Towards responsible and fair pay-as-you-go energy access in sub-Saharan Africa

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Abstract

Market-based solutions are playing an increasingly important role in advancing the energy sector in sub-Saharan Africa. This paper focuses on pay-as-you-go (PAYG) energy systems, a market-based approach that enables users to pay for energy in small amounts. Whilst acknowledging the benefits of PAYG, the paper draws attention to six areas of concern about its implementation, including the suitability of PAYG business models to serve the lower-income households, data collection and use, and the characteristics of PAYG energy providers and investors. We outline an agenda for inclusive PAYG energy systems in a proactive effort to shape a rapidly evolving sector. We hope that by anticipating these risks, we can help ensure that the PAYG sector is appropriately regulated and that its benefits accrue to the intended beneficiaries.

Keywords: *energy access; sub-Saharan Africa; pay-as-you-go energy systems; solar home systems; energy equity; data generation and sharing; energy transitions*

Introduction

Lack of access to modern energy services is a key challenge facing lower-income countries [1] and is enshrined in Sustainable Development Goal (SDG) 7's call for universal access to clean, affordable energy by 2030 [2]. The circumstances that shape this challenge vary widely between countries, for example by the extent of liberalisation in the energy market; the level of access to capital and development finance; the degree and reliability of on- and off-grid electricity infrastructure; and the government's institutional capacity to expand access to its citizens [3].

A broad array of technologies and fuels for cooking, lighting, heating and cooling are now available to deliver energy services to users, whose demands are complex and evolving. On the electrification side, technologies range in scale from pico-solar devices (e.g. lanterns) to utility-scale power generation, and from hardware inventions to novel business models. These developments have taken place alongside digital innovations reshaping the lives of citizens across the world, such as mobile money and artificial intelligence. The combination of international will to accelerate energy access, diverse country contexts and rapid technological change coalesce to produce a heterogeneous energy sector in constant transition.

Analyses of the energy access gap typically conclude that it cannot be met by governments alone and that private finance must be deployed to fill it [4,5]. A substantial role is now played by the growing for-profit energy access sector and is often bankrolled by higher income country (HIC)-based investors [6,7]. However, optimistic narratives around market-based approaches to SDG7 have been tempered by scholars who argue that they contradict a person's right to energy and are failing to provide sustainable solutions to structural issues of energy poverty [8–10]. Furthermore, the pressure to deliver returns to investors can lead to the prioritisation of profits over impact, which is particularly problematic when these revenues are being extracted from the poor [11,12].

Here we seek to advance understanding of developments in energy access in sub-Saharan Africa (SSA) by focusing on a business model that has gained considerable traction: Pay-As-You-Go (PAYG). By breaking down purchases of equipment and fuel into affordable micropayments, it provides a mechanism through which low-income households can access new technologies [13]. Over the past decade, PAYG has gone from a technological niche to an increasingly prominent business model enabled by the co-development of mobile money infrastructures and the tumbling prices of solar panels [14].

Despite the increasing role of PAYG in advancing energy access in SSA, little attention has been paid to the current and possible risks associated with this business model. These include the suitability of PAYG's configuration for its users and the way companies utilise user data. Many of these issues relate to wider concerns about the impermanence of energy access initiatives and the ethics of investor-led fintech applications, such as mobile money, that target low-income and vulnerable consumers [11,12]. These concerns uniquely combine in the case of PAYG energy systems.

In this paper, we seek to balance the widespread technological optimism associated with PAYG with a cautious examination of the model. This is important because PAYG has not yet reached a point of dominant design where its configuration becomes locked in and accompanied by an established set of actors, regulations and practices [15]. PAYG energy and its underpinning technologies are changing rapidly; indeed, many of the risks we highlight in this article are forward-looking. Although there are large differences between the countries

in which PAYG is deployed, PAYG business models are often comparably configured and may be offered by the same set of private actors. We believe there is still room to productively influence this model's design and to advocate for a responsible approach to implementation.

PAYG as a mode of energy access

PAYG has been applied to a range of energy technologies, including solar home systems (SHS) and liquefied petroleum gas. It is enabled by mobile money, a widely adopted financial service in SSA that allows customers to send money via their mobile phone and providers to process these payments automatically. PAYG models have been dubbed "strange beasts" that uniquely cut across multiple functions including sales, distribution, maintenance and financing, with a propensity to attract equity investments from HIC-based venture capitalists and development finance institutions[14]. Roughly eight million people gained access to electricity through PAYG models between 2015 and 2020 [16]. This number is set to increase in the future, as evidenced by PAYG accounting for 72% of investments in the African off-grid sector in 2022 [17].

There are two dominant configurations of PAYG: the lease-to-own model, whereby customers pay off the asset over time through micro-instalments; and a fee-for-service model, whereby customers pay small amounts for services but never gain ownership of the asset. The provider tracks energy consumption and can remotely lock the equipment when credit is depleted, nudging the customer to reactivate their system through paying. Failure to do so may trigger a field agent to be sent to repossess the equipment. Importantly, the model places the burden of ensuring consistent supply upon the provider, whether through replenishing gas cylinders or performing solar maintenance. This article primarily examines PAYG SHSs under the dominant lease-to-own model. These are typically 20-80W systems capable of powering anything from a few lightbulbs to more energy-intensive appliances like televisions and fans. They are supplied by verified sellers providing products that meeting existing regulations and standards. Energy services delivered via PAYG are thus more formalised and have the potential to deliver more power than the often-unverified pico-scale devices that dominate in the off-grid solar sector in SSA [10,17].

The PAYG model has proven successful for several reasons. It reduces the financial risk of serving low-income customers and provides them with a payment structure compatible with their incomes. It can even undercut the price of the polluting fuel being displaced [18], thus unlocking access to clean energy for previously unserved populations. The approach has been heralded as a paragon of inclusive digital innovation [19] that creates a digital credit history for the unbanked. This allows providers to offer upgrades to customers with good credit history (e.g. by modular extensions of solar systems), potentially triggering a virtuous cycle of increasing access to energy services and increasing financial inclusion [20].

By the late 2010s, PAYG solar was hailed as the ultimate solution to provide fast electricity access to unconnected populations unlikely to gain access to the grid network for years to come. However, recent evidence has cast doubt over PAYG's ability to deliver on its potential, fuelled by high-profile insolvencies [21], reports of derogatory customer treatment [22], inability to reach low-income households [23], and failure to achieve meaningful outcomes [11]. At the same time, there is growing pressure to increase access to electricity in the short-term. There is a need to analyse the role of PAYG models as they consolidate their position as an important energy access solution in SSA.

Outlining six areas of concern for PAYG systems

The suitability of PAYG to serve the poorest households

Mainstream SHS companies are unlikely to reach the very poorest as the market-led model does not incentivise electricity provision to high-risk customers [8]. This becomes problematic when policymakers rely on SHS companies to meet energy access targets, because it means segments of the population will be left behind.

PAYG systems often bear price premiums which may impact users' ability to reliably access energy. The infrastructures that underpin the PAYG service – such as meters, data services and financing – can render accessing energy services through PAYG more expensive than paying for them outright. These premiums are unregulated, can be high and vary between providers. This means that PAYG customers can experience significant financial burdens from the arrangement [8].

Concerns about the additional costs of PAYG raise further questions about what happens when users are unable to afford the service. A central aspect of PAYG is the contractual ability to deactivate and repossess assets (usually after a grace period of up to two months). Repossessions can make energy access transient and, if repossessed units are still counted towards energy access statistics, create a mirage of progress. There is no direct evidence of such miscounting, but the reliance on crude reporting of connections in government energy access programmes (e.g. KOSAP in Kenya, EASE in DRC), coupled with the infrequency of large-scale demographic surveys to accurately collect data, hints at the difficulty of tracking progress.

Repossessions can be difficult and faced with resistance from customers who are unwilling to relinquish their systems. GOGLA reports that repossessions are rare and that poor practices are not widespread [24]. Nonetheless, if performed while the neighbourhood watches, customers may feel publicly shamed [11], with negative psychological and social consequences.

Furthermore, decisions about deactivations are often made remotely by algorithms or people based elsewhere. This presents dilemmas both ethical (is it right that PAYG providers can remotely control household-level utility access?) and geopolitical (should control of energy supply to be relinquished to foreign entities?). Large geographical distances between those designing and receiving energy services can enhance the risks of abusive practices enabled by the invisibility of distance [12].

The adequacy of energy services available to users

The World Bank's Multi-Tier Framework (MTF) specifies that adequate access to electricity at the household level requires an 800W system [25]. However, over half of PAYG SHS sales in East Africa in the first half of 2021 were less than 50W [26], with some governments and PAYG companies considering these households electrified. For example, the Rwandan Government sets 20W systems as the minimum requirement under their electrification programmes [27]. This generates concerns about the ability of low-capacity SHSs to deliver on the benefits associated with energy access [28]. Nevertheless, the gains of smaller-scale PAYG systems can be notable relative to the technologies they replace. In theory, households can expand their access by upgrading to larger systems over time, although evidence of this behaviour is limited [29].

There are concerns relevant to PAYG about the longevity of solar products, which last for 2-10 years depending on the system quality and size [30]. This drives the production of e-waste with accompanying health and environmental impacts that undermine the SDGs [31]. Households can spend large sums of money upgrading parts to prolong the lives of their systems. This perpetuating energy injustices and risks a reversal of progress when systems fall into disrepair [32].

Data collection and sales tactics

Through PAYG, many households become e-commerce customers for the first time. They may have little or no understanding of the type of information being collected, its potential value and the implications of data privacy. Across the world, concerns about data misuse connected to digital literacy are increasing [33]. These are amplified by limited legal infrastructure in SSA where data protection rigour varies across countries and can even be non-existent [34]. PAYG customer rights are often not clearly defined in contracts and data protection regimes rely heavily on consumer consent, placing an unreasonable burden on individuals [9,35].

Moreover, the PAYG SHS sector has been criticised for failing to ensure customers are signing up for products they understand and can afford [11,22]. The predominantly commission-based sales agent model incentivises agents, themselves often low-income, to boost their

commissions through aggressive sales strategies. Low-income customers (the main target group for PAYG solar companies) often have limited financial literacy, and in some countries in SSA, debts can be viewed as abstract, intergenerational, or casual [36,37]. This leads to questions about how well PAYG payment plans - and penalties for non-adherence - align with local understandings of ownership, and whether it is possible to accurately profile the bankability of these users through PAYG payment data at all.

Exploitation of user data

PAYG businesses generate enormous quantities of data about individual users, such as usage profiles, risk profiles and credit scores. This data can support insightful analysis and benefit customers through optimised service provision. However, several authors have raised concerns over how this information is used [9,29]. Perspectives differ on whether exploitation of data is an ethical concern. However, data commoditisation locks in a balance of power strongly favouring the actors who control and analyse the data [38].

Some companies exploit this data with machine learning algorithms to predict the creditworthiness of new customers [39,40] and to provide additional services such as product upgrades [41]. This can increase opportunities for customers to access new products and services. However, as these datasets grow, these insights may feed into deactivation decisions and the level of payment leniency granted. There is scope for these algorithms to play an increasing role in determining who gets access to energy and how much of it they can have.

Algorithms are likely to be built on local user data but developed in HICs where the majority of machine learning technical capacity resides [42]. This is concerning because algorithms subtly normalise the biases of their designers [43], leading to particularly high discriminatory risks when created by developers from a different demographic. In the context of PAYG, this points to two problems: that algorithms may be contextually insensitive; and that, by prioritising scale-up and remote management of devices, decision-making processes in PAYG companies may rely excessively on such recommendations.

The role and mandate of PAYG energy providers

Some PAYG SHS providers have leveraged their infrastructure to expand into other product lines constituting higher-value forms of energy provision, such as LPG, smart phones and e-bikes. The shift towards asset financing could drive financial vulnerability through the accumulation of payment obligations. As more users and third-party developers join a platform, its administrator benefits from others' innovations whilst strengthening its own market share and datasets [44]. This may create opportunities to collaborate with local organisations yet also exclude them from the biggest business opportunities.

Another risk with platformisation is the potential to join multiple datasets. If a provider bundles a number of services then the linked data could be used to penalise users for none/late payments. There is the potential for PAYG super-platforms to enforce loan repayments by turning off a users' energy supply because of a late payment on a different product. Concerns about linking multiple data sources partially led to the shutdown of Facebook's attempt to enter the cryptocurrency market in 2022 [45]. However, there appears to be little scrutiny of these strategies in SSA.

The characteristics of PAYG energy providers

Many of the concerns described pertain to the concentration of capital amongst PAYG providers and financiers. This is exacerbated by the geographic separation of PAYG customers and service providers, as illustrated in Table 1. The headquarters of the largest PAYG energy providers are concentrated primarily in HICs, despite providing energy services to LMICs [6].

Company	Headquarters	Countries of operation
d.light	USA	Sell via distribution partners all over the world
Sun King	USA	SSA and Asia including eight countries in Africa
Bboxx	UK	Eleven countries in SSA
Engie	France	Nine countries in SSA
Lumos	Netherlands	Nigeria and Cote d'Ivoire
M-Kopa	Kenya	Four countries in SSA (Kenya, Uganda, Nigeria, Ghana)
Zola Electric	Netherlands	Four countries in SSA (Tanzania, Rwanda, Cote d'Ivoire, Ghana)

Table 1: The "big seven" African PAYG solar companies [26] coupled with data from companies' websites.

PAYG profits are therefore likely to accumulate more in HIC markets than local economies, threatening to widen wealth gaps between countries. This is enhanced by the way that data is expatriated alongside profits, providing HIC-based technology companies with the opportunity to derive monetisable insights about consumers in SSA. This connects to allegations that the African fintech industry, of which PAYG is a part, is continuing colonial models of economic production which prioritise the economic interests of global elites [46,47].

An agenda for inclusive PAYG energy systems

The concerns described above point to the need for a coordinated agenda on PAYG energy. The Global Off-Grid Lighting Association (GOGLA) have developed a consumer protection code to ensure industry-wide standards on best practices for off-grid energy provision [48]. The code defines six Consumer Protection Principles, as outlined in Table 2.

Principle	Description
Transparency	Provision of clear and sufficient information on the product, payment plan, services and data privacy practices
	Sharing of relevant and timely information
	Clear communication that customers can understand
Responsible sales and pricing	Adequate care to ensure customers can pay without becoming overburdened
	Customer characteristics are accounted for in the payment structure
Good consumer service	Ensures availability of technical support, including warranties and post-warranty service
	Mechanism for complaints in place
	Instructs customers on proper use, care and safety risks
	Measures taken to enable continued use of product if company fails
Good product quality	Products are appropriate, good quality, safe and perform as advertised
	The user interface and payment platform are appropriate
	Reasonable measures taken to ensure product longevity
Data privacy	Compliant with relevant laws and regulations
	Only necessary personal information is collected, used, retained and shared
	Customer data is kept secure and confidential
Fair and respectful treatment	Current and prospective customers are treated fairly with adequate safeguards against corruption and abuse
	Promotes inclusivity and non-discriminative behaviour
	Customer feedback is sought on the design and delivery of products and services

Table 2: the six principles underpinning the GOGLA code of conduct. Reproduced from GOGLA (48).

GOGLA's code makes a valuable contribution towards highlighting key issues around off-grid energy. However, its adoption is voluntary and self-governed, and the principles are characterised by a lack of specificity that leaves them open to interpretation by the reader. What, for example, is "adequate care" for ensuring ability to pay? Or a "reasonable measure" to ensure product longevity? We therefore believe the code falls short of the rigour required to provide robust protection to households.

The following section offers recommendations to proactively address the concerns described in Section 3. They span multiple stakeholder categories, alluding to the need for coordinated action across the board to effectively address the risks. We recognise that many of these actors are constrained in their ability to act. For example, governments have limited resources to spread between competing priorities, industry associations exist to serve rather than

challenge the status quo, and the capitalist nature of the global economy creates unrelenting pressure for profits. Nevertheless, our analysis points towards a small number of catalytic actors within the system who can affect change in the short-term.

The first are the regulators, who are able to set the rules of operation for their respective countries. There is a high degree of overlap between the risks we have identified and others growing in urgency across the globe, such as artificial intelligence regulation and data colonialism, which builds the case for prioritisation now. The second are academics and journalists, who have the ability to document how technologies shape people's lives and the world at large, to call out good and bad practices, and to lobby for a fair future.

Recommendations

Industry associations

We recommend revising the GOGLA principles so they are more specific and measurable. Tiers of compliance could be introduced to differentiate between companies, lending high-performing players a market advantage. Financiers should be educated about consumer protection issues so that performance against the code factors into investment decisions. Engaging external assessors would help enhance the code's credibility.

Industry associations can improve standards of service across the sector by identifying and sharing case studies of best practise. They can also create safe spaces for inter-organisational dialogue on these issues.

PAYG providers

Flexible tariffs are key to ensuring affordability for groups without regular salaries and to properly account for different living circumstances between and within countries. PAYG companies can partner with researchers and users to understand fluctuations in financial capacity and design payment plans accordingly. For example, they could experiment with overpayment facilities that allow customers to underpay at certain times of year. This will become increasingly important in the face of climate change-exacerbated vulnerabilities and could be facilitated by adaptation finance.

Companies should conduct proactive assessments over whether a prospective user is a suitable customer. This is challenging as customers typically lack credit ratings. If PAYG has limited viability, then alternative solutions should be considered.

Companies should be sensitive to customers' data literacy and recognise their role as educators. Ensuring that households understand their purchases should be a central priority and reflected in incentive structures for agents. Companies could extend customer information provision beyond legal requirements by linking customers to community-level payment support when required (e.g. from savings groups); providing troubleshooting guidance for common technical issues; and ensuring that information provided is appropriate.

PAYG companies should actively be aware of and try to avoid algorithmic bias. This may consist of unpacking the logics of algorithms and validating each step with local energy users. Furthermore, companies should ensure their data scientists have a good understanding of local contexts and aim to strengthen data science capabilities within countries of operation.

Regulators

Many of our concerns relate to the vulnerability of energy users and the need to protect their interests, alluding to the key role of regulators. Regulators must clearly define what counts as adequate energy access for their country. This must be reflected in a minimum standard of service provided by PAYG companies to citizens.

Regulators should ensure that PAYG providers continue to offer repair services and access to high-quality replacement parts once the leasing period is over. Understandings of local market dynamics and consumer behaviours must be factored into such regulations. For example, many customers favour local, informal repair services, and thus regulators should require PAYG providers to design repairability, durability and interoperability into their products [50].

Deactivation and repossession processes should be regulated and avoided as much as possible. Regulators could require PAYG providers to show evidence that each repossession is necessary and, when sanctioned, conducted with due care. Schemes incentivising voluntary product returns from customers could help reduce the overheads and trauma of this process.

Governments

Governments play an essential role in limiting exploitation of customer data. This could be achieved by shifting away from consumer consent models to impose responsibilities onto data collectors and processors; by developing a digital bill of rights that empowers customers to control their own data; and by using privacy representatives to review consumers' data profiles and check algorithmic models for fairness, bias and exclusion [35]. Governments could draw inspiration from the principles of the EU's General Data Protection Regulation to

stimulate greater transparency and responsible data sharing between parties. Such data sharing could develop better understanding of energy access gaps and help maximise the impact of PAYG solutions.

Policy makers should be more explicit about how PAYG SHS are part of a broader energy transition and actively consider how citizens will graduate to higher levels of access, whether through larger SHS, microgrid systems or national grids. Policies promoting PAYG at the expense of alternatives (e.g. systems bought outright) must be implemented carefully to ensure that local providers are not crowded out.

Future Directions

This paper sets out six areas of concern for the development of a responsible PAYG sector across SSA. They point towards an overarching dissonance within off-grid energy sector discourse. Evidence indicates that PAYG may not be suitable for the poorest and most isolated users, for whom alternative solutions may be necessary.

A more strategic and transparent approach is needed to address these concerns. This could be achieved through fostering greater openness about the challenges facing companies, requiring an altruistic shift within the sector. These insights could inform longer-term planning about how PAYG should evolve to meet growing energy demand. It could also address the currently siloed applications of the PAYG model and encourage more active collaboration or sharing of learnings between different countries, sectors and companies to maximise benefits [51].

Despite the heterogeneous contexts within which PAYG is operating, the issues raised in this article are common across SSA, where rapid expansion of energy access is urgently required to achieve SDG7 by 2030. Our recommendations therefore seek to foster open debate and action, and we welcome contributions to this agenda from actors working from different positionalities. We hope they contribute towards ensuring PAYG energy transitions are fairly implemented, appropriately regulated, and permanent.

Acknowledgements

We would like to thank Lindsay Umalla and Charlotte Heffer for their valuable feedback and guidance.

Competing Interests

The authors declare no competing interests.

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