

How Are Innovative Financing Approaches Contributing to Wider Electricity Access in Kenya?

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Rim Berahab

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Policy Center for the New South

Suncity Complex, Building C, Av. Addolb, Albortokal Street, Hay Riad, Rabat, Morocco.

Email : contact@policycenter.ma

Phone : +212 5 37 54 04 04 / Fax : +212 5 37 71 31 54

Website : www.policycenter.ma

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Rim Berahab

About the Author, Rim Berahab

Rim Berahab is an economist at the Policy Center for the New South, a think tank based in Rabat that she joined in 2014. She is currently working on themes related to energy issues and their impacts on economic growth and long-term development. Her research areas also cover trade and regional integration challenges in Africa. Previously, she has also worked on questions related to gender inequalities in the labor market of North African countries. Rim spent three months at the International Monetary Fund (IMF), in 2016, in the Commodities Unit of the Research Department. She holds a State Engineering degree from the National Institute of Statistics and Applied Economics (INSEA).

Abstract

Digital technological innovation, combined with new financing approaches, can make a significant contribution in the field of access to energy. This is the case in Kenya, where pay-as-you-go solutions, combined with solar home systems and an extensive mobile network, have enabled thousands of Kenyans to access clean and affordable off-grid electricity. This policy paper identifies the drivers of the development of pay-as-you-go solutions in off-grid systems in Kenya, assesses their successes and shortcomings based on two case studies, and develops a set of recommendations to better capitalize on the various opportunities and avoid the potential risks related to the emergence of off-grid pay-as-you-go solutions in developing countries.

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Introduction

Affordability has always been one of the main barriers to access to electricity, especially for households living in rural and remote areas where electricity supply is more expensive. For a large part of the off-grid population, connection to the grid is the best option to reduce energy poverty, because the grid theoretically provides the most electricity at the most affordable price. However, this is not always the case. Grid connection is only cost-effective if it is built to serve densely-populated areas. This implies that large centralized networks are mainly located around major urban centers, thus excluding large sections of the population living in inaccessible rural areas (Berahab, 2019). Moreover, in some countries in sub-Saharan Africa, electricity supplied via the main grid remains expensive, contrary to what one might think. In this context, decentralized power systems, such as off-grid systems, are attracting a great deal of interest, not as substitutes for the main grid, but rather as complements to it. According to geospatial analysts, the most cost-effective way to fully access electricity and meet the demand of newly-connected households is to deploy decentralized off-grid solutions, such as mini-grids or stand-alone systems, while also extending the main grid (IEA, 2019). Consequently, and given the high initial costs for the poorest households, off-grid solar energy providers have adopted a new business model based on a pay-as-you-go (PAYG) approach, to make solar panels affordable for the targeted population.

Combined with solar home systems (SHSs), this new and innovative financing approach has helped, to some extent, to address the challenge of reducing energy poverty, thus reaching thousands of people without such access in Kenya¹. One of the main factors making this possible is the high coverage of mobile phones, which has enabled interactions between end-users, electricity providers, and payment platforms. In addition, mobile services have enabled access to energy for very poor, unbanked, and underbanked people with no credit history and no other means of accessing finance (GSMA, 2015). Section 1 of this policy paper provides a brief overview of the Kenyan energy sector to contextualize the challenge. Section 2 discusses the concept of the PAYG model and the role played by digital technology. Section 3 analyses the main drivers of PAYG development in Kenya. Section 4 sets out two case studies. An assessment of the benefits and risks of the PAYG model in Kenya is carried out in section 5. Section 6 concludes with a series of recommendations.

I. Overview of Kenya's Energy Sector²

Kenya is endowed with significant renewable energy resources. Its total final consumption (TFC) of energy is dominated by biomass, in the form of wood fuel and charcoal, which is mainly used for cooking and heating in rural and urban middle and low-income communities (Figure 1, panel A). Biomass accounted for 68% of TFC in 2017, followed by imported oil (25%), electricity (4%) and other sources, such as wind and solar (<1%). Kenya's electricity production has historically been based on

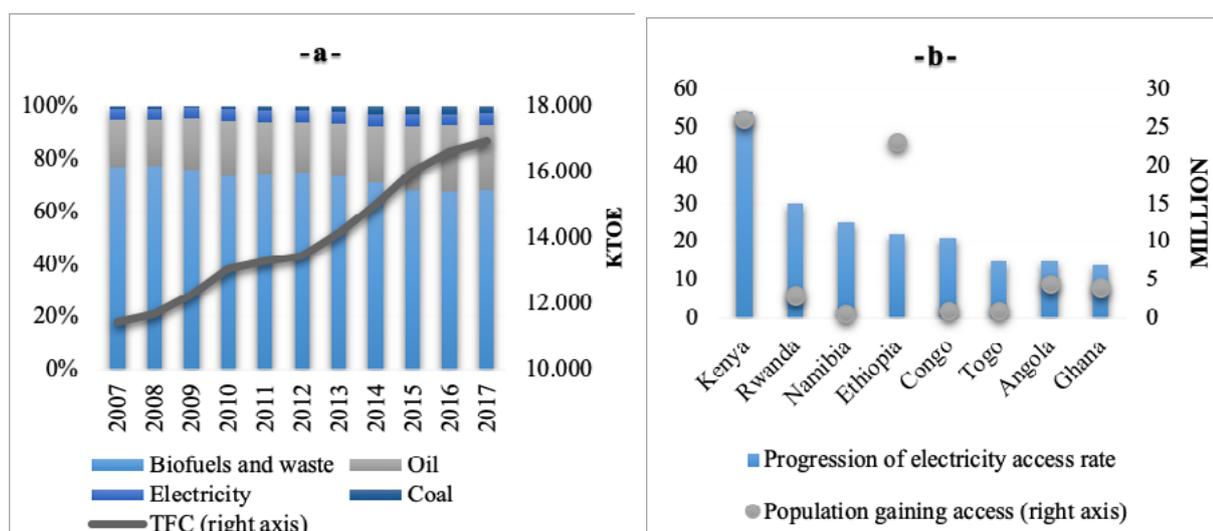
1 According to the IEA's 2019 World Energy Outlook, "Almost five million people gained access to electricity through solar home systems in sub-Saharan Africa in 2018. Many of these bought through the pay-as-you-go (PAYG) method".

2 Unless mentioned otherwise, data in this section is extracted from the IEA Database.

hydropower, which accounted for 31% of total electricity generation in 2017. However, in the past two decades, the share of geothermal energy in electricity production has increased significantly, reaching a share of 47% in 2017 and registering an average annual growth of 15% between 2000 and 2017. Kenya is home to the Great Rift Valley in the west of the country, which offers an ideal geological environment, with an estimated geothermal potential of 10,000 megawatts. In addition to hydro and geothermal, fossil fuel, mainly liquid hydrocarbons, complete the electricity mix and, during droughts, make up for the shortfall in hydropower production. Overall, in 2017, 80% of electricity generation was renewable, placing Kenya among the 20 most efficient countries in the planet for this indicator.

As for the energy regulatory framework, Kenya embarked on fundamental liberalization reforms in the mid-1990s. The Electric Power Act of 1997, the Sessional Paper No. 4 of 2004, and the Energy Act of 2006, all laid foundations for the separation, or unbundling, of generation from transmission and distribution in the electricity sector. The Kenyan electricity sector is thus now organized around the three major public companies that emerged from this unbundling: Kenya Electricity Generating Company (KenGen), Kenya Electricity Transmission Company (KETRACO), and Kenya Power Lighting Company (KPLC). Electricity generation is split between KenGen and Independent Power Producers (IPPs), which accounted roughly for 75% and 23% of electricity generation respectively in 2018, while the remaining 2% was acquired via imports (KPLC, 2019). KETRACO was created to develop new high-voltage electricity transmission infrastructures and to facilitate funding by donors and government through concessionary finance, whereas KPLC retained responsibility for operating the grid, carrying out distribution and managing old transmission infrastructures. It should be noted that the two dominant players in Kenya’s energy sector, KenGen and KPLC, are state-owned but with significant private shareholding (Eberhard et al, 2018). The sector has been through further changes since 2006 with the enactment of the Energy Act of 2019, which pursued the transformation of Kenya’s electricity sector’s framework.

Figure 1 : Total final consumption (TFC) by source, Kenya 2000-2017 (a) and Electrification Progress in Key African Countries, 2013-2018 (b)



Source: IEA.

In terms of electricity access, Kenya has been among the best-performing countries in sub-Saharan Africa in recent years (Figure 1 panel B). Electricity access in Kenya jumped from a mere 8% in the early 2000s to 75% in 2018. This progress is attributable to a combination of factors, namely: i) increased efforts in terms of grid connection through the Last Mile Connectivity Project; ii) the development of decentralized systems for electricity generation thanks to continuous support from government via the adoption of the Kenyan National Electrification Strategy (KNES) in 2018; iii) the development of a mature mobile-payment infrastructure, enabling innovative business models and payment mechanisms to emerge, which has been critical to the development of off-grid initiatives such as solar home systems (SHS) in Kenya. Despite these significant improvements however, further efforts are needed to reach universal access to electricity, which is still impeded by high energy costs. Another issue is the weak power transmission and distribution infrastructure arising from limited investment in power system upgrades, resulting in high electric power system losses and intermittent power outages (IEA, 2015).

In an attempt to tackle these issues, Kenya has sought to explore the off-grid approach, in parallel with grid extension, in order to connect the most remote areas to electricity. Off-grid technology is well-developed in Kenya, which is ranked 8th worldwide in terms of off-grid solar supply and 2nd in terms of the highest share of solar lighting systems (IEA, IRENA, UNSD, WB, WHO, 2019). The remainder of this policy paper will therefore address the impact of information and communication technologies (ICT) on the energy sector, focusing in particular on innovative consumer financing approaches, such as pay-as-you-go solutions, and their role in improving access to electricity in rural areas in Kenya.

II. The Pay-As-You-Go Model as a Basis for Widespread Access to Electricity

The pay-as-you-go (PAYG) approach has emerged as one of the effective commercially viable models for addressing the increasing energy demand of rural households through innovative consumer financing. It targets areas covered by mobile networks but not electricity grids to provide, at an initial stage, basic low-cost energy solutions, before gradually moving to medium or large-scale power appliance services³. Simply put, the concept of the PAYG model is to enable communication between the consumer, the payment platform and the electricity supplier. More concretely, the PAYG model relies on the use of Global System for Mobile (GSM) or Machine-to-Machine (M2M) technologies⁴ in combination with mobile money software platforms to remotely monitor a solar system (Sanyal, 2017). Specifically, the GSM chips and software installed by the producer on the integrated circuit board of the solar device allow communication, monitoring and execution of certain operations by automated remote controllers. Devices equipped with integrated M2M modules can thus receive proof of payment via the mobile network to unlock the service, allowing electricity to flow from the battery to the devices (USAID, 2018). This technology also allows data on product performance and customer usage to be sent to the provider via the mobile data network.

³ Basic SHS under PAYG schemes offer basic access to electricity used mainly for lighting and charging phones, while large SHS offer higher access to medium and large power appliances like TV, refrigerators and radios.

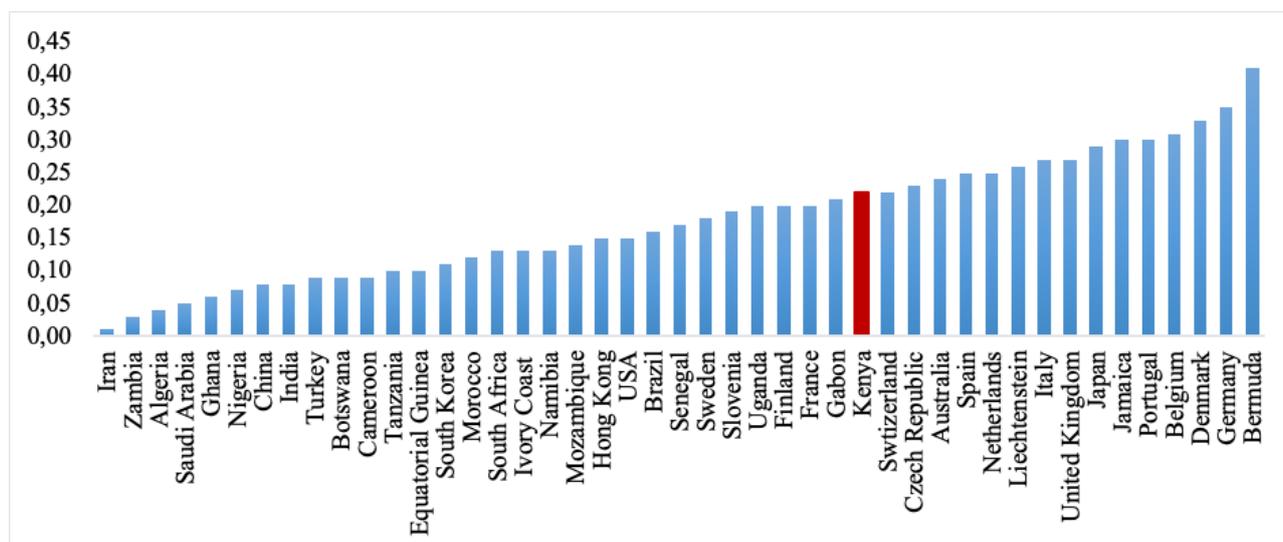
⁴ According to IBM, Machine to Machine (M2M) describes “the interaction of billions of devices and machines that are connected to the internet and to each other. These physical objects integrate computing capabilities that enable them to capture data about the world around them and share this with other connected devices, creating an intelligent network of ‘things’ or systems. This means that machines can communicate and share information without the need for human interaction”.

Paired with PAYG, solar home systems (SHS) mark a considerable breakthrough among off-grid solutions, often replacing kerosene and diesel. Solar firms rent to end-users SHSs that include a solar PV panel, a charge controller, a battery, a mobile charger, and LED lightbulbs. Basic SHSs are used mainly for lighting and charging phones, whereas large SHSs are used to run appliances such as televisions and radios. On average, these systems provide customers with Tier 1 and Tier 2 basic energy access (GSMA, 2016a and 2016b)⁵. Payment schemes for SHSs can be divided into two main business models. The first is a “rent-to-own” model, where consumers can use their phones to pay an up-front fixed amount for an SHS, and then pay for the rest of it in affordable instalments, resulting in the end-user becoming the owner of the SHS once the full payment is made. The second is the “solar-as-a-service” model, where consumers pay a regular fee for the energy service, but never actually own the SHS. The emergence and development of PAYG models, for SHSs, in Kenya has been remarkable, thanks to a combination of factors that will be detailed in the next section. At time of writing, there are four main solar firms providing PAYG payment plans for SHS customers in Kenya: M-KOPA, BBOX, Azuri Technologies, and Mobisol.

III. Key Drivers for PAYG Development in Kenya

The development of PAYG SHS solutions in Kenya would not have been possible without certain pre-existing conditions. The main initial driver for the development of alternative solutions such as PAYG SHSs is the high cost of electricity, which is one of the biggest bottlenecks to economic activity in the country. Historically, grid connection in Kenya costs around \$350. In 2015, the connection cost was reduced to \$150. However, it provided limited traction for grid connection in rural areas, since this subsidized rate applies only to customers within a 600-meter radius of a transformer. As a result, grid extension remained slow (David and Otuki, 2017). Moreover, even when connection to the grid is established, the monthly cost of electricity remains high. Available data show that in 2019, the cost of electricity for households in Kenya was around \$0.22/kWh, which is almost twice that of South Africa and is in the same range as France and Switzerland (Figure 2). As a result, expensive grid connection and high electricity costs, poor grid network, and the absence of kerosene subsidies made PAYG SHSs attractive for rural consumers in Kenya (Okulu, 2016) and created market conditions allowing their wide penetration throughout the country. Indeed, Kenya accounted for 43% of the volume of PAYG SHSs sold globally and 38% of the value of PAYG SHSs sold globally in 2019 (GOGLA, 2019) (Table 1).

⁵ A widely used method to evaluate progress toward energy access goals is the World’s Bank Multi-Tier framework (MTF). The MTF ranges from Tier 0, meaning no access, to Tier 5, referring to highest access. According to the International Energy Agency, a household is considered as electrified with a minimum of Tier 2.

Figure 2: Electricity Prices for Households, Selected Countries, June 2019 (kWh/USD\$)

Source: GlobalPetrolPrices.com.

Table 1: Top 10 Country Markets by Volume and Value of PAYG Sold (SHS, portable lanterns, multi-light systems)

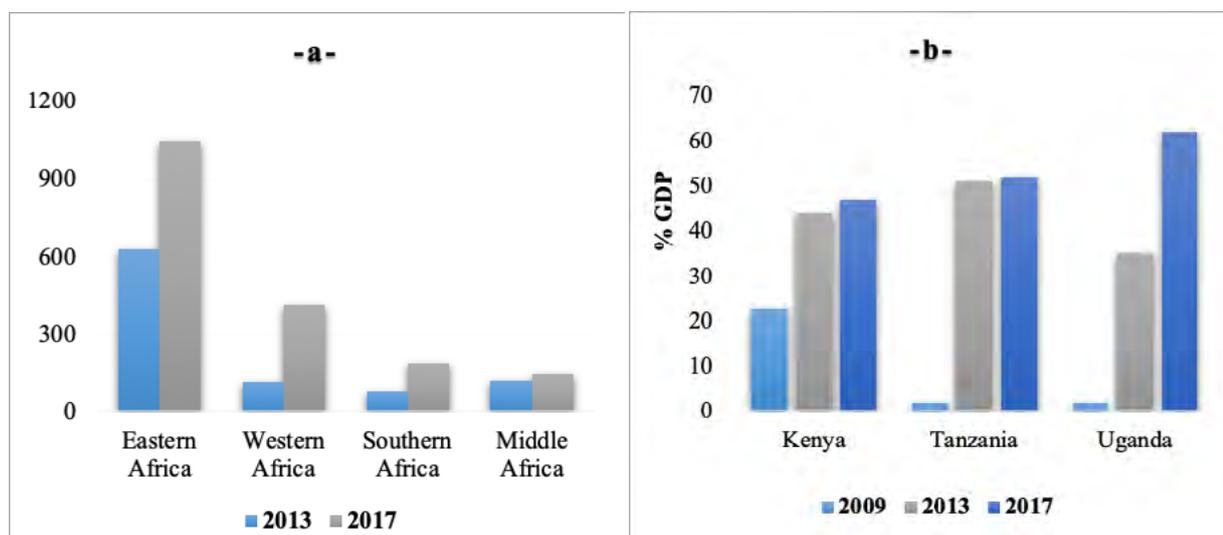
Country Name	Volume of product sold	Global volume share	Value of products sold	Global value share	Newly installed capacity (MW)	Global newly installed capacity share
Kenya	434 524	43%	\$82 572 791	38%	7.83	31%
Uganda	115 969	12%	\$20 267 981	9%	2.12	8%
Rwanda	62 096	6%	\$17 402 231	8%	1.78	7%
Zambia	51 994	5%	\$10 040 278	5%	0.82	3%
Nigeria	46 779	5%	\$5 801 480	3%	2.15	8%
Ethiopia	42 181	4%	\$3 595 846	2%	0.83	3%
Côte d'Ivoire	27 682	3%	\$10 639 049	5%	1.38	5%
Tanzania	25 676	3%	\$10 859 200	5%	1.73	7%
Togo	24 153	2%	\$12 310 423	6%	1.21	5%
Myanmar	16 278	2%	\$2 252 264	1%	0.21	1%

Source: GOGLA, 2019.

Further features can be identified as key drivers for the wider implementation of PAYG SHS solutions in rural Kenya. A high rate of mobile money adoption has contributed significantly to the growth of mobile money banking in the region, or mobile money for short (Figure 3 panel A). By the end of 2018, nearly 395.7 million registered mobile money accounts had been opened in sub-Saharan Africa, representing nearly half of the total mobile money accounts worldwide. East Africa alone accounted for 54% of the total mobile money accounts registered in sub-Saharan Africa in 2018 (GSMA, 2019). In Kenya in particular, the creation of mobile money accounts increased by an average of 12% annually between 2010 and 2017, while the value of mobile money transactions as a percentage of GDP increased from 23% in 2009 to 47% in 2017. Kenya was well positioned to adopt this new approach to traditional banking because a large part of its population was unbanked or had limited access to mainstream financial institutions.

In addition, mobile money has helped unlock new types of energy services. Mobile payment technology has enabled PAYG service providers to remotely collect revenue from customers, thereby reducing operating costs and financial losses associated with collecting cash payments. Moreover, providing end-users with options to pay via frequent, flexible, and incremental payment alternatives carried out on daily, weekly, or monthly basis has acted as risk mitigation for PAYG SHS operators. Services can be automatically discontinued at the end of a specific term or in case of non-payment. Conversely, PAYG service providers are able to offer strategic gains to mobile operators, reflecting the many synergies between mobile cash banking and the solar PAYG business. The PAYG services industry can stimulate mobile money penetration and usage, increase brand loyalty, and thus contribute to increasing the revenues of mobile operators (GSMA, 2018a). Moreover, SHS quality standards have increased in terms of durability and reliability (Hystra, 2017), and also in terms of provision of customer services. This further instills trust in end-users regarding the quality of these products.

Figure 3: Registered Mobile Money Accounts by Selected African Regions, Number per 1,000 adults (a) and Value of Mobile Money Transactions as a Percentage of GDP in Pioneering Countries of East Africa (b)



Note: For Tanzania the latest data shown is for 2015. Source: Financial Access Survey and IMF staff calculations.

In addition, the growth of PAYG SHSs has been driven by the global decline in solar photovoltaic (PV) prices, technological advances, and market innovations (Hansen et al, 2015; Nygaard et al, 2018). Since 2014, the global weighted average levelised cost of electricity (LCOE)⁶ produced by solar PV has fallen into the range of fossil-fuel costs. In 2018, the LCOE for PV solar was estimated at \$0.085/kWh, which translated into a 77% cost decline during the period 2010-2018 (IRENA, 2019). Moreover, policy measures adopted in Kenya, such as import tax exemptions for solar-related products, low taxes on solar panels, and the absence of kerosene subsidies, have created a good environment for the development of a sustainable off-grid alternative system. This has provided important incentives for the development of PAYG solar enterprises and thus created a favorable environment for market expansion. PAYG solar companies in Kenya have also benefited from strong investor interest. They have successfully raised significant capital in the form of grants, used for developing and testing products and markets, and, more recently, in the form of equity capital. In 2015, PAYG solar companies were also able to raise debt for funding, on the strength of several previous equity rounds.

IV. The Cases of M-KOPA and BBOXX in Kenya

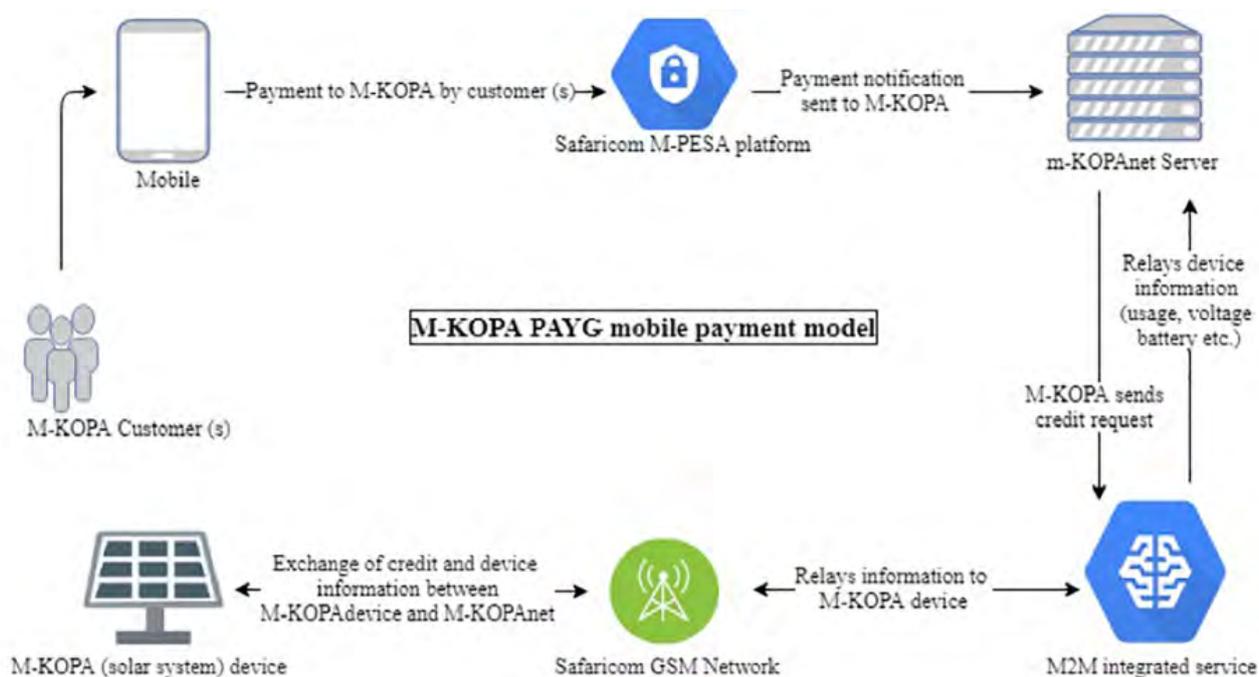
Growth in PAYG SHS sales in Kenya and on-going investment can also be attributed to the strong market activities of a small number of companies that focused on improving critical factors to promote the acceptance and expansion of PAYG SHS financing. The following section gives an overview of the business models of two of Kenya's main PAYG solar leaders, M-KOPA and BBOXX.

1. M-KOPA Solar

Established in Kenya in 2011, M-KOPA is the market leader in PAYG energy for off-grid customers. M-KOPA sells SHSs to non-electrified households on an affordable mobile payment plan for 12 months. The SHS provided by M-KOPA combine M2M technology with micro-payment solutions for non-electrified populations. It uses a patented technology platform (M-KOPAnet™) that combines integrated GSM technology for usage monitoring and metering with a prepaid mobile service to provide SHS financing (Figure 4). It also provides information on consumer behavior, which helps businesses to grow. The M-KOPAnet™ site operates through Safaricom's mobile phone banking and money transfer platform called M-PESA. M-KOPA operates in five African countries, three of which—Kenya, Tanzania and Uganda—are in East Africa. The company currently employs 855 people worldwide and has more than 2,100 direct sales representatives (DSRs) active throughout East Africa (M-KOPA Solar, 2019).

⁶ The LCOE is the full price of energy (electricity in most cases) over the lifetime of the equipment that produces it.

Figure 4: M-KOPA PAYG model



Source: Nique & Smertnik, 2015.

Under M-KOPA’s model, customers make an initial deposit of about of 3,500 Kenyan shillings (around \$33.50) then pay daily instalments of KES 50 (or about \$0.48) via a mobile money service (M-PESA), until the balance is paid off. This payment can be adapted to a daily, weekly, or monthly installment, allowing customers to adapt payments to their income. Once this repayment is complete, customers own the unit outright. M-KOPA Solar’s selling point lies in tiny daily repayments that are lower than the daily cost of kerosene. Given that the system can provide power for both lighting and phone charging, its cost compares favorably to the KES 50 that a typical Kenyan would spend on kerosene alone. The system also allows customers to buy units of credit for their lighting systems at any time, without formal collateral or credit history, as it saves households money that they would otherwise spend on kerosene. The project was initially piloted using grant funding that allowed M-KOPA to demonstrate the viability of its concept and develop its business model. After about a year and half, M-KOPA was able to scale up its project, and raised equity financing from impact venture capitalists. The project was later converted from a pilot into a commercial business. More recently, capital has come in form of debt financing to support M-KOPA’s further expansion, as the company is investing in research and development of their products and services.

2. BBOXX

In the wake of M-KOPA, and given that the market conditions for the development of PAYG models were well established, several competitors also entered Kenya, including the now well-established BBOXX. Founded in 2010, BBOXX’s initial business model was wholesaling SHSs to distributors. However, given the lack of upfront capital to purchase an SHS outright, it became clear in 2013 that the model would not scale up. This resulted in the transformation of the BBOXX business model by utilizing the PAYG approach. BBOXX now designs, manufactures, finances, and distributes SHSs,

mainly in Kenya and Rwanda. BBOXX systems can be paid for via a mobile PAYG scheme by customers in monthly instalments over three years (Table 2). The payment includes the price of the product and the ongoing maintenance costs. BBOXX prices its solar home systems to match the costs of alternative energy sources, spreading payments over time to widen its customer base, thus enabling various segments of the population to purchase clean renewable solar energy.

Table 2: Product Offerings Of The Two Market Leaders In Kenya

Company	Product	Payment terms	Total cost
M-KOPA	8W system (4 × 1W LED + torch + radio)	50 KES (US\$0.48) per day for 365 days 3,500 KES (US\$33.5) upfront deposit	21,750 KES (US\$208)
	15 W system (4 × 1W LED + radio)	950 KES per month (US\$9) for 36 months 950 KES (US\$9) upfront deposit	35,150 KES (US\$336)
BBOXX	50W system (4 × 1W LED + radio + 19*LED TV)	2,150 KES (US\$21) per month for 36 months 2,150 KES (US\$21) upfront deposit	79,550 KES (US\$761)

Source: WRI, 2016.

BBOXX developed its own solar kit called SMART Solar. It combines knowledge of small scale off-grid SHSs, Internet of Things (IoT)⁷ and Machine to Machine (M2M) technologies. SMART Solar kits have remote monitoring and control capabilities, similarly to M-KOPA. This enables an operator to monitor products remotely in order to disable them if customers' monthly payments are not made, and to detect any deliberate attempt to tamper with the devices. This reduces the risk for investors and provides an incentive for customers to make their monthly payments. SMART solar is also used to gather data on product performance and customer behavior. Information about customer usage and potential errors or improper use help BBOXX to extend the life of products and provide adequate customer service (Movellan, 2017). Customer data also helps to better understand this emerging and fast-paced market of off-grid solar energy. The track record of PAYG models in Kenya has allowed BBOXX, like M-KOPA, to continue to attract investment (Table 3). The flexibility of payment offered by both M-KOPA and BBOXX and the utilization of technology that disables the system in the event of nonpayment by the consumer, have made a previously unattainable cash purchase of an SHS affordable to thousands.

Table 3: Funding secured by M-KOPA and BBOXX

	Years	Amount (\$ unless otherwise noted)	Source
M-KOPA	2011	~ 1.9 million	Led by LGT Venture Philanthropy (LGTVP)
	2013	£ 350,000	GSMA grant
	2014	20 million	Debt financing syndicated by Commercial Bank of Africa
	2015	12.45 million	Led by LGTVP
		9 million	Led by Generation Investment Management

⁷ According to the International Telecommunication Union, the Internet of Things (IoT) is “a global infrastructure for the Information Society, providing advanced services by interconnecting objects (physical or virtual) using existing or evolving interoperable information and communication technologies”.

	2016	4 million	Impact debt issuance programme established in partnership with Liechtenstein banking group
		6.3 million	US Securities and Exchange Commission
	2017	80 million	Debt Financing: Stanbic Bank (\$9 million), CDC (\$20 million), FMO (\$13 million), Norfund (\$13 million) and \$25 million (from responsAbility, Symbiotics, and Triodos Investment Management)
BBOXX	2013	0.30 million	AECF REACT Round 2
		1.9 million	Synergy Growth and Khosla Impact
	2015	3 million	DOEN and Bamboo Finance
		15 million	Synergy Energy, Khosla Impact, MacKinnon Bennett & Company, DOEN, Bamboo Finance ENGIE, Ceniarth and Oikocredit
		17 million	Unknown
	2016	20 million	Engie, Kawisafi Ventures, Khosla Impact, MacKinnon Bennett & Company, DOEN and Bamboo Finance
		2 million	Banque Populaire du Rwanda
	2017	5 million	Essential Capital Consortium

Source: Sanyal et al, 2016, Crunchbase, 2017.

V. Evaluation of PAYG-Based SHSs Model in Kenya: Benefits and Risks

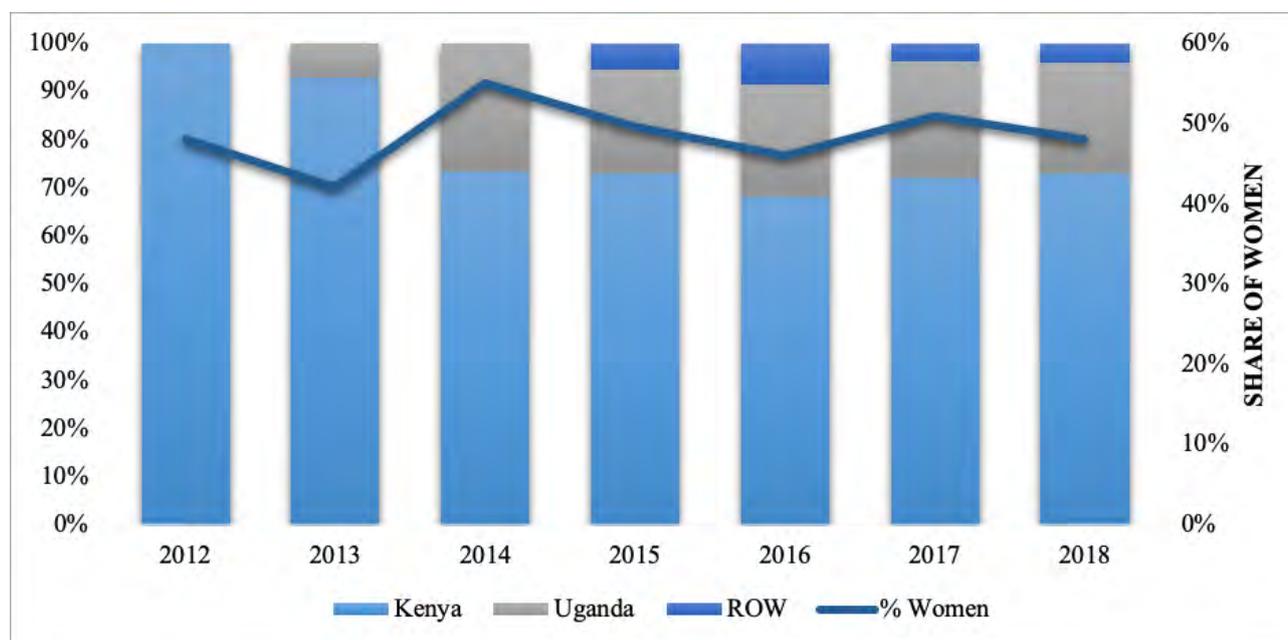
Based on the evidence discussed in sections III and IV, it appears that Kenya has become a mature market for PAYG SHS models. This is due to favorable policy conditions and the involvement of private enterprises, which have been innovative in terms of product development and have gradually adapted their business strategies. On the basis of the literature analyzing the successful experiences of PAYG start-ups and electrification programmes, several benefits, opportunities and risks can be identified for end-users and PAYG SHS companies.

1. Benefits and opportunities

The main benefit for end-users is affordability. In fact, the initial down-payment on a PAYG SHS reflects, to a large extent, the income of the targeted customers. Also, periodic payments are structured to be lower than or equal to the amount spent on alternative sources for the same level of energy service, which leads to increased savings otherwise spent on candles, kerosene, or batteries. It is believed that poor Kenyan households spend typically about KES 17,200 (US\$200) per year (Yadav et al, 2018), or the equivalent of 20% of their income (GSMA, 2013), on kerosene. In addition, the flexibility of the payment plan overcomes the issue of seasonal income, which is prevalent among off-grid households in sub-Saharan Africa. According to M-KOPA, nearly 71% of households save money by replacing kerosene and phone-charging expenditures with M-KOPA, around 25% of M-KOPA customers use available cash to purchase food and 24% dedicate it to children’s education (M-KOPA Solar, 2019).

Another crucial benefit of PAYG-based SHSs is economic inclusion by offering flexible and affordable credit. Lack of access to financial services continues to hamper development and economic inclusion. Low-income individuals still face major obstacles, such as lack of collateral, low financial literacy, and a history of borrowing, despite progress in the area of microfinance. PAYG asset-based financing helps off-grid consumers build credit histories and provides them with financing opportunities if payments are completed successfully. For instance, M-KOPA enabled over 450,000 low-income Kenyans to establish creditworthiness. Therefore, the PAYG approach represents a first step towards the financial inclusion of unbanked people, as it proves their ability to pay off a debt through regular payments. Other economic opportunities include new job opportunities and better productivity due to the extension of working hours. Indeed, compared to traditional cash sales models, the PAYG model requires more customer support, technicians and maintenance profiles, and sale representatives. The distribution of jobs created by M-KOPA shows that almost 73% are in Kenya and that almost half of the total jobs created are held by women (Figure 5). In addition, a briefing note by Vivid Economics and GOGLA estimated that current off-grid solar jobs in East Africa would rise from 77,000 to 350,000 in 2022 (Vivid Economics and GOGLA, 2018). Also, nearly 45% of households using an PAYG solar system in East Africa were able to support a business or income-generating activity, worked longer hours, or secured a new job thanks to the system.

Figure 5: Distribution of jobs created by M-KOPA by country



Source: M-KOPA Solar, 2019.

Moreover, newly acquired electricity delivered by SHS via a PAYG solution generates other social benefits, such as improved education thanks to extended study time during the evening, as well as improved health, safety, and security. According to a study performed by GOGLA in East Africa, 91% of households reported a health improvement after they replaced kerosene lanterns with PAYG SHSs (GOGLA, 2018c). According to the same study, up to 90% of households feel safer due to a reduction of in-house pollution, fire accidents, and injuries related to kerosene or candle burn, as well as a sense

of security thanks to external lights at night. Furthermore, SHSs supplied by PAYG providers also contribute to climate action through the use of efficient appliances and the adoption of the circular economy. These systems, particularly the large ones, aim to maximize electricity production in order to enable customers to benefit from modern energy services generated by renewable energy—solar in this case—thus helping to minimize, to some extent, carbon footprints. They also give a second life to returned, yet restorable, components through circular economy principles (M-KOPA Solar, 2018).

From a business perspective, one of the major opportunities of PAYG SHSs is the increased market potential. Roughly 600 million people don't have access to electricity in sub-Saharan Africa, and all are potential customers for off-grid solar companies. Secondly, an estimated 200-250 million people who currently experience unreliable supply may want to purchase an SHS as a backup system. This would lead to the unlocking of market potential in untapped countries. So far, only a few countries have a competitive PAYG off-grid market, namely Kenya, Tanzania and Uganda. The growing penetration of mobile money and recent improvements in connectivity are turning other nations into potential new markets to start new PAYG-based businesses, or to increase the number of PAYG platforms providers in countries where PAYG is already established. Moreover, PAYG business models have led to reduced default rates. As mentioned in the previous sections, PAYG platforms allow the enabling and disabling of SHS outputs based on repayments made to be automated. Such automation means a quicker response to payment delinquencies. This remote control capability has led to an 82% reduction in payment default rates in the case of BBOXX in Kenya, going from 11% to just 2%. It has increased payment efficiency, thus reducing late monthly payments by 45%. Also, PAYG reduces logistical problems and risks related to collecting and transporting cash in rural villages. Less cash circulating is reflected in fewer robberies from vulnerable field agents.

2. Risks and challenges

Despite their rapid success in Kenya and East Africa, PAYG companies still face a set of challenges. One of the main challenges in disseminating PAYG SHSs in Kenya is related to distribution and access to technical support (Silva, 2018). The availability of technical assistance close to end-users is crucial to ensure the smooth functioning of SHSs and thus increase consumer confidence in the products. However, the dispersed nature of end-users, especially in remote and hard-to-reach areas, prevents the establishment of well-structured distribution and technical-support centers. As a result, navigating rural terrain to reach customers can be costly for the agents and maintenance technicians who provide the services. Another challenge is the lack of digital literacy among residents and the lack of awareness and understanding of new technologies (Pueyo, 2013). These two factors, combined with the necessity of owning a mobile phone, which could be a problem in areas where mobile phone penetration is still low, may limit the market penetration of PAYG SHSs. The low customer base of M-KOPA, Azuri and Mobisol in relation to the total number of people without access to electricity in Kenya is evidence of this.

Moreover, the development of internal IoT solutions by PAYG companies can be a lengthy process and may not be viable for many small and medium-sized solar energy companies in particular. This may therefore cause them to lose competitive advantage over other suppliers, preventing them from pursuing market growth and undermining their efforts to reach more communities without electricity (Nique and Smertnik, 2015). In some countries, such as Kenya, there is indeed strong competition between different PAYG companies. While the larger PAYG players have access to the resources needed

to attract the attention of mobile phone operators and aggregators in these markets, smaller players struggle to integrate and fall below the threshold required to attract their attention. This ultimately leads to a less-diverse PAYG sector and limited end-user choice, along with increased costs for the emerging PAYG sector due to the presence of an aggregator (GSMA, 2018b).

Other challenges include the cost of data and services from local network providers, which are necessary for these technologies to function properly, and the reliability of networks for remote monitoring and mobile-payment applications. Systems that rely heavily on communication uptime for service provision may face considerable challenges because of the unreliability of GSM networks, which in turn may hamper the growth and scalability of these solutions (Nique and Arab, 2013). In addition, changes to mobile money regulations might delay further development as «regulatory progress to support the digital financial services (DFS) market remains stalled, and off-grid PAYG solar companies struggle to innovate in order to survive in the midst of a highly fragmented network of DFS providers» (USAID, 2018).

VI. Lessons and Recommendations

SHSs have become the most widely used technology with PAYG financing, making them increasingly competitive with diesel and kerosene. While the high upfront costs of SHSs have traditionally been a significant barrier to their widespread deployment, the PAYG approach has helped reduce these costs by offering flexible payment plans for energy. This flexibility is important for low-income households, as they generally have discontinuous incomes. The case of Kenya provides an interesting and relevant insight into the impact of new financial approaches, such as PAYG, on access to off-grid electricity in remote areas. Several conclusions can be drawn to serve as a basis for recommendations to Kenya to increase its market base, and to other countries that seek to explore this alternative:

First, mobile services play a crucial role in generalizing the use of the PAYG SHSs. It is therefore of paramount importance to insure sufficient mobile network coverage. The example of Kenya is compelling in the sense that mobile services have affected electricity access in three ways. First, the digitalization of financial services through mobile-based payments has served as a financial gateway for unbanked customers, thus promoting financial inclusion. Second, mobile services have led to technological system innovations, which have allowed remote monitoring and control of the solar devices and appliances. Third, mobile services have enabled insight into customer data, which can underpin more effective design practices centered on users. However, it should be noted that the potential for utilizing data collected through PAYG SHSs systems in Kenya is yet to be fully realized. This points to the need for further improvement in data collection and analysis in order to enhance customer satisfaction, improve cost-competitiveness and performance, and minimize resource use, hence leading to sustainability.

Moreover, policy should focus on implementing a well-defined regulatory framework, to promote, monitor, and evaluate the performance of off-grid solutions, and also to regulate the mobile money sector. It is therefore important to provide incentives to lower the cost of decentralized solutions by rationalizing the rules on the location and the manner of the deployment of mini-grid solutions, mitigating investment risks, and clarifying future grid plans so that investors and customers can plan and manage their investment decisions appropriately (IEA, 2017). Targeted measures, including

import tax exemptions on solar-related items, as is the case in Kenya, could also potentially help with affordability. It should be recalled that in addition to tax waivers, Kenya integrated the development of off-grid systems at the heart its 2018 National Electrification Strategy. Hence, governments should send strong signals to private sector operators and the commercial sector by making energy access a national priority, on which both private and public actors must participate.

Additional recommendations include developing a strong market quality control for solar products in order to improve their technical performance, and strengthening the actors across the value chain of the PAYG business model, from distribution to control and maintenance, through capacity building and skills learning. All in all, SHSs, facilitated by ICT and payment tools, are anchoring efforts to bring modern sustainable energy services and new sources of productive employment to remote populations. However, the emergence of PAYG SHSs should not be in direct competition with existing efforts to improve access to the electricity grid, but should rather be an alternative, complementary approach. In fact, companies such as M-KOPA and many others started their business by selling basic appliances that provide up to Tier 2 level of access to households. The impact of these technologies became greater over time when suppliers started providing higher levels of electricity for productive uses as well, thus stimulating economic activities in remote areas that were initially deprived of electricity. Therefore, PAYG SHSs are not a permanent solution for un-electrified areas, but rather a trigger for breaking the vicious circle of energy poverty. They constitute the first step towards a greater level of electricity access for low-income and rural populations.

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Policy Center for the New South

Complexe Suncity, Immeuble C,
Angle Boulevard Addolb et rue Albortokal,
Hay Riad, Rabat - Maroc.

Email : contact@ocppc.ma

Phone : +212 5 37 27 08 08

Fax : +212 5 37 71 31 54

Website : www.policycenter.ma