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Reaching universal energy access in Sub-Saharan Africa: The promises of pay-as-you-go business models under comprehensive electrification planning

LEAD AUTHOR
Grégoire Jacquot

OTHER AUTHORS
Ignacio Perez-Arriaga, Divyam Nagpal,
Robert Stoner

MITei
MIT Energy Initiative

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Executive Summary

Solar has recently emerged as the new driver of energy access in Sub-Saharan Africa. Over the past fifty years, African States have gone through valuable experiences in electrification providing planners with important lessons about the design and implementation of solar projects at scale. In addition to highlighting the major technical, operational and financial risks facing solar projects, the African experienced showed the paramount importance of sustainable business models tailored for the specific features of each territory.

The dramatic expansion of a new generational of digitally prepaid solar systems, namely “pay-as-you-go” solar home systems, has recently reshaped energy access policy and made solar the most dynamic and financially attractive segment of the electrification sector. Pay-as-you-go business models constitute a flexible and easy solution to the issues of technical unreliability, difficult access to capital among rural households and lack of synergies between technical, operational and financial actors that long prevented the development of solar across Africa.

However, harnessing the full potential of venture-backed solar companies in the most complex rural markets will require a dramatic change of paradigm from the current private sector-driven electrification approach and substantial public involvement. Subject to high profitability expectations, solar companies primarily target the top-50% percentile of Base-of-the-Pyramid households and focus their activities on urban and peri-urban areas characterized by low distribution costs and high abilities to pay. Supportive regulations and subsidization schemes have proved necessary to foster the diffusion of solar in remote rural areas unlikely to be electrified through on-grid solutions in the medium or long term. A paper, published by the MIT/Comillas Energy

Access Lab, details options to operationalize these guidelines and expand the reach of solar into underserved areas.

This paper has a double objective. First, it reviews significant experiences of pay-as-you-go business models in sub-Saharan Africa and tries to elucidate what has succeeded or failed, and why. Second, it extracts from the sub-Saharan African experiences the lessons learned that can be useful in the design of the forthcoming deployment of standalone mostly residential solar home systems in vast semi-isolated areas of Colombia that do not have electricity supply. Colombian authorities could derive valuable lessons and action items from the sub-Saharan experience. First of all, we recommend that solar projects rely on a holistic technical, operational and financial appraisal of the challenges and possible solutions, preferentially under a single authority or company in charge. Colombian authorities could typically partner with a pay-as-you-go company, possibly from Latin America, such as Kingo. Second, the electrification of remote rural communities is best conducted through well-endowed national programs benefitting from strong political support aiming at balancing affordability for local populations and profitability for local solar companies. We recommend the design and timely implementation of targeted subsidies for modest households and demand aggregation through productive uses of electrification. Lastly, public authorities should not rule out the development of mini-grids in remote areas. We advise local authorities to leverage solar data to assess demand and investigate any possible on-grid electrification opportunities that may arise over time.

General context and past experiences in solar electrification projects in sub-Saharan Africa

The past fifty years of electrification projects in Sub-Saharan Africa have shown the paramount importance of idiosyncratic energy access strategies best tailored to the specific context of each territory and departing from grid-dominated approaches derived from western experience. The African experience in solar has not only highlighted the need for technically, operationally and financially viable business models in solar but also led to the development, as of the late 2000s, of what has now become the new norm in solar-driven electrification, namely digitally prepaid solar home systems.

Solar cannot scale without technically, operationally, and financially viable business models

Due to technological and logistic limitations, the first solar electrification programs were use-specific with direct applications in telecommunication, water supply,

irrigation and rural health. Large-scale achievements remained limited to the development of small irrigation systems in Mali, the installation of a few solar televisions in Niger and solar refrigerators in dispensaries in Zaïre (now DRC)[1,2]. Concurrently, a substantial number of solar kits was deployed in East and North African countries with a certain success among wealthy rural families. Around 5% of Kenyan and Moroccan rural households managed to afford solar home systems with financial support from the diaspora[3].

However, as African countries explored non-traditional electrification pathways more suited to low-population density and limited power demand, immature governance arrangements for energy access and the lack of adequate business-models for the diffusion of solar home systems prevented solar projects to scale up. Solar products had not yet reached higher levels of resilience and cost efficiency, and most solar kits and lanterns proved to be too costly for most African households. What is more, reliability issues affected the large-scale deployment of these solutions and created a widespread distrust among rural populations towards what was perceived as deceptive "high-price for low-quality" electrification solutions[4]. Also, most projects focused on setting up initial distribution channels while underestimating the critical importance of a broader issue: the development of local value chains for solar electrification. Without adequately trained technicians and salespeople and sustainable financing mechanisms, the success of grant-based solar programs proved to be unsustainable and primarily relied on the support of international donors and volunteers[5,6].

In hindsight, the development of the first generation of solar projects allowed local States to face, for the first time, the issue of decentralized electrification programs in remote and low population density locations. The lack of financial and technical financial resources quickly put an end to short-lived pilots that had emerged throughout the continent.

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[1] CNRS (2011), Chronologie *évolutive des recherches sur les énergies solaires en France et à l'international*, available at: http://www.cnrs.fr/ComiHistoCNRS/spip.php?article61

[2] Debeugny *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris

[3] Liébard, N. (2015), *L'évolution de la politique des énergies renouvelables depuis les années 1970*, CGDD, Ministère de l'Écologie, Paris

[4] *Ibid*

[5] *Ibid*

[6] Christensen et al., (2012), *Enhancing access to electricity for clean and efficient energy services in Africa*, UNEP Risø Centre, Technical University of Denmark, Roskilde

The potential of solar is fully harnessed when used as part of national electrification plans

The 1980s and 1990s played decisive roles in the structuring of modern rural electrification policies. Not only did they confirm the lessons learned from the 60s but also demonstrated the potential of solar for universal energy access when backed by strong technical, operational and financial resources, comprehensive planning and supportive regulation.

Building on the key lessons derived from the 1960's, western development banks progressively abandoned the "one-size-fits-all" approach and proposed a new approach of rural electrification meeting different levels of demand with different levels of electricity service – in other terms, the grid was not appropriate for everybody and solar was a credible option for households unlikely to be connected to the national grid in the near future[7,8,9,10]. The objective of this approach was to provide electricity *"in little quantity, everywhere and right now"* while traditional national grid extension projects followed the much more ambitious and elusive goal of distributing *"potentially important quantities of electricity, but only here and there...and in the very long term."*

The idea of using solar at scale relied on a number of socio-technical innovations that appeared as groundbreaking at the time:

i) a detailed analysis of the different services that electrification should provide, before ultimately choosing the most appropriate electrification technology and planning;
ii) the joint analysis of both uses and production of electricity, a practice previously unknown in conventional electrification;
iii) the search for large-scale complementarity between grid extension projects, local mini-grids, and individual PV systems;
iv) the introduction of batteries as possible vector of electricity distribution in remote regions characterized by low consumption levels;
v) the introduction of efficient and low-consumption bulbs and portable lights, now affordable to low income households and bringing substantial energy savings.

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[7] *Ibid*

[8] Liébard, N. (2015), *L'évolution de la politique des énergies renouvelables depuis les années 1970*, CGDD, Ministère de l'Écologie, Paris

[9] Iskander, Natasha (2005), *Innovating State Practices: Migration, Development, and State Learning in the Moroccan Souss*, Industrial Performance Center, MIT, Cambridge

[10] World Bank (1995), *Photovoltaic Applications in Rural Areas of the Developing World*, ESMAP, World Bank, Washington, D.C.

These innovations have played a key role in the development of modern electrification programs11.

Building on these new concepts, Morocco launched in the 1990s an emblematic energy access project with a significant solar portion and that has remained the only African success story in energy access to date (c.f. specific case study on the Moroccan experience in solar). The Moroccan government decided to deploy solar as a credible alternative to grid connections leveraging innovative governance arrangements on advanced public service delegation agreements (or *délégation de service public* in French) well-suited to the specific context of rural electrification[12]. Grid extension and mini grids were developed by the State-owned utility, while well-defined territorial concessions allocated to privately-owned companies, more experienced than the State utility in the installation and maintenance of solar systems, allowed for the limited diffusion of solar kits on market terms in remote areas. Careful preliminary planning and sound governance arrangements allowed Morocco to electrify with solar home systems around 150,000 households that couldn't be connected to the grid. However, the success of public service delegation agreements and territorial soar concessions remained limited to Morocco, where pre-existing institutional, financial, and technical frameworks for electrification allowed for a quick implementation of DFI-backed project.

While the Moroccan experience allowed local stakeholders to develop advanced skills in the design, implementation and management of off-grid electrification solutions, most State-led electrification programs remained at an embryonic stage in other countries. In other countries, solar projects suffered from political interference, and more generally, the lack of clearly-defined and inclusive technical, economic, financial, and institutional frameworks and resources for electrification. Senegal, the only other African country to have adopted another ambitious universal energy access program in the late 1990s, experienced a very limited diffusion of solar in its different concessions due to the absence of adequate local value chains, regulations and subsidy regimes. Electrification rates stagnated at low levels and long-term grid extension projects remained the norm in Sub-Saharan Africa.

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[11] Debeugny *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris

[12] Choukri et al. (2017), *Renewable energy in emergent countries: Lessons from energy transition in Morocco*, Energy, Sustainability and Society, Springer Berlin Heidelberg, Berlin

Business models and institutional arrangements: the new promises of "pay-as-you-go" SHS

It is not until the 2010s that a conjunction of technological innovations dramatically reinvigorated the moribund sector of rural electrification. The emergence of digital businesses and individual solar kits as new drivers of rural electrification have reshuffled the cards of the energy access sector and propelled venture-backed digital off-grid solar solutions, so called "pay-as-you-go" solar home systems, at the forefront of universal energy access initiatives[13]. These solar systems – and all associated business models - will be the focus of this report.

Going forward: the pay-as-you-go business model

A new generation of business models for solar, developed in the late 2000s by East African start-ups, may have solved the technical, operational and financial challenges that long prevented the development of solar across the continent.

As a matter of fact, and until then, off-grid solar-based electrification initiatives had experienced a quite limited success in developing countries (with the exception of Morocco) **due to three major obstacles**:

- the limited access of rural populations to capital and affordable financing;
- the low quality and life expectancy of solar products, usually sold without technical guaranty;
- the absence of cooperation and synergies between the operational, technical and financial actors involved in the solar value chain (e.g. NGOs, MFIs, solar SHS suppliers).

The key objective of this new generation of SHS was precisely to address all three issues and to provide remote rural markets with sustainable, affordable and safe electricity on market terms. Usually limited to basic lighting and phone charging, the use of these kits is prepaid by mobile payments allowing companies to significantly reduce the costs associated with bill recovery in remote rural areas, and payments are made on a "pay-as-you-go" (PAYG) basis conciliating affordability and profitability.

In order to guarantee affordability to the greatest number, companies usually align their prices with the daily or monthly amount traditionally devoted by rural households to traditional energy sources such as kerosene and phone charging. Remote controllers blocking the system once the prepayment balance is spent out - or

[13] Debeugny *et al.* (2017), *L'Électrification Complète de l'Afrique est-elle Possible d'ici 2030 ?* Afrique Contemporaine, Agence Française de Développement, Paris

prolonging (or re-establishing) use after each new prepayment - create strong incentives for rural populations to prepay on time.

Lastly, pay-as-you-go solar companies provide technical warranty and after-sale service during the entire repayment period, a key factor in establishing a trust-based relationship between private companies and local populations but also maintaining the profitability of the company's fixed assets[14].

Successful solar products are simple, reliable and connected

While the details of the business model and the products can vary widely among companies, most successful business models for solar do share a few common elements.

Most PAYG solar home systems are entry-level kits. They typically include a 5-200W_p PV panel, a battery, a M2M communication hardware and basic appliances such as 2-10 LEDs, 1-2 torches, a phone charger, a radio and a TV if the size of the solar panel permits.

Customers receive the solar product after a small down payment, typically 10–30 percent of the fully financed cost (typically $15-50). They are then required to prepay for the ability to use the solar product via mobile money or through alternative mobile-based energy credit models. Technology within the product denies energy service if the customer's prepaid balance has been used or expires, enabling access again when the customer adds prepaid credit to their account. Monthly fees are usually determined based on the household expenses traditionally dedicated to energy (kerosene, candles, batteries, phone charging). Most companies have adopted rent-to-own models whereby customers pay off their kit in 12 to 36 months and ultimately owns the asset (Rent-to-own). Early PAYG solar companies have developed energy-as-a-service models with limited success and later transitioned towards RTO strategies for profitability purposes.

Data plays a critical role in PAYG solar businesses and constitute a critical competitive advantage against any other actor in the rural energy access sector as PAYG companies collect thousands of data points from each customer weekly. These software platforms often include an SMS or data gateway for automated communication with products, customers, and agents, and some integration with a digital payment platform to receive mobile payments from customers. Some Global System for Mobile Communication (GSM)-enabled PAYG solar products track live

[14] Alstone et al. (2015), *Off-Grid Power and Connectivity, Pay-as-you-go Financing and digital supply chains for pico-solar*, Lighting Global, IFC, Washington, D.C.

product performance (e.g. solar panel and battery voltage) and customer usage, sending data back to the central software hub on regular intervals via the GSM network.

Making solar available everywhere: the need for vast and reliable supply-chains

This end-customer transaction structure dictates key features of the PAYG solar business model, such as the design and management of large and efficient sales and distribution channels, 24/7 customer service, after-sales service and agent networks.

Given the logistical challenges of reaching deep into rural areas, PAYG solar companies have established strategic partnerships with numerous organizations to facilitate sales and product distribution. Nearly all PAYG companies have partnered with Mobile Network Operators (e.g. Orange, MTN, Safaricom), often co-branding their products with the mobile operator, and leveraged the MNO's authorized product, mobile airtime and mobile money agent networks for sales and distribution of the PAYG solar products.

The success factors of the pay-as-you-go solar sector: flexibility, profitability and integration

The flexibility of "pay-as-you-go" business models allows solar companies to effectively address major economic and financial constraints of rural populations. By **integrating within the same structure the financial, technical and operation functions previously split between a wide range of local actors** – NGOs, MFIs and solar product suppliers, PAYG solar business models reduce information asymmetries as well as bargaining and coordination issues and ultimately increase connectivity along the entire solar value chain.

This model allows companies to focus their activities and investments on high-added-value downstream segments of the solar business - namely low-cost distribution and maintenance channels - and seek the most appropriate capital structure for capital-intensive privately-owned start-ups. The major innovation of PAYG solar initiatives is thus to pursue rural electrification **on market terms** with high levels of profitability, in sharp contrast with the unattractive records of most traditional actors of the energy access sector. Unsurprisingly, exponential SHS diffusion rates have quickly attracted funding from foundations, international development banks, ventures capital and private equity investment funds at unprecedented levels, at the expense of more traditional stakeholders.

Paradoxically, the PAYG solar sector are now about to undo the integration work of the past few years, building on the proof of concept done by successful PAYG solar companies over the past few years to identify and focus on the most valuable

segments of the solar value chain. In order to further increase their impact and their profitability, companies have therefore recently engaged into the unbundling of the PAYG solar sector. Solar companies are now splitting into several entities typically specialized in areas such as SHS design and production (e.g. d.light, Greenlight Planet), customer and operation management software (e.g. Lumeter, Angaza), and distribution (e.g. Zola, M-Kopa, Fenix). While increasing the overall efficiency and financial attractiveness of the sector, this movement remains at best poorly understood and often ignored by planners, and further complicates the integration of all actors of the solar sector within cooperative integrated electrification frameworks.

The exponential diffusion of pay-as-you-go solar

This is not a surprise if, within less than a decade, digitally financed off-grid solar has transitioned from pilot scale to a diverse and substantial sub-sector of the global energy market and now constitutes the extreme majority of solar businesses in sub-Saharan Africa. Today, more than 2,500 PAYG SHS are sold every day in the sub-continent to date by nearly fifty companies operating in dozens of sub-Saharan economies, often independantly from public supervision or any national electrification plans. The number of PAYG SHS sold in Kenya is now about to reach a million kits per year, which is commensurate with the number of new rural households to be connected to the national grid within the same time range.

So-called “pay-as-you-go” solar companies have now become the fastest-growing and most mediatized electrification actors in the sector, overshadowing NGOs and MFIs but also local utilities that found themselves unable to compete with the growth of venture-backed private companies developing large-scale solar electrification activities on market terms in rural markets. **The private sector reshaped the dynamics of rural electrification by making energy access profitable.** Strong political leverage, significant fundraising capabilities, and powerful networks within Western decision-making spheres have allowed off-grid solar electrification companies to become prominent actors in the energy access sector with significant bargaining power in the design of national electrification programs and regulations[15].

At the end of the day, the diffusion of the PAYG business model showed that the most limiting factors for solar projects may not be technological (the technology of a pay-as-you-go SHS remains fairly simple), nor financial (provided that attractive business models are in place), but rather the ability to design and implement financially,

[15] GOGLA (2017), *Providing Energy Access through Off-Grid Solar: Guidance for Governments*, GOGLA, Utrecht

technically and operationally sustainable initiatives tailored to local contexts under the leadership of a single entity.

Affordability versus profitability: solar remains out of reach for remote and BoP populations

The development of PAYG solar offers unprecedented opportunities for energy access in areas hardly reachable for the national grid or mini-grid developers but is not a panacea and does not entirely close the gap left by on-grid solutions. Next to 30~50% of Bottom-of-the-Pyramid (BoP) populations may currently either not afford pay-as-you-go systems or simply not have the possibility to find such systems in their area of residence[16].

The PAYG solar sector suffers from issues typical of purely private-sector-driven initiatives subject to high expectations of profitability. In order to maximize profits and limit risks, most companies operate in urban and peri-urban areas, where distribution costs are low and the ability to pay relatively high, leaving aside large rural areas where energy access rates remain comparatively lower. What is more, large upfront payments act as filters and deter the most modest households, thereby allowing PAYG solar companies to pre-screen their customers and select the top-50% and most creditworthy portion of the population. The lowest half of BoP populations is limited to solar lanterns – systems of limited use, often sold without technical guaranty, that remain too small to be offered on a PAYG basis and that can only be purchased in cash and in full. In the absence of any incentives for solar companies to expand their activities into untapped regions or portions of the populations, there seems to be limited prospects for change in the near future – if any.

The next frontier: integrating pay-as-you-go solar within national electrification programs

The recent success of PAYG solar has not only revived the solar sector but also highlighted the need for advanced and integrated strategies for energy access – not only at the company level, as PAYG solar companies did – but at the national level in order to develop truly universal electrification programs reaching everybody while balancing profitability and affordability through well-targeted public intervention and support.

As a matter of fact, the lack of appropriate regulation and electrification frameworks has led to the development of independent public- or privately-led, on- or off-grid, and

[16] Lepicard et al. (2017), *Reaching Scale in Access to Energy: Lessons from Practitioners*, Hystra, Paris

urban, peri-urban or rural initiatives without structured dialog or cooperation between DISCOs, mini-grid developers and solar companies. Fostering competition rather than cooperation and synergies among actors, today's uncoordinated approaches are also unlikely to lead to optimal electrification schemes mobilizing the best available electrification strategy to meet local demand.

This situation may now be about to change with the emergence of so-called "Integrated Distribution Frameworks" developed by the MIT/Comillas Universal Energy Access Lab (UEAL), already implement, albeit at a small scale, in Nigeria and Rwanda. The UEAL also published a technical note specifically focused on possible avenues to integrate solar within integrated distribution frameworks and proposes possible transition models from solar to mini-grids by leveraging solar customer data[17]. Such planning guidelines could prove particularly useful in countries trying to bring electricity to the last unelectrified households living in remote areas where traditional grid extension programs are most feasible on reasonable financial terms, such as in Latin America (Peru, Colombia).

Building successful public-private partnerships: a new hope in the PAYG solar sector?

A decade after the emergence of the PAYG solar business model, energy and communication multinationals have recently engaged in the energy access sector and acquired partially or fully leading PAYG solar companies to develop their activities at scale. The weight of international companies such as Engie or EDF has allowed these latter to develop extensive discussions with governments in Togo, Benin and Cote d'Ivoire and design ambitious public-private partnerships leveraging direct public subsidies to extend the reach of solar within rural areas.

Togo was the first country to implement, as of 2018, **a public subsidization scheme** for PAYG solar to support the expansion of a solar company into untapped regions. An electrification project of 300,000 solar home systems was signed between EDF/Bboxx and the Togolese government and entails the provision of a XFA2000 monthly subsidy to each household owning a pay-as-you-go system (the allowance covers ~25% of the monthly fee for the use of the system).

[17] See *"Towards Actionable Electrification Frameworks, Reassessing the Role of Standalone Solar"*