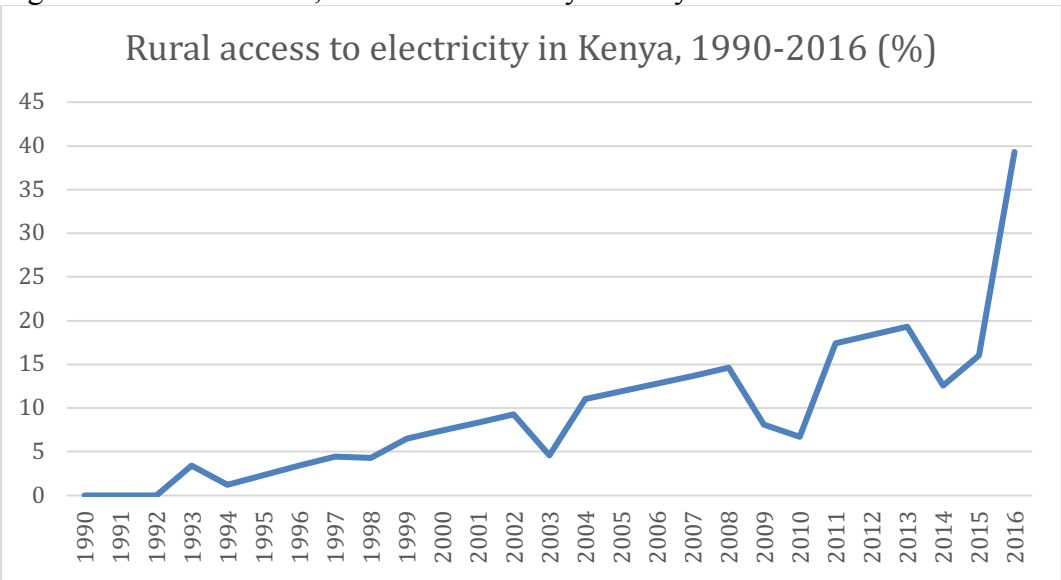
The literature review will introduce relevant findings from existing literature related to the diffusion of renewable energy technology in rural areas of developing countries. But first, brief information will give about the Kenyan electrification context as well as the role that minigrids could have in the challenges of rural electrification. A look at studies that have identified the challenges that small-scale (i.e. minigrids) renewable energy developers in rural areas face will be presented, as the aim is to uncover what

The departure point for this thesis, in regards to the research framework and discussion, is that of Innovation Systems and diffusion theory which will be discussed in-depth in *Section 2.2*.

2.1 Kenya's Electrification Context

According to the World Bank (2018), energy access in Kenya in 2016 was stated as 56 percent. In just two years' time, energy access is at almost 75 percent in Kenya, according to Kenya Power (2018). Kenya Power (2018) states that this is in part due to programs that have made grid extension more plausible. Specifically, the Last Mile Connectivity Project which helped fund and plan grid connections to households that were in close proximity to Kenya's main grid. The Energy Progress Report, published by the World Bank (2018) states that Kenya was among the World's countries with the strongest gains in energy access between the years 2010 and 2016. However, there is a large discrepancy between access in the urban context and the rural context. In rural areas, energy access was at approximately 40% in 2016.

Figure 1: Rural vs urban, access to electricity in Kenya



Source: World Bank database, 2017. Adapted by author

2.1.1 Minigrids as a Solution to Rural Electrification Challenges

Since it is clear from previous research that the economics behind a main grid extension to cover all rural areas is likely not feasible in Kenya (Nkiriki & Ustun, 2017), the focus then lies on implementing alternative solutions (Oji, Soumonni & Ojah, 2016). A popular and well-researched off-grid solution has been the use of Solar Home Systems, which provide small amounts of electricity generation capabilities to consumers (Hansen, Pedersen & Nygaard, 2014). Essentially, the power from solar home systems is sufficient for charging a mobile phone, powering lamps, radios or TV's, in some cases. Solar home system companies have shown impressive penetration into the rural and peri-urban consumer markets in countries like Kenya, Uganda and Tanzania. In part, their success has been dependent on their innovative business models that have tailored payment plans and local agents present in target areas (Hansen et al, 2014). This has helped them spur private investment into the sector, at times with investment rounds in the tens of millions of US dollars. However, a major criticism of solar home systems is the lack of usable energy generated; the energy as previously stated is enough for various low-voltage uses but not usually sufficient for operating machines or larger appliances (Safdar, 2017; Schmidt, Blum & Wakeling, 2013). The difference with minigrids is that generational output would be considerably higher, which could play a part in stimulating economic activity and productive use of energy in regions where it is needed most (Safdar, 2017; Schmidt et al, 2013; Cook, 2011). For scale, the following table will define various tiers of minigrids in tandem with their generational capacity in comparison to solar home systems.

Table 1, Types of Minigrids and their generational capacity

Type of System	Market Description	Generation Capacity
Small pico-systems like solar lamps/lanterns	Charging of batteries and use of lamps	1-10 W
Solar Home Systems	Off-grid electricity for private homes	10-100 W
Village Minigrids	Decentralized power for a single village with up-to hundreds of households	0.2 – 5 kW
Anchor-business-community (ABC) Minigrids	Powers an anchor load (such as a mill) and nearby villages	0.2 – 15 kW
AC Village Minigrids	Hybrid minigrids (diesel, solar, hydro, wind). Up to hundreds of households, multiple villages	1 – 300 kW
Large Minigrids	For multiple villages or large towns that are not located in proximity to the national grid	300 kW – 2MW

Grid Extension Projects	Projects that have the objective of increasing the generation capacity that feeds into national grid	4 MW and above

Source: adapted by author from Pedersen (2016) and Hansen, Pedersen & Nygaard (2015)

Essentially, minigrids are viewed as the "third alternative" for rural electrification, landing somewhere in-between micro-scale systems, like solar home systems, and large-scale projects, like grid extension (Pedersen, 2016). Renewable energy-based minigrids are also stated as providing more reliability in terms of generation capacity. Currently, the majority of sub-Saharan Africa's population live in rural areas, and getting these areas reliable electricity could improve education (due to night time study), small businesses and healthcare (drug refrigeration, improved lighting etc.) (Nikiriki & Ustun, 2017). Increased access to electricity may also be used for the operation of machines such as mills or for fisheries, stimulating productivity. Therefore, minigrids could play a more central role in energy access and promoting economic growth and social services in rural areas.

2.1.2 Financing of Private Renewable Energy Minigrids in Kenya

Several studies have mentioned the role that grants play in financing renewable energy projects in Africa. Typically, grants are most appropriate for smaller-scale projects but are useful in regions with underdeveloped financial markets (Schwerhoff and Sy, 2017).

The World Bank (2018), Kenya Miniwind (2018) and Safdar (2017) note that in a private sector model, private actors will build, operate and maintain their minigrid independently. Therefore, there is often the need to procure funding through equity and loans in a commercial context.

However, it is also stated that the public sector has previously played a role in subsidizing investments into private minigrid projects.

2.2 Theoretical Framework

2.2.1 Innovation Systems

The framework used a departure point for this thesis is that of innovation systems. Innovation systems deem innovation as a process that takes place between many different actors in a wide network (Malerba, 2005). Innovation systems, also referred to as sectoral systems, may provide a useful framework to the composition of a complex sector in a developing country like Kenya. A principle when considering this system is that innovation happens in a collaborative manner; firms do not generally produce innovative offerings in isolation. Innovation systems are often defined as; "*systems of innovation are networks of institutions, public or private, whose activities and interactions initiate, import, modify, and diffuse new technologies"* (Freeman, 1987).

Innovation systems are comprised of three pillars which are (Malerba, 2005);

- Technology, knowledge and skills
- Networks of actors
- Institutions

Technology, Knowledge and Skills
The knowledge, skills and technology are used to characterize a sector. All sectors have a knowledge base that is somewhat consist among actors in a sector, and technologies that change over time (Malerba, 2005). However, the boundaries of a sector are not considered as being set-in-stone. In other words, the sectoral boundaries should be considered dynamic and transformative over time.

Networks and Actors
Networks can be comprised of actors like non-governmental organizations, private firms and government institutions, policy-makers, consumers or entrepreneurs (Mondal, Kamp & Pachova, 2010). These actors implement new knowledge and technologies within their networks which promotes the transfer of knowledge and experiences between parties. Agents intermingle within their network through activities such as cooperation, exchange and competition (Malerba, 2005). Interactions can both take the form of market related or non-market related. Essentially, the network is a description of actors behavior and actions surrounding the exchange of knowledge in regard to the commercialization of innovation.

Institutions
Institutions are what shape the actions and interactions among each other within the system (Malerba, 2005). 'Institutions' can in this context be known as regulations, laws, norms or established practices, among others. Malerba (2005) notes that they varies among a spectrum of less-binding to binding and in regard to ones imposed on agents (laws etc.) or ones stemming from interactions between agents, like a contract. Institutions can be relevant for all sectors, which are called national intuitions, or can be specific to a certain sector in the form of sector-specific labor markets. Innovation is affected by the role of institutions within the system in several ways (Malerba, 2005):

1. Regulations and other national institution systems effect sectors in various ways and this effect may manifest itself in various forms, depending on the sector.
2. There is variance as to how an identical institution produces effects on sectors depending on the country and context.
3. National institutions often better fit the needs of sectors that are a good fit with their competencies as opposed to sectors that have vastly different specifics.
4. National institutions can at times come from sectoral institutions, meaning an institution may start as sector-specific but can overtime become important for other sectors, thus becoming a national institution.

It is also important to understand the role of demand within innovation systems. As agents are considered to be heterogenous, varying in their needs and wants, their interactions are shaped by the impositions from institutions within their sectors. And as demand evolves over time, the evolution of sectoral systems may also change in tandem (Malerba, 2005).

2.2.2 Theory of Diffusion

An important concept to understand and one that can be interlinked with innovation is that of diffusion. Diffusion is used to comprehend why some innovations have higher levels of uptake than others. Rogers (2002) defines diffusion as a process in which "*an innovation is communicated through certain channels over time among the members of a social system*." There are four main pillars in the diffusion of new ideas (Rogers, 2002):

- Innovations
- Communication channels
- Time
- Social system

An innovation can be considered as a new idea, process or product. The successful uptake of an innovation can be based on it's *relative advantage, compatibility, complexity, trialability* and *observability.* Relative advantage concerns users perspectives on the benefits of an innovation in regard to the previous or current solution. Compatibility concerns the needs of users and how an innovation aligns with past experiences. Complexity is in regard to the difficulties in understanding an innovation in terms of its applicability and use. Trialability refers to the ability to 'trial' an innovation before it is put into use. Observability concerns how observable the effects and results of an innovation are. It is noteworthy to mention that innovations are deemed to spread from the consumers by word of mouth from their close-peers, and not based off of the recommendations in literature or from experts. Eder, Mutsaerts & Sriwannawit (2014) note that relative advantage is likely to be the first and most significant aspect users will take into account. In regard to communication, Eder et al (2014) state that "*Communication is the process through which information is created, received, and shared. A main goal is to achieve mutual understanding among the participants*." Time is used in the context of diffusion to describe the rate at which users adopt an innovation. The last pillar, social systems, concerns the differences and similarities of actors within a social system. As found in many cases, users tend to be heterogeneous, so firms need to take into account the local context when introducing an innovation (Eder et al, 2014).

2.2.3 Innovations in Developing Nations

Within the social systems of developing countries, the process of introducing an innovation to the market should not be considered a product breakthrough at a fixed point in time but rather a process that requires the transfer of knowledge between various actors for the effective adoption of an innovation (Eder, Mutsaerts & Sriwannawit, 2014). Innovations require the use of 'feedback-loops' to be able to ensure participation from various actors along the diffusion process (Eder et al, 2014). Innovations in developing countries need also to pay special consideration to the end-user as they ultimately will play a substantial role in the uptake of innovations. Prahalad (2009) mentions that engaging the low-income section of a population for energy development and poverty eradication is paramount.

In a developing country context, there are numerous barriers to implementing innovations which has been noted by Reddy (1991) as being particularly true for the energy sector. Barriers can be diverse, but can be in regard to the challenges of dealing with segments that have low incomes consumers or in regard to firm and national-level challenges such as bureaucracy that hinder the diffusion of innovations (Eder et al, 2014). In the following section, a look at barriers and challenges identified in existing literature is summarized in specific regard to minigrids.

2.2.4 Barriers and Challenges for Minigrids

This section will summarize findings from literature stating the most prevalent challenges and barriers that minigrid developers face in the developing country context. However, it is important to keep in mind that barriers and challenges can be seen from two perspectives, or holistically. Adoption can be from the perspective of the consumers solely, and the barriers that they face in buying electricity from minigrids, such as lack of income (Eder et al, 2014). It can also be viewed from the perspective of the private minigrid developer themselves, and considering the lack of focus on the their perspectives, this thesis will take this approach. Ideally, barriers and challenges to diffusion of minigrids could be viewed holistically with an in-depth analysis of both the users themselves and the developers.

Access to finance

The main bottleneck is arguably access to finance. Steurer, Manatsgruber and Jouego (2016) state that for rural electrification projects in sub-Saharan Africa, both equity (initial capital expenditure costs) and debt financing (longer term financing) are challenges to find private investment for. The problem here is two-fold; one, local financial institutions are generally unknowledgeable within energy project finance and are unwilling to take on such projects (Steurer et al, 2016); two, development finance institutions (DFIs) and institutions providing commercial debt and equity are looking for bigger-ticket investments while rural energy projects are typically small in investment size (Steurer et al, 2016; Malhotra, Schmidt, Haelg and Waissbein, 2017). Therefore, commercial minigrids in off-grid areas lack access to viable commercial investment and finance options. The Ministry of Energy and Petroleum of the Republic of Kenya (2016) state that this is in part due to the unproven business models of

minigrid operators, coupled with regulatory uncertainty. The overriding theme for off-grid minigrid developers is that their projects are 'high risk/low return, making the process of acquiring commercial debt from private investors a challenge (Malhorta et al, 2017). In a study by Oji, Soumonni and Ojah (2016) it was found that investment firms see rural and peri-urban renewable energy projects as more high risk than urban projects in a broad, sub-Saharan African context.

Willingness/ability to pay from consumers

Private minigrids, in general, are more expensive to implement and provide electricity at a higher cost than to consumers that are connected to the main grid of a country (Safdar, 2017). However, they still are seen as the most viable solution for connecting millions of off-grid customers to electricity in sub-Saharan Africa as the costs associated with electricity from minigrids is still often lower than current sources of energy, such as kerosene or coal (Kenya Miniwind, 2018; Safdar, 2017). In rural areas, many of the consumers that will benefit from minigrid connectivity are at the bottom of the economic pyramid in Kenya and have low levels of purchasing power (Sovacool, 2013). Therefore, it is considered a challenge to tailor services and business models that not only ensure consumers' ability to pay, but also ensure that they are willing to pay a certain amount for electricity.

Regulatory uncertainty

A major factor determining the price of electricity is that of the tariff (CrossBoundary Energy, 2019; EEP Africa, 2018). Off-grid minigrids are often unsubsidized and therefore tend to charge a higher tariff on electricity which ultimately raises the price rural consumers pay. These types of tariffs are called cost-reflective tariffs as they reflect the reality of renewable energy projects; the upfront capital expenditure is often high (CrossBoundary Energy, 2019)

Demand uncertainty

Researchers Lee, Miguel and Wolfram (2016) looked into the economics of both supply-side and demand-side energy infrastructure projects in rural areas. For their study, they chose 150 rural communities in Kenya. Their findings indicated that cost and demand are correlated with each other, and that when costs go up for grid connections, demand decreases. What is also interesting to mention is that Lee et al (2016) find that even when high subsidizes are offered for grid connections, demand only increases slightly.

Table 2, summary of barriers for minigrid developers found in literature review

Barrier	Description	Source(s)
Access to finance	For minigrid developers, accessing equity and debt finance is a challenge due to the high risk/low return nature of minigrids in rural areas of developing nations.	Steurer et al, 2016; Malhorta et al, 2017; Oji et al, 2016; Ministry of Energy and Petroleum, Republic of Kenya, 2016.
Willingness/ability to pay	Due to the nature of rural	Kenya Miniwind, 2018;

	populations in developing countries, many have low purchasing power to purchase electricity.	Safdar, 2017; Sovacool, 2013
Regulatory uncertainty	Subsidies are often lacking for private minigrid developers in developing nations. Tariffs and other regulatory concerns are often uncertain. There is a general lack of minigrid-specific regulation in developing countries in the off-grid context.	CrossBoundary Energy, 2019; GMG Facility 2016
Demand uncertainty	It is often unclear as to how much electricity that users will actually consume, therefore the risk lies in revenue	Lee et al, 2016; GMG Facility, 2016
Productive Use	Stimulating the productive use of electricity in communities is essential in spurring demand, although it is often a challenge to be able to find productive uses of electricity in rural and poor areas.	GMG Facility, 2016
Business Models	There is a general uncertainty about what business models are viable, considering the complexities around productive use, regulations and demand in the off-grid context.	GMG Facility, 2016; TFE Consulting, 2017.

2.2.5 Public Private Partnerships in Energy Access

A PPP model is a broad term used to describe the shift of historically public goods and activities to the private sector (Sadka, 2006). It should be noted that as a principle in PPP structures, there is an element of public good features in PPPs. A bridge project, for example, may be undertaken by private sector actors but the public sector will likely play a continued role in its maintenance and operation. Historically speaking, PPPs were originally meant primarily for the financing aspect of a project with the private sector providing the finance. However, Sadka (2006) notes that PPPs have developed into more substantial partnerships

that manage and share risks between the private and public sectors efficiently. In a developing country context, PPPs can play an important role in furthering and speeding-up social and economic development. The Finance Minister of South Africa, Trevor Manuel, wrote in a government release (National treasury PPP Unit, 2004) that the public sector must do more to support the private sector, in infrastructure projects and the like, to help alleviate poverty.

The role of the state in providing essential utilities, like electricity, has fundamentally changed in the last three decades in many parts of the world (Bancioglu, 2017; Sovacool, 2013; Sadka, 2006). As many countries have moved towards privatization of basic utilities, cooperation between the public and private sectors has become paramount in financing investments into large infrastructure and energy projects for several reasons. In the energy context, the state may not have the ability to completely finance the energy sector to meet the needs of all its citizens (Balcioglu, 2017). And furthermore, the private sector may be able to meet the demands and needs better of lower income and traditionally unprofitable customers (Sovacool, 2013). This may be especially relevant for a country like Kenya, where there is a documented perception that off-grid customers will need to be serviced by both the public and private sectors (Pedersen, 2016). Schwerhoff and Sy (2017) argue that improving the private investment climate for renewable energy projects in sub-Saharan Africa could possibly be done through PPP arrangements. Safdar (2017) does note that the Privatisation Commission in Kenya has been working to develop a PPP model specifically tailored to the redevelopment of existing diesel minigrids into renewable energy-based minigrids. However, little is known as to exactly how this model works in practice. When the history of privatization in energy is looked upon closer, Balcioglu (2017) finds that between 1990 and 2014, Latin America, the Caribbean and East Asia were found to have the most prevalence of PPPs in energy development.

Risk Allocation in PPPs

A major reason for implementing PPPs is to effectively share and manage risks. Sadka (2006) notes that essentially, risk is being transferred to the private sector in many PPP arrangements. However, effective PPP structures should not demand that the private actor takes on the brunt of the risk, as they are not more equipped to deal with it than the public sector. Therefore, Sadka (2006) argues that the public sector, or the end users, should often bear the majority of the risk for efficient PPP arrangements. However, the author does note that in some cases, the private actor is more effective at managing risks than the public sector– risk is contextual to the location, project and socioeconomics of users. A major advantage of the PPP model is that of bundling (Sadka, 2006). In this scheme, projects that have a long time frame (20-30 years) such as factories or bridges, the construction and operation can be locked-in for a specified time period. This mitigates risk for both the public and private sectors. In this structure, the construction and operation is managed by the private player but must be returned to the public sector at the end of the tenure, thus creating incentives for maintenance. However, one major risk for the private sector, and especially so in an energy context, is that of future demand (Sadka, 2006). One way of circumnavigating this risk is for the public player to guarantee a ‘fixed revenue’.

2.2.6 PPPs for Low-Income Segments

According to the UN and Perez-Ludena (2009), the pillars of effective PPPs for servicing the poor lie with the role of the government in creating regulations and effective subsidies, the private sector and communities and NGOs. The roles of the public and private sector will be examined in more detail. The role of the community, and potentially NGOs, refers to the need to proactively engage the local populations to ensure their perspective is heard. This can be done through establishing community-based organizations for specific projects or through the use of existing NGOs.

The Government's Role
The government is expected to protect the long-term interests of its citizens. However, the main responsibilities for the government in regard to PPPs are to provide adequate regulations and subsidies.

- *Regulations*: often viewed as one of the major reasons for PPP failure in the developing country context. Regulatory concerns should be separated into independent public agencies. It is also important that regulations serve the needs of both the private sector's commercial interests, as well as the best interests of the consumer. Flexibility in amending tariffs and other regulations is paramount in the process of creating effective regulations.
- *Subsidies*: due to the nature of the poor in developing countries, Perez-Ludena (2009) argues that subsidies will be required to reach these populations and serve them effectively. One-off subsidies are easier to manage than permanent or long-term subsidies schemes.

The Private Sector's Role
Generally, for the private sector to be incentivized to serve low-income populations, there should be attention to the opportunities for profitability. And for the private sector to function properly, the investor climate needs to be strong enough to promote investment. Perez-Ludena (2009) argues that it is the role of the government to provide a stable investor climate through incentives, such as substantial subsidies, and through support, and various other advantages. Investment promotion firms have the ability to promote opportunities for both local and foreign firms to serve the poor through investment.

2.2.7 Pro-Poor PPP Model Types for Energy Access

According to Sovacool (2013), there exist eight main types of pro-poor PPP models. The following eight types will be presented in the following table with a brief description of their main purposes.

Table 3, Pro-Poor PPP Model Descriptions

PPP Model	Description
Tech Improvement and Market Development	Aim is to lower cost and help to advance improvements

Project Finance Model	Loans and funding for small to medium-sized projects from commercial sources
End-user Microfinance Model	Microfinancing for end users so they are able to purchase what is being offered
Community Fund	Redirects revenue and funding into community-based needs
Cooperative Model	Ownership is shared among members of the community
Fee for service Model	Ownership is by private sector, but fees are paid, usually in installments, for use of service/product
Cross-subsidization Model	Tariffs are increased for those for can afford them so to be able to subsidize the poor
Hybrid Model	A combination of appropriate aspects from all models

Source: based on Sovacool (2013), adapted by author

3 Methods

This section will discuss the research approach and specific methods used for the data collection in this thesis. A qualitative approach was taken, due to a limited amount of quantitative data available on the Kenyan minigrid sector, with semi-structured and informal interviews conducted with minigrid developers, financiers and other experts in the field. Moreover, an overview of the sampling, data analysis and limitations are given.

3.1 Research Preparation and Topic Selection

An initial and thorough literature review was conducted on the topic of rural electrification and solutions to access to energy challenges in the preparatory stage of this research. Additionally, the author was in contact with a small wind technology manufacturer, called Primo Wind, during the topic selection process. During the deliberation stage of solidifying a topic and research question, Primo Wind stated their take on East Africa and the challenges of entering the commercial market of a developing country. In tandem with an analysis of current literature on the topic, renewable energy-based minigrids and the challenges that go along with them stood out as an interesting and relevant research area. The research topic was subsequently scoped down to only focus on Kenya, and not on East Africa as a region. During this stage, an overview of who the important actors were in the minigrid sector was gained which proved useful in reaching out to potential interviewees and networking while on-site in April, 2019. This was done from online research of academic literature, news articles (Distrupt Africa, PV Magazine etc.) and public sector reports (Ministry of Energy of Kenya, The World Bank, etc.) and private sector reports. The researcher spent approximately 16 days on-the-ground in Nairobi during the data collection process. The design of this research includes the perspectives of 12 participants with practical experience in the renewable energy and minigrid ecosystem in Kenya. A table compiling the interviewees and from what organization/company they represent can be found in section 3.3.

3.2 The Research Approach

Due to the complexity and relative newness of the Kenyan minigrid sector, the research design of this thesis takes a qualitative approach using case studies. Creswell (2014) states that case studies are used to gather information in an in-depth fashion of a program or process. Establishing a minigrid in Kenya could be considered a process and understanding the ecosystem better, including the policies, challenges, barriers, and various actors, requires a

methodology that ensures an in-depth view can be taken. Another reason behind the rationale of choosing a case study design is because it takes into account the context of a phenomenon (Yin, 2006). Yin (2006) also suggests that researchers focusing on complex and contemporary topics use a qualitative method. In other words, the Kenyan minigrid sector could be considered unique in itself compared to countries in developed countries, or even surrounding countries, due to the inherent variance of energy policy, financing opportunities and actors involved in the market. Therefore, case studies were deemed an appropriate design for this study as it can be considered highly contextual and contemporary.

When looking at the literature, a common approach found is indeed qualitative or a mixed-methods approach, incorporating some form of interviews. EEP Africa (2018) implemented a case study methodology in their review of minigrids in their portfolio. Schäfer, Kebir and Neumann (2011) state the need for "carrying out research in this field in close exchange with practitioners (e.g. funding institutions, administration, politics and engineers) in order to be able to integrate their expertise." Additionally, Troost, Musango and Brent (2018) applied a qualitative design due to the "exploratory nature" and demand for "rich and in-depth data." Schmidt, Blum and Wakeling (2013) also conducted field interviews with actors in the private sector minigrid market in Indonesia with the aim of understanding barriers to investment and potential solutions. The authors followed Schäfer et al (2011) recommendations, mentioned above, that deemed it necessary to combine perspectives from various practitioners in the field. There have been numerous studies applying quantitative methods, however, they tend to focus more on demand estimations of consumers (EEP Africa, 2018), operational and technical aspects of minigrids or portfolio management strategies (Malhorta, Schmidt, Haelg & Waissbein, 2017). For the purposes of this study, the recommendations by Schäfer et al (2011) will also be followed by including respondents from across disciplines but with knowledge/experience of rural electrification and/or the minigrid sector in Kenya.

As this research can be deemed exploratory in the sense that it aims to understand the processes found within the minigrid ecosystem in Kenya, much emphasis has been put on going back and forth to the relevant literature. As mentioned in section 4.1 above, a literature review was conducted before the researcher's trip to Nairobi, Kenya. Upon returning, another literature review was conducted as new topics were deemed as significant to the study.

3.3 Sampling and Conducting Interviews

Before the field trip to Nairobi, the aim was to set-up interviews with actors in the renewable energy minigrid sector from both the private sector and public sectors. Additionally, a focus was put on financiers of renewable energy projects in Kenya, such as impact investors and development finance institutions (DFIs). In total, 30 potential interviewees were contacted through directed messages on LinkedIn, personal emails (if available online) or general company emails (e.g. info@company.com). A total of 14 responded, resulting in 11 interviews. Although, three of the 11 interviews were the result of contacts gained during the visit to Nairobi. During the first literature review and process of understanding the different players involved in the Kenyan minigrid sector, an Excel sheet was created, mapping out companies and organizations and categorizing them by their functions. Relevant contacts within the companies were listed along with their contact details. A pre-interview script was

created before the visit to Nairobi with a set of questions grouped in accordance to theme (See Appendix A). The questions were open-ended as the intent with a semi-structured format is to give some leeway in the conversation for the interviewee to open to new topics of discussion, that arise from the questions (Creswell, 2014). The table below shows the participants in the study, as well as their position within the company and area of expertise.

Table 4, Description of Interviewees

Organization	Interviewee	Area of Expertise	Position	Interview Date
African Solar Designs	Mark Hankins	Policy and Implementation	Managing Director	5/4/19
Responsibility Energy AG	Wilfred van den Bos	Developer	Head of Investments	5/4/19
Trine	Matthew McShane	Financier	Investment Manager	9/4/19
Sida	Lena Berglöw Elm	Financier	Senior Advisor, Loans and Guarantees	10/4/19
GIZ	Jackson Mutonga	Policy and Implementation	Advisor, Component Leader (minigrids)	11/4/19
Ministry of Energy, Kenya	Kihara Mungai	Policy	Renewable Energy Engineer	12/4/9
PowerGen	Tobias Dekkers	Developer	Senior Manager, Commercial Development	16/4/19
Virunga Power	Bernard Mullins	Developer	Senior Manager, Project Execution	15/4/19
OikoCredit	Wanjiku Kariuki	Financier	Investments	11/4/19
Ascenda Finland	Sari Seppanen	Policy and Implementation	Founder	22/4/19
I-DEV	Nakul Sharma	Policy, Financing and Implementation	Associate Partner	11/4/19

Semi-structured interviews were conducted with 5 actors involved with the practical implementation or operation of private minigrid projects in Kenya, 4 with the financing of private minigrid projects and 2 with primarily the shaping of policies influencing the private minigrid sector, and 1 with considerable experience in the renewable energy sector in Kenya. As one central theme of this thesis is challenges and barriers to investment into minigrid projects, it was deemed important to get perspectives from both private and public players in addition to policy-makers. This could be considered an attempt to 'triangulate' the findings as argued significant by (Schmidt et al, 2013). However it should be noted that the functions of many of the interviewees overlap. For example, some of those involved with the financing of minigrids may also be involved in the shaping of policy in the sector or the practical implementation of minigrids.

9 of the 11 interviews were recorded and later transcribed, while the remaining two are based off of notes taken by the researcher during the interview. In regard to the ethical considerations for recording interviews, the researcher aimed to make it clear how their responses would be used and for what purpose the interviews were being recorded (Cooper and Schindler, 2014). All interviewees were given the option to remain anonymous, which none decided to opt for. During the visit, there was much opportunity for the use of 'snowballing' which implies gaining relevant contacts from referrals of previous interviewees (Atkinson and Flint, 2001). Due to time constraints, few of the opportunities from 'snowballing' could be utilized but would have been useful, especially in reaching people in government ministries, if time had permitted. In general, interviews lasted between 25-50 minutes, although some lasted over 60 minutes. All interviews started with a brief introduction of the research topic and researcher in order to give the interviewee an expectation of the process of the interview. Interviews were transcribed and uploaded to Google Docs in preparation for coding.

3.4 Data Analysis

When all interviews had been transcribed, the researcher read through all of the interviews along with re-listening sessions if the transcription seemed unclear. During the analysis, key themes were recorded and grouped together by color coding sentences or paragraphs and then copy-and-pasting them into a separate document. This allowed for various themes to be grouped together from separate interviews. Primary and Secondary codes were generated. Barriers and challenges for minigrids that were found in previous research, along with the research questions, were used for the generation of primary codes. From attempting to analyze patterns and relationships between data, codes were generated (Silverman, 2016). Some of the primary codes were discarded due to a low prevalence in the actual findings while new codes were generated if found to be reoccurring. Codes and themes were given a description (Creswell, 2014) to ensure that information added to their corresponding document was in fact appropriate. Additionally, some codes were combined when they appeared to be interlinked. For example, 'grid-extension' and 'regulatory environment' were unquestionably mentioned together often, as they are related. From this procedure, a better sense of the data collected was gained which helped structure the findings in a more coherent manner.

3.5 Limitations

The main limitation that affected the research process was that of time constraints. 16 days in Nairobi allowed for a substantial amount of data to be collected from various key actors in the sector. However, it is true that a longer field trip would have most likely resulted in more extensive findings. Considering the amount of interviews that there just was not enough time for, especially with actors involved in Kenya's energy policy-making, the results may have

differed. Although the author is confident in the results drawn from the data in this report, a longer time-span would have been beneficial. An additional benefit other than speaking to more actors, would have been conducting follow-up interviews in order to observe changes in policy and financing overtime.

Related to time constraints is the limitation of using a qualitative method. The process of setting-up interviews, traveling to interviewees, conducting them, transcribing and then coding them proved to be extremely time consuming and demanding. In-line with the time constraints of a Master's thesis, it would be more beneficial to undertake a study with this method and magnitude over a longer timeframe. Another limitation that may have influenced the quality of the data, and mentioned by Creswell (2014) is that when using interviews, the information provided is filtered through the experiences and perspectives of the interviewee. At times, it seemed that interviewees showed bias in their answers which would not be prevalent in a quantitative study. Additionally, the years of experience between interviewees differed which may have influenced their responses. It should also be noted that the participants of the study were from various backgrounds; being financing, developers and policy-makers. Some focused on both on-grid and off-grid projects while others were exclusively on-grid or off-grid. This could have affected their answers, however, from analyzing the findings, there seemed to be congruence in perspectives from interviewees across various disciplines.

Schäfer, Kebir and Neumann (2011) state the problem that many publications in this sector are funded by public financing entities, like DFIs, who evidently have to prove a potential successful outcome of their programs. Therefore, much of the available data and previous research cannot be considered completely transparent. The World Bank (2018) also notes that data collection is not consistent in Kenya and that there are significant variances in different datasets. The World Bank (2018) calls for the need to improve data quality and statistics procedures in Kenya. Therefore, this could impact any use of datasets and especially so in a purely quantitative approach

4 Data Analysis

4.1 What are the challenges and barriers inhibiting private sector minigrid diffusion in the off-grid Kenyan context?

4.1.1 Business Model Complexity and Uncertainty

Based off of the findings of this report, a major challenge to implementing minigrids and proving commercial viability in Kenya is that various business models are being applied, but it is unclear as to what will be successful. Key themes mentioned within business models are stimulating local economic growth and thus productive use of energy, and subsidies and tariffs. Business model design could be considered a result of the environment that they are to applied in, and it is important to note that various other barriers and challenges will be mentioned in this section.

Productive Use

Productive use (PU) concerns the use of electricity in ways that add value to society, economically or socially (GMG Facility, 2016). For example, this could be the use of machines in a local factory or refrigerators for storing fish on a commercial scale. The majority of the respondents active in the actual deployment of minigrids mentioned that incorporating programs to stimulate productive use in their business models was a challenge (Interviews).

"We basically did a sector mapping exercise, where we spoke to every major player in the minigrid sector in Kenya to ask them what are the key challenges you are facing… And the consensus view was that minigrid developers need assistance in conceptualizing and deploying productive use of energy applications. The issue that we discussed with the business model has to do with the fact that the communities where you're setting up these minigrids, you're not able to generate enough demand only from households to make the minigrid economics work. You need businesses, you need enterprise to be able to generate that demand, consistent demand, to make the economics work." (Interview with I-DEV*).*

This sums-up a key challenge for minigrid developers in Kenya. As a minigrid developer, much of the complexity lies in ensuring long-term usability and profitability from the actual consumers of energy. Several interviewees (I-DEV, African Solar Designs (ASD), Virunga Power, GiZ & PowerGen) expressed the challenge of stimulating productive use. Therefore, private minigrid business models have to take into account the broader potential implications of their site selection and their role as a support mechanism of promoting local economic growth. In the interview with the GiZ, the interviewee stated:

"…from projections of course sometimes you can see the people are not much obliged to pay for private electricity so that comes with a lot of burden for you as the investor, to create productive use of electricity for the people. So you have to work very hard with the people to engage them and to teach them, educate them, train them, on productive uses"

For private minigrid developers, this implies wide-sweeping challenges. As a private, or semi-private venture, the commercial implications mean that there is the need to recover investments and eventually turn a profit. For the "economics of minigrids" to function properly, there needs to be high enough demand for electricity. And in many of the off-grid areas, the people are low-income with few appliances or machines that would consistently demand power (Interview with ASD & I-DEV). Designing and implementing business models that take this into account can be difficult. That's where the major challenge lies for the viability of the private minigrid sector in Kenya, going forward (Interview with I-DEV).

Tariffs and Subsidies

Related to productive use and business model complexity is the topic of tariffs. Numerous interviewees expressed the fact that private minigrids in Kenya operate in an unsubsidized fashion, or with a very low subsidy, and thus often charge cost-reflective tariffs; "*The private sector is charging cost-reflective tariffs which are much higher than the national utility tariffs*." (interview with GiZ); "*Because you have such high upfront capex (capital expenditure) requirements, you need to be able to recuperate, that's why you charge higher tariffs"* (interview with I-DEV); "*The regulatory environments* (in Kenya*) quite hard because of the tariff setting*" (interview with PowerGen); "*One of the big risk that comes with the minigrids is the tariffs*." (interview with Ministry of Energy).
The implications of this trend found in the findings indicates that due to the lack of subsidies for off-grid minigrids in Kenya, a cost-reflective tariff is often applied. Considering the fact that many rural and off-grid customers are low-income, this makes the economics of minigrids in off-grid areas that much more challenging. As noted by GiZ, the Kenyan government has a law that grid connected customers pay a uniform tariff. In the off-grid setting, there is no such uniform tariff, so developers can request to set their own tariffs, but must be approved by the government. *"Now you have connected people and then people are not really consuming as expected. So, it becomes a little bit risky. Because now you either come back to government and ask for a higher tariff, which government may say no to."* (interview with Ministry of Energy). Reaching a realistic tariff rate that takes into account customers willingness and ability to pay, plus recover expenditures, is a daunting task without the help of subsidies on a large scale.

"*The one glaring omission for minigrids and I don't see it in the near term is the subsidy specifically for minigrids. The current subsidy is something along the lines of 12 US cents for KWh".* (Interview with I-DEV). According to the interview with I-DEV, this is not sufficient for minigrids; "*to break even, you're looking at anywhere from USD50 cents per KWh and above, on average per KWh*."

The Kenyan national tariff, is made possible by the method of cross-subsidization. Meaning,

On-grid or Off-grid Business Model?

It was also noted that it was unclear as to exactly where minigrids are most suitable. The GiZ noted that "*on-grid minigrids in Kenya, especially for the peri- urban population are gaining traction*." This is in reference to government-supported projects in tandem with international development agencies and the private sector. Giz continued, "*customers are connecting because of the reliability of minigrids, its 24/7 supply."* The context here is that it was found that Kenya Power, the national utility, is not always providing reliable access in certain rural and peri-urban areas, and therefore minigrids can be used as a supplemental generation source with more reliable output. However, it was also noted that the majority of interviewees do see the need for off-grid minigrids as well. The consensus was that minigrids will play a role in both peri-urban and off-grid areas for reaching universal electricity access in Kenya. For renewable energy projects in general, Sida mentions that the most common approach is to sign a PPA agreement with the national utility and then feed your generation into the main grid.

4.1.2 Regulatory Barriers and Challenges

Grid Extension Uncertainty

A major theme found to be reoccurring was that of uncertainty of what would happen if the main grid was to be extended into an area serviced by a private minigrid. It is true that electricity from the main grid would be cheaper than that coming from the private minigrid. And as many of the private sector's minigrid projects have been historically in rather close proximity to the grid, this is a valid concern. In an interview with the Ministry of Energy, it was mentioned that: "*the private sector in Kenya and some guys from America who are doing these (minigrid projects) also focus on areas that are very near the grid*." This may be because communities that are closer to the grid may have more economic development than areas far from the grid. In the interview with GiZ, the same concerns were raised. However, what was also noted was that new minigrid-specific regulations were to be expected soon which explicitly tackled this issue. *"So, the regulations are still in draft form…things will become much, much more clear and they will be proficient for when the grid is extended, and will cite their options."*(Interview with GiZ). In interviews with GiZ, I-DEV and the Ministry of Energy, the expected options were cited. It is unclear as to when the regulations will be published, however June 2019 was noted as a possibility. The options were:

1. Compensation from the government for your minigrid site. The private mini-grid project will be ended. Compensation possibly based off of minigrid developer's revenue the year before, plus depreciated cost of assets (I-DEV).
2. Moving your minigrid to another government allocated site.
3. Become a small power distributor by buying from the utility and using your existing network to distribute power.
4. Small-scale PPA where you feed your power into the utility grid and they buy from you.

PowerGen decided to completely avoid this area for minigrids as it was mainly a question of securing funding.

"If you can say for sure, 10, 15 years, the grid is not going to come when it's like a km away, I think that's risky. And I think financiers will have a serious problem with that." (Interview with PowerGen).

The overall, consensus here is that grid-extension is a powerful uncertainty that has consequences in terms of accessing funding and site selection.

Licensing and Permitting

Another challenge and barrier for minigrid developers is understanding and dealing with the process of permitting and licensing (Interviews with I-DEV, GiZ, PowerGen, Virunga Power, Sida). The main hurdle here is that the process is often delayed and that the permitting and licensing requirements are complex and daunting. Theoretically, the time the licensing process is expected to take for minigrids is 3 months, however, "*in practice, it's taken significantly longer, and as a result of that obviously investors lose patience*" (Interview with I-DEV). There are two main approvals that minigrid developers need before implementing a project (Based off of I-DEV Interview):

1. Tariff Approval: this is done to safeguard the consumers of energy to ensure that predatory tariffs are not being created. The aim is to make sure that consumers are not being charged significantly more than they can afford. This approval process is looked at on a case-by-case basis, increasing the time needed to make a decision.
2. Generation and Distribution Licenses: as a minigrid developer and operator, you need both.

This stage is *"…frankly, the most frustrating part of the process for all parties involved*." (Interview with I-DEV). GIZ interviewee concurs, stating: "*It takes a long time from the regulator. It's really, really tiring. Sometimes, you can wait for it 1 year, 6 months, ideally it should take 90 days. So, getting a permit is not easy.*" Also, in relation to the licensing and permitting process is the finding that requirements are very stringent and require many documents. For example, a 'a memorandum of understanding' is required which is a document ensuring the community that your minigrid will service, agrees to your plan (Interview with GiZ). It's also not a one-time meeting, as it can take several meetings to produce an agreement. As a minigrid developer you also need an approval from the local county in which your minigrid will be placed. Additionally, you need confirmation from the

Rural Electrification Authority (REA) that there are not active plans for grid extension to your proposed site. In some cases, an impact assessment is needed which is then sent to the National Environment Management Authority for permit processing (Interview with GiZ). Overall, the process is lengthy and complicated. *"A lot of typical challenges are to get a project in such a shape that investors and lenders are comfortable to put their money on the table and for that you typically have very lengthy processes in negotiating*" (Interview with Responsibility Energy).

4.1.3 Access to Investment and Financing

A major barrier to securing investment as a private minigrid developer is a combination of the above mentioned barriers. The regulatory uncertainty coupled with the business model complexity and uncertainty are significant in the eyes of private investors, and may partly explain why private investors are reluctant to invest in private minigrids. This section will take a deeper look at this barrier and go beyond the above mentioned barriers and challenges. Specifically, the perspective from the financiers and investors that participated in this study will be shared.

Local/Traditional Financial Institutions

The local financial institutions and banks in Kenya were found to be quite risk-averse and lacked awareness and experience of the minigrid sector. Therefore, they are generally not involved in financing minigrid projects, which makes acquiring investment more challenging in Kenya (Interveiws with GiZ, PowerGen). "*Some of them* (minigrid developers) *have struggled to access finance for more than 6 months*" (Interview with GiZ). There are too main issues:

1. Debt financing from local institutions is available but the interest rate is too high (at least 14%).
2. Local financial institutions have minimal knowledge of minigrids as they have more experience financing larger, grid-connected projects.

"*Access to finance is a challenge, especially for pure private sector minigrids*" (Interview with GiZ). This interviewee also expressed a lack of impact investors in the country that were dealing with minigrids, so some minigrid developers have turned to foreign financiers. However, it seems that due to the high risk nature of off-grid minigrids and expected returns in the single digits, many traditional financial institutions (both foreign and local) are reluctant to provide financing. "*It's just not interesting* (for traditional financial institutions) *and also such a high-risk market."* (Interview with Trine).

The Role of Project Finance

Based off the interview with PowerGen, the role of project financing is seen as a step towards commercial viability, moving away from grants and DFIs and a 'pilot stage' and more towards privatization. This is significant as it shows one major barrier from the eyes of

commercial financiers and investors; minigrid projects are small in scale and commercial financiers are often structured for larger scale projects.

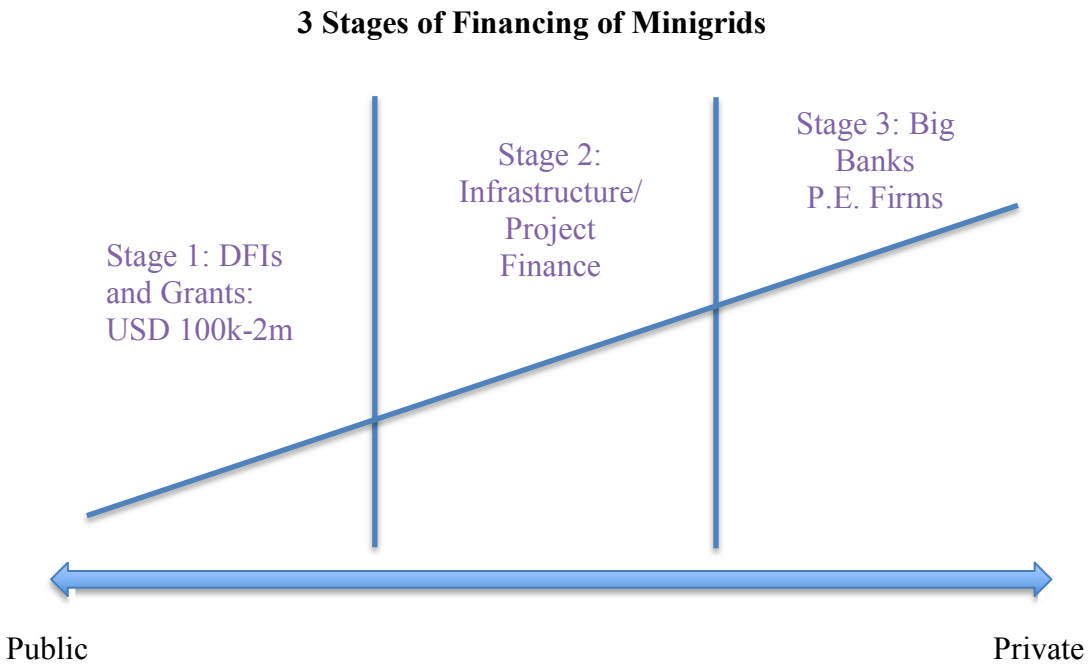


Figure 2, based off of drawings made by PowerGen interviewee during interview

"We see 3 phases, so this is kind of where the minigrid sector was for a very long time (Stage 1)*, this is like the piloting phase where you do a couple thousand connections. You raise grants, on-balance sheet kind of financing like 100k to 2million or something. It's kind of for one-off grants. And here, at the end of this phase (Stage 3), where you're a fully accepted utility, you do over 1 million connections and your projects are like 10s to 100s of millions* (USD)*."* (Interview with PowerGen).

Within project finance, there is infrastructure finance which is used to fund large-scale projects, like roads, bridges and utility projects. PowerGen expressed the need to move closer, and closer to this stage of financing. As a private company, their business is only viable in the long-term if they reach this stage. "*We're setting up the first, what they call SPV, special purpose vehicle, specific to our project. Where we're bundling all our different minigrids to one legal entity and then get financing specifically for those projects*." As minigrid projects scale, there is a larger need for financing that helps offset the capital expenditure needed by the minigrid developer, and this is viewed as not being viable for DFIs and organizations providing grants; the numbers need to be bigger, which is often more suitable for infrastructure financiers. This needs to happen, according to the PowerGen interviewee, to be able to save on cost and reduce their capital expenditure overtime on minigrid projects.

4.1.4 Summary of Findings for RQ1

RQ1: What are the current challenges and barriers inhibiting further private sector minigrid development in the off-grid Kenyan context?

The minigrid sector is in a state of experimentation to see what works, and are actively aiming to overcome the challenges that relate to the criteria private investors and financiers have. Business models are complex due to the nature of typical off-grid consumers. Rural populations often have low demand for energy. The economics behind private minigrids rely on substantial energy demand to recuperate high upfront investment expenditure. Therefore, a challenge is to stimulate demand and productive uses of energy in areas where there are few machines and appliances. Additionally, the regulatory environment is complex and slow which can make investors lose patience and trust in the system. Grid extension to areas already serviced by a private minigrid and the lack of regulation as to what happens, was seen as a major barrier to private minigrid deployment and investment from private financiers. Local financial institutions were seen as lacking in knowledge of the minigrid sector and therefore reluctant in financing minigrid projects. Last, acquiring commercial level finance for minigrid projects is a challenge as infrastructure financiers are structured to handle large scale projects.

4.2 What do existing PPP models look like for off-grid minigrids in Kenya?

This section will highlight findings in relation to the above research question. An analysis of examples in practice of public private partnerships will be presented.

One example presented was a pilot minigrid project funded by the GiZ in Naruk County, Kenya. This project was 100 percent funded by the German government as funds were transferred to the Kenyan government for the implementation of the minigrid. "*Naruk County contracted a private company to operate the mini grid. Implementation was by public sector, and operation by private sector."* From this project, a results-based financing scheme was born where grants were given to companies who were either implementing minigrids or investing in off-grid areas, but only after results had been achieved. The program is currently supporting four minigrid companies to develop 14 minigrids (Interview with GiZ). The process is as follows:

PPP Model : GiZ and Private Minigrids

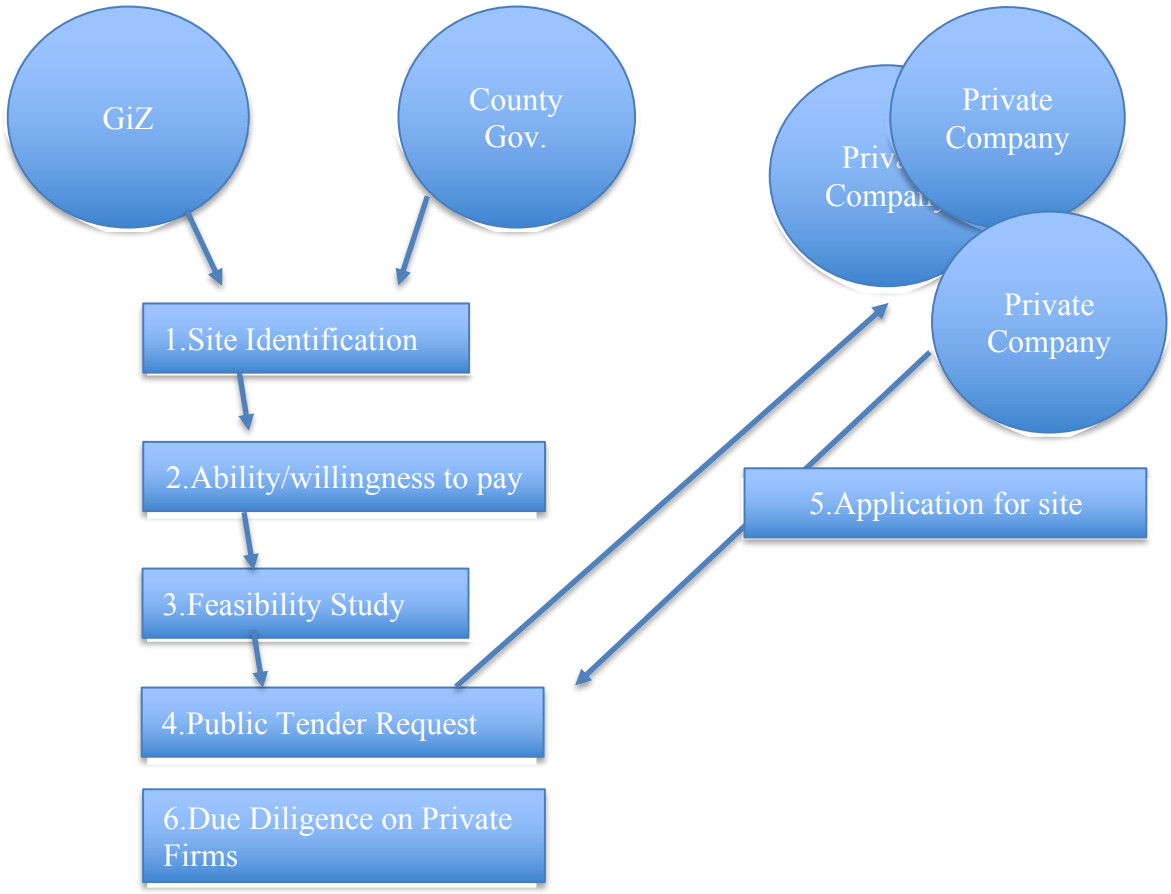


Figure 3, based on interview with GiZ

In this PPP model, there seem to be three actors involved; the GiZ (German public sector); a county government (Kenyan public sector); private minigrid developer. The GiZ uses their access to human capital to oversee site selection and the remaining feasibility aspects. They also perform both technical and financial assessments on private companies that have applied for a site. This is to ensure that they have the financial means to cover 100 percent of the upfront capital expenditure as the results-based financing scheme only pays out grants after they have been achieved (Interview with GiZ). Results are based primarily off of number of connections that have been made. "*The maximum incentive or grant we can give is 50 percent of the capex, that is where it is capped. So that means if they achieve the results and we give them the 50 percent capex, they still have the 50 percent to recover from the sale of electricity"* (Interview with GiZ). It should be noted that the legal requirements, such as licensing and permits, are handled solely by the private company.

Another example mentioned was a PPP model being implemented by the Rural Electrification Authority (REA) in cooperation with funding from the World Bank; the program is called the Kenya Off-grid Solar Access Program. They are planning to implement 120 minigrids "*where the private sector will invest in generation systems, and the public sector will invest in the distribution system."* (Interview with GiZ).

The benefits of partnering with the government to reduce risk in a PPP model are large (Interview with GiZ). The process supposedly would tackle the issue of the demand risk of dealing with the consumers of energy. The private sector would invest in the generation system, i.e. the actual technology being used in the minigrid, while the public sector would invest in the distribution network, i.e. the poles and cables. The agreement would be based on a Power Purchase Agreement (PPA) with Kenya Power and two distinct charges; the capacity charge and the energy charge (Interview with GiZ).

Capacity charge: this refers to private sector's installed capacity in the minigrid. Under the PPA, Kenya Power will pay (unspecified amount) for your generation capacity. This would, in theory, safeguard against the risk of low demand and would help ensure private developers that there will be some form of guarantee in the long-run to offset capital expenditure.
Energy charge: In addition to the capacity charge, the public sector would pay the private developer for every unit of energy they do sell.

This model is significant for another major reason; tariffs. By partnering with the government, the consumers of electricity would benefit from the national utility tariff because they are, on paper, receiving energy from Kenya Power (Interview with GiZ). This is done from a cross-subsidization method, where urban consumers pay a slightly higher tariff to be able to offset rural energy connections. As opposed to cost-reflective tariffs, which tend to be found in purely private minigrids and are higher.

4.3 Discussion

4.4 What are the challenges and barriers inhibiting private sector minigrid diffusion in the off-grid Kenyan context?

From the barriers identified, many of them are congruent with findings from minigrid studies in other developing countries. In a broad sense, access to funding, regulatory concerns and the more operational challenges of tailoring business models to fit the needs of low-income rural segments were mentioned by various authors in the Literature Review (see section 2.2.4; Steurer et al, 2016; Malhorta, 2017; Oji, 2016). However, the findings in this study seem to shed more light on what is argued as the main challenges for minigrid developers in specifically the Kenyan context. Seeing the sector holistically, one could argue that the barriers and challenges are interlinked; meaning, access to funding is in part a challenge due to the weak regulatory environment and lack of subsidies and inappropriate tariffs. Additionally, the investor climate is affected by minigrid developer's uncertainty on what business models are best suited for their projects. Productive use was mentioned several times (I-DEV, PowerGen, Virunga, Sida, GiZ, Ministry of Energy); minigrid developers are dealing with segments of the population that need support in using enough energy to make demand sufficient for the private minigrid to be economically sustainable. All of these issues make for weary private investors due to the untested nature of private minigrids in Kenya. Additionally, more light is shed on challenges within the realm of funding for minigrids. PowerGen mentions that dealing with commercial financiers is difficult due to the relatively small investment sizes needed for minigrid projects; this is in-line with what CrossBoundary Energy (2019) and Malhorta et al (2017) have found in the minigrid context in developing countries. They mention the practice of aggregating or 'pooling' minigrid sites together to create a larger fundable entity. PowerGen also mentioned that they were working with this approach.

Applying an innovation systems framework to the barriers identified, it can be argued that the *Institutional* aspects are lacking in the minigrid sector. More closely examined, it seems that sector-specific institutions are lacking. I-DEV noted that there are many regulations that indirectly impact the minigrid sector. The uncertainty of grid extension proved to be a major barrier for the further development of private minigrids in the off-grid sector and was perceived as creating an uncertain investor climate. However, both the Ministry of Energy and GiZ mentioned that new regulations are in draft-mode that will evidently cover these issues. From a diffusion theory perspective, the main barrier to the diffusion of minigrids could be argued as being related to the social system. For example, the main issue is that both minigrid developers are struggling to find the appropriate method of serving a varying user base in differing local contexts; regulators are struggling to appropriately support a complex and heterogenous private sector. The communication aspect of diffusion may also be lacking, as it has been noted in literature (Schnitzer, 2014; Schäfer, 2011) that the transfer of experiences in the sub-Saharan context is lacking. This may also be true in the form of

complexity. PowerGen, I-DEV and GiZ mentioned that the process of dealing with the government is cumbersome and inefficient at times. There is some evidence of sector-specific regulatory committees set-up or in the process of being established, however, the way in which communication is being disseminated and shared seems to be a barrier. Likewise in the innovation systems lens, networks seem to be lacking in the form of partnerships and the sharing of commercialization-related information.

4.5 How could PPPs help in overcoming the barriers that off-grid minigrid developers face in Kenya?

Taking into account the PPP structures presented in RQ2 (see section 5.2), two different PPP schemes that are in practice in Kenya will be used for the basis of understanding how they are helping to overcome barriers and how they could be tailored to better fit the needs of private minigrid develoeprs.. If the pro-poor PPP principles in the government context (Perez-Ludena, 2009) are applied, regulations and subsidies are a part of the model. In the first model presented, the financing scheme is a results-based one, meaning the private firm must reach agreed upon results before receiving the publicly-funded grant from the GiZ. The second model seems to be a hybrid variant (see section 2.2.7) which combines aspects of cross-subsidization and tech improvement and market development. The key in this model is that risk is more effectively managed by the public sector, which Sadka (2006) argues is often the public sector's responsibility, due to the guaranteed revenue. This model takes into account several barriers found to be hindering diffusion of private minigrids. First, the business model issue of dealing with productive use and demand uncertainty is partly mitigated through this guaranteed revenue. Although the amount is not specified, this may at the very least buy private developers more time and freedom in testing productive use applications and other schemes to increase demand. The risk of grid extension would also be mitigated. Since the private sector would sign a PPA with the national utility, the minigrid would in theory be protected from an expansion of the grid for a specified time period. However, it is unclear as to how the process runs in reality and if the complexity and time consuming nature of dealing with the public sector is true also in the PPP context.

In the context of funding, PPPs seem to be able to better the investor climate substantially by mitigating many of the barriers hindering investment. However, the role of project finance explained by PowerGen (see section 5.1.3) does not seem to be taken into account in these models. Sovacool (2013) does mention that one pro-poor PPP model is a project finance variant– however, project finance is not clearly taken into account from the explanation of the two PPPs in findings in this study. Strengthening the network and actor environment of the minigrid sector in Kenya seems to be principal in supporting the private sector's off-grid minigrids. The two PPPs presented in this study may be a step in the right direction towards a better bond between the public and the private sector in the development goal of universal access to electricity by 2022 in Kenya. However, it should be mentioned that not all minigrid developers that participated in this study have engaged in PPPs and that some decided not to deal with the public sector due to the frustrating and complex process.

5 Conclusion

One of the UN's Sustainable Development Goals is to ensure universal access to clean and reliable electricity to all. Likewise, the Kenyan government has declared that they will aim to reach universal access by 2022. The current access to electricity rate in Kenya has improved drastically in the last 3 decades, mainly due to grid-extension projects that cover urban areas. A major challenge for Kenya to reach universal access is to electrify rural and off-grid areas, where extending the national grid is not viable due to large costs and the socioeconomics of rural Kenyan populations. A potential solution put forward in academic literature and in practice has been the use of renewable energy minigrids to create decentralized energy generation for areas not connected to the national grid. Minigrids have historically been implemented by the public sector in Kenya, however, the private minigrid sector has been expanding rapidly in the country. This thesis aimed to apply an innovation systems framework to discuss the barriers to diffusion of private minigrids in the country. Furthermore, it looked at the role that PPPs could have in overcoming identified barriers to the further development of private minigrids in the country.

A qualitative approach was used; semi-structured interviews were conducted with minigrid developers, regulators and financiers in Nairobi, Kenya during a 16-day study trip in April, 2019.

The findings of this report showed that business model complexity and uncertainty, regulatory concerns and access to financing were some of the most prevalent barriers to the further diffusion of the private minigrid sector in Kenya. It is argued and shown that several barriers can be potentially mitigated through the use of PPPs to support the private sector. One, PPPs can effectively manage business model complications such as the risk of low demand or regulatory uncertainty, from grid extension for example, through the use of PPAs. Additionally, PPPs can help in improving the investor climate so that more investment can flow into the sector. However, one barrier within funding, namely project finance (on commercial scales) was identified as being an important step in the continued commercialization of minigrids but not dealt with effectively in the PPP models mentioned in the findings of this report. Overall, due to improvements in renewable energy technology and falling per unit costs, the future of the private minigrid sector in Kenya will ultimately depend on the scale of support and involvement from the public sector. However, it is clear from this research that both private and public minigrids will play an important role in the country's path to universal electricity access by 2022.

5.1 Practical Implications

This study may shed light on the some of the current barriers that minigrid developers face. It could be especially relevant for anyone not familiar with the off-grid and minigrid sectors in Kenya as some major challenges, like stimulating productive use and demand, are presented. Additionally, regulators may find the perspective of the private sector useful, in regard to their cumbersome licensing and permitting process, for creating more flexible and adaptable regulatory committee and processes.

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6.1 Appendix A

Interview Questionnaire Sample Questions:

Financing-related Questions:

Can you briefly describe what your role is?

Do you invest in small-scale RE projects? What type of projects and can you elaborate on what type of financing you offer?

What is the motivation for (INSERT COMPANY NAME) behind investments being made into RE projects in Kenya? Are they purely financial?

How many small-scale RE projects has (INSERT COMPANY NA ME) been involved with in Kenya?

What are some of the investment criteria that need to be fulfilled in order to invest into a RE project?

What are some of the major risks associated with investing in mini-grids?

Differences between investing in on and off-grid projects?

What novel approaches to investment are you taking to invest into mini-grids?

PPP Focus:

Do you ever partner with the government in mini-grid projects? What role does the public sector usually play?

How has the regulatory environment in Kenya impacted investment into RE/mini-grid projects?

Does the Kenyan public-sector have specific guidelines in place for mini-grid development/cooperation?

How do you experience the support from the public-sector in regard to mini-grid projects?

What are the main barriers to investment from the private sector?

Regarding the role of subsidies; what can be improved?

What agencies are in charge of supporting off-grid projects? REA, ministry of energy?

What needs to change in order for more private sector actors to mobilize capital in Kenya? (in regard to mini-grid projects)

How has the regulatory environment in Kenya impacted investment into RE/mini-grid projects?

Does the Kenyan public-sector have specific guidelines in place for mini-grid development/cooperation?

How do you experience the support from the public-sector in regard to mini-grid projects?

What are the main barriers to investment from the private sector?

Regarding the role of subsidies; what can be improved?

What agencies are in charge of supporting off-grid projects? REA, ministry of energy?