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Market Analysis: Real-time Monitoring, Control and Payment Technologies for Mini-grids in Kenya and Rwanda

Introduction

An estimated 1.6 billion people worldwide do not have access to electricity. This is manifested in Kenya by a low access rate of around 40%[1], the majority of which resides in cities and urban areas. Less than 20% of the households in rural areas are connected to the national power grid. In Rwanda, a similar scenario is depicted but with a much lower national access rate of 18%[2]. When disaggregated, rural access is found to be only 8%.

Given that in either country existing power generation infrastructure is not able to keep pace with growing power demand, interest in decentralised or off-grid energy generation has grown over the last twenty years as the practical and affordable option for increasing rural energy access in many contexts. Subsequently, mini-grids are playing an important role in both Kenya and Rwanda to accelerate electricity access to the populations not served by the centralised supply.

While much technological advancement has been made to make mini-grid technologies more viable, there still remain a number of challenges which must be overcome before mini-grid coverage can expand by the degree required to deliver universal electricity access. Key among these challenges is the recovery of capital investment, or in some cases even coverage of operational costs. Given that cost recovery is mostly achieved via the tariffs and charges consumers pay for their electricity, high rates of customer default can ultimately make investment in mini-grids unattractive. At present, payment collection is almost always done manually and mechanisms to discourage default are slow-acting and often ineffective. This is the reason why automated monitoring, control and payment can have strong positive effects on mini-grid financial viability by improving the grid operator's capability to recover the invested capital and generate profit.

Although far from widespread in either country, Kenya contains a greater number of examples of the application of "smart-grid" technologies and is the home of, or a focal location for, several pioneering enterprises that are innovating and developing these technologies. In contrast, Rwanda has yet to pick up on integration of smart grid technology to energy systems.

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[1] According to the National Energy and Petroleum Policy 2015, in June 2014 only 32 % of the population had access to electricity.
[2] World Bank Meta Data Based on Rwanda's 2012 census

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This report introduces the current market size for mini-grid monitoring, control and payment technologies in each country, considers market segmentation with respect to ownership/operating models, and discusses the likely expansion of the markets as East Africa moves towards a position of universal electricity access. It goes on to explore "customer" perceptions of smart-grid technologies, for both mini-grid operators and electricity end users, and the emerging trend of integrating mini-grid revenue collection systems with mobile money.

Current market size and segmentation

This report assumes that the number, scale and specific characteristics of mini-grids operating in a particular country dictates the current market size and segmentation for smart grid technologies. However, it must be noted that automated monitoring, control and payment can also be beneficially deployed on grid connections and distribution systems. In Kenya, pre-payment meters for grid connections have been used since 2009, though these devices are not connected to central data collection or control systems. Data-connected smart meters are currently being deployed for large electricity customers only. In Rwanda, pre-payment meters are also increasingly becoming the norm, but as in Kenya smart meters are being deployed only tentatively in small numbers.

Subsequently, the following section analyses market size and segmentation in terms of the size of the mini-grid sector both in Kenya and Rwanda.

Kenya

In Kenya the mini-grid landscape is characterized by three distinct ownership/operating models[3]:

- Community owned mini-grids
- Public mini-grids – these are developed by the Rural Electrification Authority (REA) and/or Kenya Power and Lighting Company (KPLC), and subsequently KPLC operates the systems on exclusive concessions, charging mini-grid customers uniform national tariffs in line with grid customers
- Private mini-grid concessions, operated by investors and Non-governmental institutions such as NGOs

In their analysis, Economic Consulting Associates find that in all of Kenya's community owned mini-grids, the community is responsible for the operation and maintenance of the whole system, from generation to transmission and collection of dues. In general, the communities have management committees comprising of a chairman, vice chairman, a treasurer and a manager responsible for technical operation of the whole system. Further, payment collection is face-to-face whereby member(s) of the committee move from house to house collecting payments. Collecting revenue this way presents challenges owing to high rates of default. Therefore there is good potential for the application of remote monitoring, control and payment technologies for community owned mini-grids in Kenya though important barriers exist related to skills and capacity as well as the cost of the technology.

[3] Study by Economic Consulting Associates (ECA) titled *"Project Design Study on the Renewable Energy Development for Off-Grid Power Supply in Rural Regions of Kenya".*

Publicly owned mini-grids are operated by the electricity distribution company; *Kenya Power*, which is also responsible for managing the national grid. Currently the number of state-owned mini-grids stands at 22. In all these public mini-grids, payment is done through one of two models. The first one is post-paid where *Kenya Power* technicians visit customers' premises occasionally to record meter readings, after which *Kenya Power* sends a bill to the consumer. The second model is through a pre-paid meter billing system where the customer pays before consumption through platforms such as *M-PESA* (mobile money), and tokens purchased from vendors. Currently *Kenya Power* is responsible for the collection of revenues, as well as monitoring and control of these public mini-grids. Nonetheless, in the recent past, the media has reported of plans by *Kenya Power* to outsource these functions. It remains unclear on whether the outsourcing will happen, but in the event it does, then it represents a market potential for smart grid technologies that incorporate additional monitoring and control functions.

Private mini grid concessions are owned and operated by Private Sector Investors and Non-Governmental Associations. Each grid operator has customised systems for monitoring, controlling consumption and collecting revenues. The systems deployed by private grid operators range from the rudimental to sophisticated and "smart" technologies able to carry out monitoring, control and payment functions automatically. *GIZ,* a development agency, has deployed such "smart" technologies on some of the solar PV mini-grids it has set up in Kenya. Overall, there is market potential for smart grid technologies for grid operators that are still relying on rudimental methods of remote monitoring, control and billing.

Rwanda

As of 2014, off grid electricity generation (including powering mini-grids) accounted for 1% of the total electricity generation mix in Rwanda. Ownership models of Rwandan mini-grids include:

- Privately owned plants where the owner of the plant the owner of the plant is fully responsible for the operation and maintenance (O&M) as well as any emergency repairs.
- Community run plants – where the community is responsible for the operation and maintenance of the whole system, and are generally characterized by poor performance and reliability problems.

Currently Rwanda has 9 off-grid micro-hydro power plants (>10kW) which provide a total capacity of 1,740 kW (refer to Table 1 below). Most of these were originally developed by the Government but later handed over to local administrations for management and operation. In response to challenges related to the management of the schemes, several sites have been leased out to private developers as of 2015.

Table 1: Existing Off-grid hydropower plants (Source REG/MININFRA)

Site Name	Installed capacity (MW)	Year of commissioning	Operating Company
Nyamyotsi I	0.1	2007	Energicogel & Adre HydroPower
Nyamyotsi II	0.2	2011	Energicogel & Adre HydroPower
Agatobwe	0.2	2010	Carera-Ederer & Tiger
Mutobo	0.2	2009	REPRO Ltd
Rushaki	0.04	2011	Public (GoR)
Nyabahanga	0.2	2012	Public (GoR)
Janja	0.2	2012	Rwanda Energy UK Ltd & Africa Energy Services Group Ltd
Gashashi	0.2	2013	Prime Energy Ltd
Nyirabuhombohombo	0.5	2013	Rwanda Energy UK Ltd & Africa Energy Services Group Ltd
Total	**1.74**		

However there are also a number of isolated pico-hydro power plants in the range of 1-10 kW which are either public owned and run by the local communities, or entirely private. None of these mini-grids are known to make use of smart monitoring, control and payment technologies.

The above list is not exhaustive, but it provides an initial list of potential grids that could make use of smart-technologies to improve monitoring, control and collection. Through its contribution to the ESCoBox research project, Practical Action Consulting (PAC) carried out pilot test of an automated monitoring and control system on a small-scale mini-grid in Rwanda. A "BitHarvester" system manufactured by SteamaCo (http://steama.co/) was installed on a pico-hydro system located in *Ngororero*. From this pilot test, it was concluded that the functions of remote monitoring, billing and control are highly beneficial to mini-grids' success and sustainability.

Market growth outlook

The World Bank notes that localised electricity networks (mini-grids) offer a faster solution for connecting millions of people to modern energy services than grid extension[4], and as such many countries with large electricity access deficits and dispersed populations are looking to mini-grids to provide significant proportions of the populations with electricity access.

The Kenyan government has shown a high degree of engagement with the SE4All initiative, having finalized its Action Agenda and Investment Prospectus in 2015 and early 2016. Exceeding the ambitions of the SE4ALL goals and SDG7, a national target is in place to achieve 100% electricity access by 2022 in both urban and rural areas through a mix of on-grid and off-grid solutions. . A report commissioned by DFID written by consulting firm IED estimates that about 23% of the population would be most economically served by mini-

[4] World Bank web article, 7th July 2016, "Mini Grids: Bringing Low-Cost, Timely Electricity to the Rural Poor". http://www.worldbank.org/en/news/feature/2016/07/07/mini-grids-bringing-low-cost-timely-electricity-to-the-rural-poor

grids, indicating a significant potential for mini-grids in Kenya. A similar, geospatial electrification planning study is currently being undertaken by the Ministry of Energy and Petroleum (MoEP). Their results, expected in Q4 2016, will provide an updated view on the potential of mini-grids. The Kenya SE4ALL Action Agenda identifies as one of the priority actions the need for the development of a mini-grid policy and programme[5]. Several programmes are on the horizon that promise to radically increase the number of mini-grids operating in Kenya: the UK aid-funded "Green Mini-grids" programme is expected to support private investment in the installation and operation of over 110 renewably-powered mini-grids[6]; Enel Green Power and Powerhive expect build and operate mini-grids in 100 villages with an investment of 12 million US dollars[7]; the SREP (Climate Investment Funds) Investment Plan for Kenya outlines the intention to hybridise (with renewable energy) several existing plus 27 new state-owned mini-grids, and implement new renewable energy-based mini-grids, with a budget of some $68 million[8].

Rwanda is some way behind Kenya with the SEforALL process, although the degree of engagement is nevertheless encouraging. The Rwandan government finalised its Action Agenda in 2015 and its Investment Prospectus is currently under development. A national target is in place to achieve 100% electricity access by 2030 in both urban and rural areas through a mix of on-grid and off-grid solutions, and this target is linked to the multi-tier framework: the country aims to progress to higher quality and quantity of electricity over time, with >50% of the population having tier 3-5 access by 2030.

Rwanda's Action Agenda includes the target of 537,000 households accessing electricity through off-grid systems (mini-grids plus SHS) by 2018, up from 24,000 in 2015.[9] A proportion of these new mini-grid connections (at least 145,000) will be funded through the African Development Bank-hosted Sustainable Energy Fund for Africa (SEFA), which awarded an $840,000 grant to the government of Rwanda in early 2016.

Consumer perceptions

Successful integration of smart grid technologies requires appropriate inclusion of consumers and the community at large. This is especially the case when incorporating a smart grid technology into an existing off-grid electricity system requires consumers to change behaviour patterns. More often than not, this scenario presents the greatest hurdle in the successful adoption of the smart grid technology and rejection of smart technologies often stems from perceived negative implications of the technology.

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[5] Sustainable Energy for All (SE4ALL), Kenya Action Agenda, January 2016 and http://www-cif.climateinvestmentfunds.org/sites/default/files/events/kenya-action-learning/Mini-Grid-in-Host-Country.pdf

[6] https://devtracker.dfid.gov.uk/projects/GB-1-203990

[7] http://www.powerhive.com/investment-in-renewable-mini-grids-marks-major-milestone-for-energy-access-low-carbon-development-in-east-africa/

[8] http://www.renewableenergy.go.ke/downloads/policy-docs/Updated_SREP_Draft_Investment_Plan_May_2011.pdf

[9] http://www.se4allforum.org/sites/default/files/SE4All%20Country%20Action%20in%20Africa%20-%20Rwanda.pdf

In both Kenya and Rwanda, informal discussions with a selection of mini-grid operators have indicated that those firms and organisations are receptive to smart-grid technology, since it presents an opportunity for improving efficiency, cost/investment recovery and plant reliability. On the other hand, end-user (domestic or small enterprise electricity consumer) reception depends largely on the developer's prior engagement and communication efforts with regards to the intentions behind the incorporation of smart technologies into the grid.

Emerging trends

Mobile Money and SMS activation

The integration of mobile payment platforms with smart grid technologies is allowing the sale of electricity under tariffs related to actual consumption where previously administration and technology costs prohibited this. It is allowing consumers greater control over their electricity bills and suppliers to benefit from more efficient collection of payments.

In Kenya, the heavy penetration of cellular networks and the widespread adoption of mobile money platforms have in many cases enabled the adoption of cashless energy service payments through smart grid technologies. Alternative business models make use of mobile phone communications without relying on mobile money, using the mobile phone as a way of securely linking the customer's cash payment to their own electricity supply (often via scratch cards which are validated by the user sending an SMS containing the number on the card to the server of the energy service company). Once the mobile money payment or scratch card code is received, the electricity supply is either remotely activated or the user receives a pass code to enter into the household energy system which allows it to operate for a period of time. Both these systems allow consumers to pay only what they can afford with much ease.

In Rwanda the use of mobile money platforms has not yet been picked up at any significant scale, although it has already been piloted by various mobile service providers. This means that in Rwanda, energy service companies wanting to use smarter systems for revenue collection mostly resort to the scratch card "village model", enlisting agents in each village to electricity tokens in the form of a scratch card with the code.

Market players

The following is a list of some of the market players in the smart mini-grid space in East Africa:

Rwanda: Mobisol, Angaza, Azuri Technologies Ltd.

Kenya: M-Kopa, PowerHive Ltd, SteamaCo

Tanzania: Off-grid Electric, Devergy Ltd.

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Take Practical Action. Work with us.

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