

OFF-GRID POWER AND CONNECTIVITY

PAY-AS-YOU-GO FINANCING AND
DIGITAL SUPPLY CHAINS FOR PICO-SOLAR



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Table of Contents

EXECUTIVE SUMMARY	4
ORGANIZING PRINCIPLES AND STUDY SNAPSHOT	4
ACCESS TO ENERGY, INFORMATION, AND FINANCE THROUGH PAYG	5
BUILDING A STRONGER PAYG MARKET	7
NOTES ON THIS STUDY	9
TRENDS SUPPORTING PAYG SOLAR	11
PAYG AND CONNECTIVITY TAXONOMY	12
DIMENSIONS OF PAYG	13
STUDY METHODS AND CONTEXT	19
OVERCOMING ENERGY ACCESS BARRIERS WITH PAYG	23
UP-FRONT COST	23
TRUST	25
RETAILER RESOURCE CONSTRAINTS	26
AFTER SALES SERVICE	26
MARKET INTELLIGENCE	27
NEW INTERFACES AND CHALLENGES	28
PAYMENT AND VERIFICATION	28
TRANSACTION COSTS	29
FEATURE REQUESTS	29
PAYG ECONOMICS	30
RISK PROFILES	30
DOWN PAYMENT	33
COMPETITION AND MOBILE MONEY MARKET SHARE	33
UNIFORM PRICING	33
ACCESS TO WORKING CAPITAL	34
SOCIAL AND FINANCIAL RETURNS	34
DATA PRIVACY AND UTILIZATION	35
SUPPORTING A ROBUST PAYG MARKET	36
NOTES ON M-KOPA APPROACH	40
NOTES ON SUNNYMONEY APPROACH	40

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Cover photo: street scene from Kericho, Kenya, at the retail end of supply chains for off-grid power, during a field research interview with the owner and staff of a shop that incorporates connectivity through mobile phones, internet, and through digital financing through PAYG (as agents) and normal retail / wholesale operations (photo: P.Alstone)

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EXECUTIVE SUMMARY

Digitally financed off-grid solar has transitioned from pilot scale to a diverse and substantial sub-sector of the global off-grid energy market. Today nearly 30 companies operating in at least 32 countries provide access to consumer capital for off-grid solar using digital finance, opening access to vital electricity services. Building on the burgeoning pico-power and solar home system (SHS) progress of the last decade, information and communication technology systems are accelerating and reshaping the dynamics of off-grid electricity access by providing financing and increasing connectivity throughout the supply chain. Mirroring trends in mobile money adoption rates, Kenya and other countries in East Africa are early focus areas for deployment, shown in the map below.



Figure 1: PAYG reach circa 2015: the number of providers identified through a market scoping search, by country. (source: author desk research)

ORGANIZING PRINCIPLES AND STUDY SNAPSHOT

There is a wide range of business models that fall under the loose category of digitally-financed or “pay as you go” (PAYG) off-grid energy.¹⁻³ Varied combinations of energy systems with connected hardware and software are currently being explored in a diverse set of regional markets throughout the developing world. The diversity of business models and technologies provides a rich opportunity for learning best practices in customer acquisition, portfolio structure, loan product design, etc. Some of the common models are described as “DESCO” – distributed energy service companies that provide a given level of energy service in exchange for

ongoing payments¹. Others are better described as asset finance or microloan providers, with a transfer of asset ownership to the user after a limited payment period. Others still act as business-to-business (B2B) intermediaries, supplying hardware and software support from global operations to last-mile energy service and payment logistics.

In this report we use a catchall category descriptor of “pay-as-you-go / PAYG” to capture this range of approaches. The dimensions of PAYG for off-grid power include a range of system scales, from ~1 W pico-powered lighting to kilowatt-scale solar home systems and community-scale grids. Connectivity also varies significantly and includes systems with embedded GSM (mobile phone machine-

to-machine transfer) modules and mobile-money payment systems as well as those with scratch cards and remote keypads for entry.

We completed an in-depth field study of PAYG systems in Kenya during 2014, where there has been significant PAYG market growth over the course of the year. The focus of our data collection was on study lamps and pico-solar home systems that are sold to end-users coupled with a credit mechanism (see additional notes below on datasets). Kenya is a unique case study for an “early adopting” country, with a mature mobile money sector (and a dominant provider—M-Pesa through Safaricom), a competitive and growing off-grid solar market, and the city of Nairobi that has emerged as an important hub for information technology, finance, and development aid organizations for all of East Africa. We support our field insights with extensive desk research that focused on the PAYG landscape, energy access needs, and connectivity data.

ACCESS TO ENERGY, INFORMATION, AND FINANCE THROUGH PAYG

PAYG systems catalyze increased energy access through financing and through increased connectivity across the supply

chain, from head offices to end users operating remotely monitored systems. While the full measureable benefit of PAYG has not yet been rigorously established, early indications are that PAYG dramatically increases levels of access through consumer markets for off-grid power. In SunnyMoney's pilot trials of PAYG study lamps offered through a school sales campaign, the adoption rate was 20-50% while the normal level without PAYG in the same sales channel is 10-15%. This suggests **roughly a doubling to tripling in sales** for lamps in that category. In the case of systems with greater up-front capital investment, including community mini-grids, PAYG technologies and business models are also catalyzing significant growth. As lessons learned are accrued among enterprises and users, accelerated growth in access to solar through PAYG appears possible through a range of channels. In this section we sketch a summary of the different forms of support that PAYG provides to the off-grid lighting market.

Financing Energy: The most obviously valuable feature of PAYG systems is the opportunity to lower transaction and management costs on loan and energy service payments, thus enabling consumer



Fig. 2. A view of Wote, Kenya where there is mixed access to the electricity grid in the vicinity of a small urban cluster, and the mobile phone tower is the most distinctive feature of the market center.

financing for loan sizes that are much smaller than previously possible. This access to consumer-level financing had long been recognized as a critically important factor for increasing energy access for cash-poor buyers, and it was noted as an important and valuable opportunity by the people our research team heard from in the field. The providers that were the focus of our field research have developed pricing strategies that closely match the daily kerosene spending of potential customers. This allows for cash-constrained consumers to roughly maintain typical spending on energy while receiving a much higher level of service. Furthermore, PAYG models often implicitly help finance the retail supply chain, since smaller outlays are required by sales agents and retailers for stock than a wholesale purchase and resale model.

Building Trust: Our findings also showed that the offer of financing helps overcome another critical hurdle: building trust in the quality, performance, and expected utility of systems. Customers in focus groups told us (translated from the Swahili here and in most quotations from focus groups or survey participants) that because PAYG systems have financing they are expected to be “...better because

you can return the light before payment is complete if it is not working...that means [the sellers] have confidence with their product”. For the study lamps sold through Sunny Money, nearly 15% of customers chose to pay the lamp in full after far fewer payments than were available in the loan (<30 days, versus the available 70), strengthening the assertion that some buyers were using PAYG to overcome a trust barrier, more so than a capital constraint.

New consumer insight: For many PAYG customers, purchasing the system will be among the first times they have had access to financing that is easily traceable and verifiable. In addition, mobile-enabled PAYG provides a window for providers into user behavior that is otherwise unavailable for shaping and supporting off-grid power systems. PAYG systems open opportunities for using repayment histories to establish credit records, and allow for monitoring of nearly real-time power consumption to better understand access dynamics and changing customer demand.

Amplifying access through finance for expanded service: Owners of PAYG solar products can leverage their asset for the acquisition of new products if refinancing, or other follow-up offers for

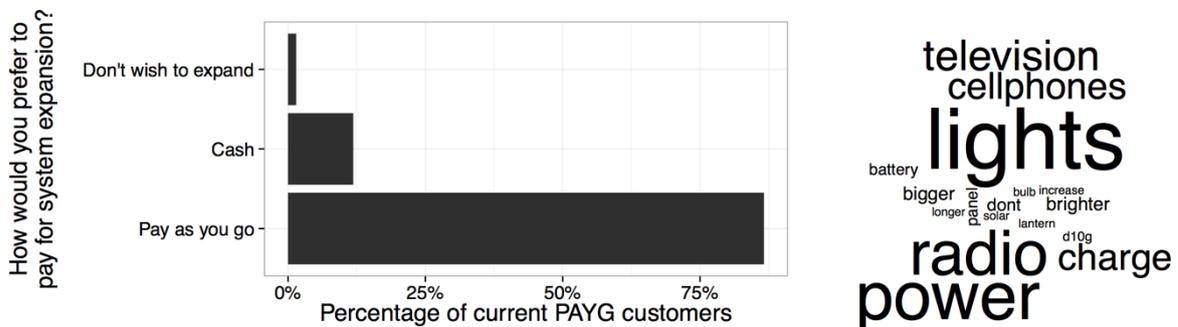


Fig. 3. Preferences for system expansion among customers with aspirations for access to greater levels of energy service. The payment preferences are from surveys of n=205 current PAYG customers. The word cloud is constructed from responses to an open ended question about ways to expand service that preceded the question about payment preference that is shown in the bar graph.

financing, is offered. This can enable the addition of extra system components, compatible appliances, or other goods and services that were previously unaffordable. Over 80% of the customers we interviewed in phone surveys reported interest in financing an expansion of their system through PAYG, particularly for appliances including additional lights, television, radio, etc. (see Figure 3). Furthermore, many organizations engaged with PAYG cite the potential to develop credit scoring and other repayment data derivatives that could open access to financing beyond energy service and appliances.

Maintenance and monitoring: GSM technology allows PAYG providers to more closely monitor and respond to changes in system performance, improving the service reliability and durability of energy access. Deploying machine learning and other techniques to analyze large-scale data can lead to prediction and identification of issues with system maintenance (or customer repayment). Furthermore, PAYG allows many providers to have more direct interactions with customers, providing an ongoing channel for after sales service, payment reminders, and other information via

BUILDING A STRONGER PAYG MARKET

PAYG approaches benefit from ongoing support of the broader off-grid power market, but there are some special concerns for specifically encouraging PAYG market growth.

Access to capital: Like the broader off-grid solar market, one of the core barriers to scale for PAYG is access to appropriate working capital financing (with a preference for local currency). Access to working capital allows PAYG providers to stock more product in-country, supply larger inventory to retailers and agents, and extend better loan terms to consumers. All of these factors ultimately contribute to higher levels of access. At this point, investment in the PAYG sector

SMS. The strength of connected PAYG (and other connectivity-enabled approaches) for supporting reliable, adaptive solar energy access will become clearer as the first wave of systems entering the market today age and are supported with maintenance, expansion, and replacement.

Connecting supply chains: Building off-grid power markets means having robust supply and service chains to support adoption, maintenance, and reinvestment. We find that connectivity across the sector, including PAYG and non-PAYG sales, is now a core requirement for successfully delivering good quality and trusted off-grid power systems to retail markets. This means, as growth continues, there are opportunities for a growing, digitally literate young population to engage in “green jobs” for off-grid power (replacing or adding to the activity for sellers of kerosene, batteries, or recharging service). Sales agents, sub-distributors, technicians, and logistics specialists, along with salaried positions farther up the supply chain are all pieces of the off-grid power labor force.

has been insufficient to fulfill capital needs for providers. Although more than \$70 Million of equity and debt investment in PAYG firms has been publicly announced (originating from over 60 unique investors), a recent report by the Global Off-Grid Lighting Association (2014) cited a sector-wide need of over \$1.5 Billion to support consumer finance over the next 2 years⁴. Bridging this gap will be crucial for growth in PAYG and the broader market.

Data showing the reliability of customer repayment in the early market may prove to be a critical element for attracting critically needed financing for growth in the PAYG market. Debt repayment streams from large groups of customers can be securitized in portfolios that free working capital. Proof of the reliability for repayment (so far many firms claim >90%) provides a foundation for growth capital.

Transaction fees for mobile money payments: Many PAYG approaches rely on mobile money systems for payment processing, while others use alternative approaches like agent networks who can receive cash with mobile phone apps or scratch cards. In both cases, there are transaction costs that add to the cost of financing. For mobile money, the costs result from fees levied on transactions by network operators, and for other approaches there are embedded marginal costs for card printing, agent margins, and other needs. These are not insignificant costs and can add up to 15-20% to the overall outlay required by customers based on the observations we made in the field. Reducing these costs could improve PAYG financing access to reach greater numbers of the poor. While there are logistical barriers to reducing costs associated with physical agent networks, the pricing for mobile money systems also depend on the particular mobile payment business model; many services charge relatively large fractions of the total in lower-value transfers. If these fees were waived or reduced for social goods payments like off-grid power access, it could accelerate and streamline progress along with reducing friction in payments.

Friction in interfaces (both UI and B2B): There are interface growing pains on both “sides” of the PAYG business model: both the customer user interface (UI) and business to business (B2B)

relationships between PAYG and mobile money providers. Users are offered a wide range of both payment and transaction verification systems, most of which are not in common use and may require new learning of the payment steps and processes for every new provider that offers service at costs on the order of several \$100's of thousands USD for software and hardware integration to support deployment (based on anecdotal evidence from a range of implementing and supporting organizations in the PAYG market). PAYG firms also need to manage relationships and software systems with telecommunications firms and equipment providers, often co-locating server hardware and needing careful software development to build a system that can scale and handle enterprise-level payments. In both areas, UI and B2B, there are significant opportunities to reduce barriers to competition between devices and entry to new markets through standardization of the user interfaces and application programming interfaces.

Reduce exposure to pricing and currency risk: Any consumer finance platform incurs risk when accessing capital from abroad. Fluctuations in currency can drastically alter the ability of a PAYG provider to service international debt. This risk is less prominent for suppliers of pico products, but should be recognized by providers of larger systems with longer loan tenors.

Changes in technology pricing can also introduce a new risk for PAYG providers and consumers. If a product is sold with a multi-year loan term and the underlying technology drastically drops in price⁵ over the repayment period, consumers may feel inadequately served by the provider. This could result in default or consumer dissatisfaction.

Respect Data Privacy Concerns:

Customer data access and privacy concerns are important factors in the early market. Many PAYG firms are collecting data on system use but there are scant examples of how these data are put to use for business decisions and processes beyond tracking repayment histories and

improving customer service. In focus groups, there was a universal concern over private consumer data being shared externally by the provider, while recognizing the potential for positive returns to consumers from prudent and confidential uses.

NOTES ON THIS STUDY

This study builds on other reports on PAYG that explored key opportunities for accelerating the market. A report from GSMA in 2013³ pointed to the need for low-cost machine-to-machine GSM chipsets among other recommendations, and in 2014, a report issued by CGAP² mapped the emerging PAYG market and discussed potential opportunities to improve scale. Our work is based on field data in combination with desk research to provide new depth of insight into particular models and markets. This report is rooted in the analysis of the Kenya market, where our work was focused.

Kenya as a pilot: Kenya is a special case for PAYG due to numerous favorable conditions, including an established mobile money sector, popular awareness of solar power, and supportive business and regulatory environments. Many of these same conditions however, are emerging in other markets. There are currently 255 live deployments of mobile money systems in 89 countries and growing⁵. The off-grid solar sector has also experienced recent and rapid growth in other areas of sub-Saharan Africa and Asia, particularly India, Bangladesh, Nepal, Uganda, Tanzania, and many Southeast Asian island countries⁶. Finally, many governments are showing increasing support for renewable energy in the form of VAT reductions, subsidies, and other measures.

Datasets: We draw on several new datasets that were gathered to support this study and other reports during 2014. We primarily highlight insights based on data and observations we obtained through research partnerships with two commercial organizations delivering PAYG-enabled off-grid power in Kenya: SunnyMoney and M-KOPA. M-KOPA is the largest early PAYG solar operator in the world, and during our field research partnership in June 2014, the organization passed 100,000 units sold, nearly all in the previous year. At the time, M-KOPA offered a 5-watt pico solar home system for sale through a retail agent network in Kenya, with payments through the M-Pesa mobile money system. SunnyMoney

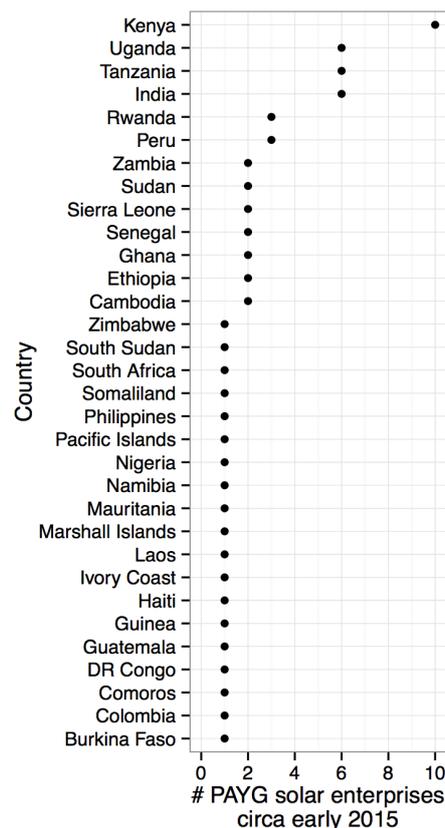


Fig. 4. A summary of the countries where PAYG enterprises are active, circa early 2015

was pilot testing two technology platforms for PAYG study lamps during the period: divi and Angaza. Divi and Angaza are two start-up companies focused on building general PAYG technology platforms (hardware and software combined with payment integration). In the pilot they supported PAYG integration in study lamps (like the Greenlight Planet Sun King Eco, in which the Angaza system was integrated for the pilot). The study lamps were sold in a set of pilots directed by SunnyMoney through a modified version of their institutional school sales program, which, along SunnyMoney's growing retail network, has led to purchases of over 1.6 million pico-powered lighting systems. Working with implementation and internal research teams at those organizations, we conducted customer telephone surveys and, in the case of SunnyMoney, a set of focus groups. We also worked to better understand the business models and supply chains for PAYG for those and other organizations active in the space. Data was collected from public sources, such as CrunchBase (for investment data), company press releases, external case studies, news reports, and public interviews. A detailed listing of data generated for this study is in the Annex, and there are more details on the SunnyMoney and M-KOPA PAYG enterprises in the main report.

Keep in mind... It is important to note that the PAYG market is incredibly dynamic. New business models appear almost daily, companies pivot and change approaches, funding is raised, and players disappear. This report presents a snapshot of what our team observed during the June and July of 2014. Since then, even our partners have altered their approaches, with the most notable change coming from M-KOPA, which shifted to a more vertically integrated model that now includes proprietary manufacturing of the system itself. Any conclusions presented in this report are a product of data available during the study period, and do not reflect many of the changes that have occurred in the market since. We have, however, attempted to update general investment and deployment numbers to be current as of February 2015.



*Fig. 5. Focus groups for off-grid solar in 2012
(not part of this study, from previous work with Lighting Africa)*

TRENDS SUPPORTING PAYG SOLAR

The off-grid solar market has gone from pilot scale to meeting the needs of millions of people over the last 10 years by leveraging trends in the cost and performance of solar photovoltaics (PV), batteries, and efficient loads to move from a nascent technology concept to a growing industry with multiple large players⁷. One measure of this growth is the number of products sold—over 6 million pico-solar products have been sold through channels supported by the Lighting Global program alone. Other off-grid solar channels have also shown strong growth over the same period, notably the IDCOL Solar Home System support program in Bangladesh (over 4 million sold). Solar has been cost competitive for years with kerosene and fee-based mobile phone charging, and the opportunity to eliminate these expensive and, in the case of fuel-based lighting, harmful energy service methods is clear. High quality ready-made solar energy kits are now available at scale on the global market, and a range of business models to deliver and support their adoption are emerging, including PAYG.

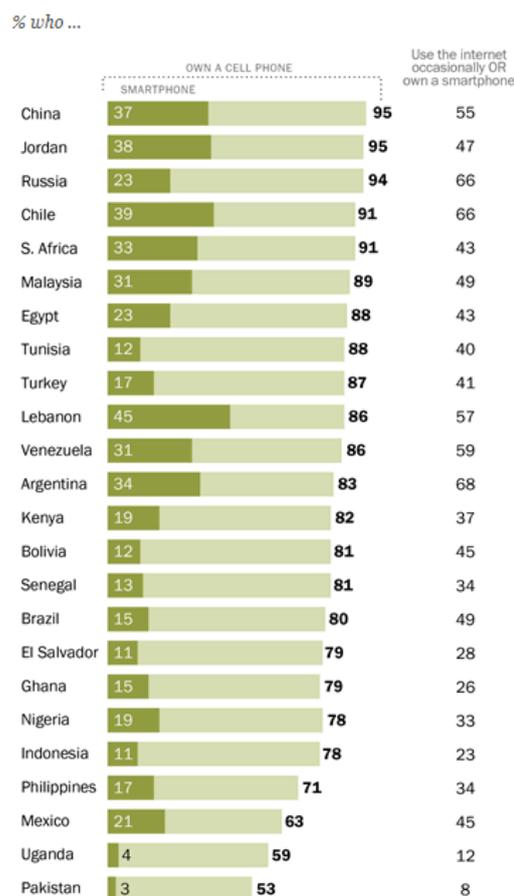
The growing standardization of SHS products lends itself well to PAYG business models that limit customizability and repayment schedules. “Traditional” approaches to SHS deployment, where each system is bespoke and has a unique price, offer challenges to financing since each system would thus have unique repayment terms and transaction costs. With modular and standardized technologies, a broadly applicable (countrywide) payment term can be offered, which becomes much easier to administer and market.

Over the same period that pico-solar has become a more prominent tool in supplying energy access to the poor, peoples’ **access to mobile phones** has

dramatically increased in the developing world. There are currently 90 active mobile phone subscriptions for every 100 people in the developing world (70/100 in Kenya), and a growing share of the population is using smart phones (currently about 10% with projections for fast growth as the price of handsets fall)⁸.

This new wave of connectivity has led to a range of changes across developing world economies, notably the rise of mobile money systems that are core to several PAYG strategies. Kenya is an early leader in mobile money utilization, with the majority of the population (roughly 70% as of 2013⁸) reporting using mobile

Cell Phone, Smartphone Ownership and Internet Access



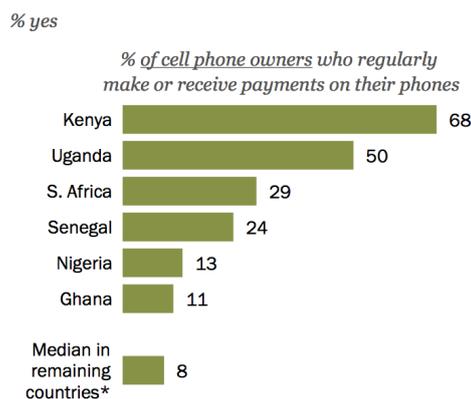
Source: Spring 2013 Global Attitudes survey, Q66-Q68. PEW RESEARCH CENTER

Fig. 6. Mobile telephony access circa 2013 (from Pew Research Center)

payments on a regular basis. In other developing world nations, rates of use are lower but growing fast.

PAYG companies have taken advantage of the growth in mobile money markets, establishing operations in many of the early adopter regions: Kenya, Tanzania, Uganda, India, and others. The early growth in the Kenya PAYG market (see figure 1)—over double the size of the next market—can be attributed to both the early availability and rapid national adoption of mobile money. Kenya is a lead country in mobile money uptake due to a range of factors, including a strong telecom with a large market share (Safaricom), a relatively loose regulatory framework during the early growth of the service, and broad support and investment in marketing and developing a network for the service.⁹⁻¹¹

Mobile Payments Popular in Africa



* Median percentages based on 18 non-sub Saharan African countries.

Source: Spring 2013 Global Attitudes survey, Q76g.

PEW RESEARCH CENTER

Fig. 7. Mobile money use circa 2013 (from Pew Research Center)

PAYG AND CONNECTIVITY TAXONOMY

Pay-as-you-go solar has become a catch-all term to describe off-grid PV energy systems coupled with connectivity or IT-enabled payment systems, allowing a range of business models built on asset finance or fee-for-service models. At this time, we have identified 28 companies currently operating in 32 developing economies that fit our definition of PAYG. According to publicly available information, collectively the firms have deployed over 250,000 systems (across different service levels) and have raised over 80 Million dollars in investment capital (philanthropic, debt, equity, hybrid) from 72 unique organizations and firms. In this section we provide a brief outline of the broad PAYG landscape.

The core of PAYG is that it is a **financing platform** that builds on the unique opportunities in each market. Some of the key factors present in most current business models are: the active use of mobile telecommunications systems, widespread agent networks, distribution partners, and a longer term firm-consumer relationship than standard retail. While PAYG is primarily a means of providing

PAYG in a nutshell:

PAYG is a microfinance platform for household energy systems that have relatively high up-front capital costs for off-grid consumers.

There is an information technology system that underlies the platform, allowing automated payments and system monitoring / activation. The range of *payment* and *verification* systems includes GSM-enabled mobile money payments, scratch cards and tactile keypads, or premium SMS.

In essence PAYG allows manufacturers and distributors to act on behalf of their customers to access financing through working capital and other funds.

financing options to consumers, it also enables a greater degree of after sales service and remote system monitoring and data collection, which allows the business to have a longer-term direct relationship with the consumer and the opportunity to offer referrals and other benefits.

Traditional finance institutions have tended to avoid consumer credit in the off-grid energy space for a number of reasons. First, the transaction costs associated with managing such small loans (anywhere from \$10 for pico-products to more than \$250 for larger home systems) can be disproportionately high in comparison to the returns. The risk profile for such products is still largely unknown, and

until recently, the technology risk was perceived as too high to extend long-term loans. Finally, lending for off-grid energy products is outside of the core business of traditional financial institutions, which means that there is often an overall lack of internal technical capacity to (a) assess product quality, (b) select products among a wide range of competitors, or (c) effectively market or distribute products. While there are examples of microfinance providing successful programs in support of off-grid energy (Grameen Shakti in India, Prodem in Bolivia, IDCOL in Bangladesh), few have been able to scale to the degree that PAYG companies have been able to *without* subsidy.

DIMENSIONS OF PAYG

The PAYG landscape can be delineated for comparison using a number of product and business model attributes. We will attempt to classify the distinguishing characteristics here, although the landscape is ever evolving and will include other novel approaches in the near future. This section will make the following distinctions:

1. System Size
2. Customer Relationship
3. Payment Platform
4. Connectivity
5. Partnership Strategy

System Size

PAYG solar products can be divided by the system size, which dictates the service level that each provides. While there is no agreed on and fixed taxonomy of systems, many are categorized as **pico solar**, ranging typically from 0.5W to 10W, and include study lamps, lanterns, and **basic solar-home systems** like the M-KOPA III. Others may provide standalone systems that are either be self- or professionally-installed (such as the one provided by SunTransfer or SolarNow), and include the ability to power small appliances such as fans, DC televisions, and even small refrigerators with a solar module power rating of roughly 10 to 200 Watts. **Community level, shared**

mini-grid systems are an equally broad category, and range from the kilowatt scale (such as Mera Gao's DC mini-grid), which provide basic services, to larger multi-kW systems (such as those being developed by Power Hive), which often power AC appliances and supply productive power. The distinguishing characteristic of mini-grid systems is the interconnection between homes (and businesses), which can allow for a more efficient use of generated power and enables economies of scale from diversity in loads and declining unit costs in some basic technology systems.

At this time, pico and household products are seeing the largest growth in the PAYG space, with over 200,000 systems deployed to-date. However, the market potential for the off-grid energy sector overall is largely untapped, with over 500 million households globally lacking reliable power^{7,12}.

Customer Relationship

The broad categories of consumer relationships available are **micro-loan, energy service, and business-to-business (B2B) hardware/software**.

Within each category there are also different approaches, which are outlined below:

Micro-loan: Firms such as M-KOPA, Nova Lumos, Azuri, and Simpa Networks fall under the umbrella of asset finance, or micro-loan. While the specific criteria differ between firms, typically the same three-step process is followed for end customers:

1. Down payment and relatively informal credit check
2. Payment series via proprietary or licensed platform
3. Device is unlocked and owned by the customer

Energy Service: Another approach is the distributed energy service company model, employed by firms like Off:Grid Electric, where rather than financing an asset, the company provides an electricity service much like a modern utility does. That service comes from a company-owned solar system which is roof mounted. The user provides an installation or down payment, slightly de-risking the investment for the firm; however at no point does the consumer own the asset outright (even after the full cost has been repaid).

B2B hardware/software: There are significant needs in the PAYG market for specialized IT hardware and software. Some firms focus on B2B offerings that provide critical support for providers to better serve their customers, as

exemplified by the approach of two of the firms we worked with in detail, Angaza Design and Divi Power. Both provide specialized software and hardware, producing and supporting technology systems that can be integrated with an off-grid solar product to allow for remote activation and deactivation, payment stream management, and usage tracking. In general these approaches are neutral to the consumer relationship and could support either a micro-loan or service model. Many firms that developed in-house hardware and software platforms for deployment in markets also now offer their platforms as licensed technology.



Fig. 8. A rough categorization of PAYG enterprise circa early 2015 along the dimension of customer relationship.

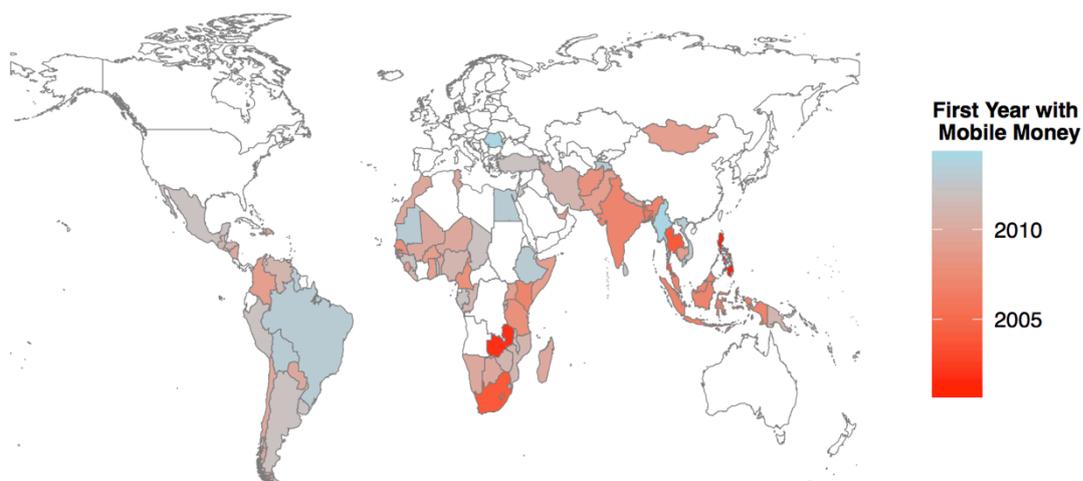


Fig. 9. The global roll-out of mobile money systems, from 2000-current day. (Data source: GSMA)

Payment Platform

PAYG providers employ a number of approaches to enable payments for their product or service. Some, like M-KOPA, rely on an established mobile money network. In their case, a partnership with M-Pesa in Kenya allows for nearly seamless product activation with no agent interaction after the initial purchase. Others, such as Simpa Networks and Azuri Technologies, have developed a scratch card model with distributing agents across the countries where they operate that doesn't depend on mobile connectivity but does require management of the agent network. Nova Lumos employs mobile airtime as a virtual currency, allowing users to pay for service using mobile phone credit. Other models require specialized agents to accept cash payments, and then activate solar lights through either (a) a cable, (b) bluetooth, (c) or a manually-entered SMS code. Overall, 60% of the firms we identified use mobile payments and 40% use an alternative.

Product repayment periods vary widely amongst systems and depend on (a) the total cost of the product, (b) the risk mitigation strategy of the firm (the longer the tenor, the higher the risk), (c) the cost

of capital to the PAYG firm, and (d) the regulatory framework in the market, such as VAT and other regulations that influence system price. For the products that we studied in Kenya, payment tenors ranged from just over 10 weeks to just under 1 year for average repayment. Some current PAYG systems in Kenya have terms that extend up to 3 years.

Partnership Strategy

Firms in the PAYG space have diverse levels of integration across the supply chain and approaches to marketing and distribution. Partnerships are being made on hardware, distribution, payment, or other core aspects of the business. For example, some firms (such as Azuri) have an essentially **vertically integrated supply chain** from manufacturing / design to last-mile distribution and payment. Others, such as Fenix International and Nova Lumos, have **partnerships with local telecommunications companies** to support sales and delivery to the consumer. Still others, like M-KOPA (circa June 2014), have a device that is branded with a telecommunications company logo and partner manufacturing logo, but conduct the majority of marketing and distribution themselves.

Some “business to business” oriented firms (e.g., Angaza and divi) are focused on situating themselves as a coordinator between manufacturing, distribution, and telecommunications integration.

Connectivity

PAYG technologies can also be distinguished by the level of connectivity used for payment, verification, and customer relationship management. The choice depends on the availability and adoption rates for mobile payment and data transfer service, reach into rural areas without continuous connectivity,

and other priorities. The spectrum runs from systems that are fully online, including mobile money and remote, real-time connections with the energy system to those that are only tenuously or intermittently connected. The different arrangements have implications for the way business models can be structured, the cost of implementing the system (additional hardware or integration costs), the implied requirements for connectivity and access to mobile phone networks for operating the system, the frequency and scale of system monitoring data available, and the user and retailer experiences.

“Full connectivity” systems like the M-KOPA III often include a GSM component embedded in the hardware for the solar energy system, allowing bidirectional communication with central servers in near real-time (“machine to machine” or M2M data). These systems not only support remote lock and unlock capability, but also operations and performance data transfer. In systems with full connectivity, payments are often made via mobile money, and central staff can reach customers for service and repayment inquiries. The retail staff may also have augmented access to information and financing for stock through digital connectivity to the PAYG provider.

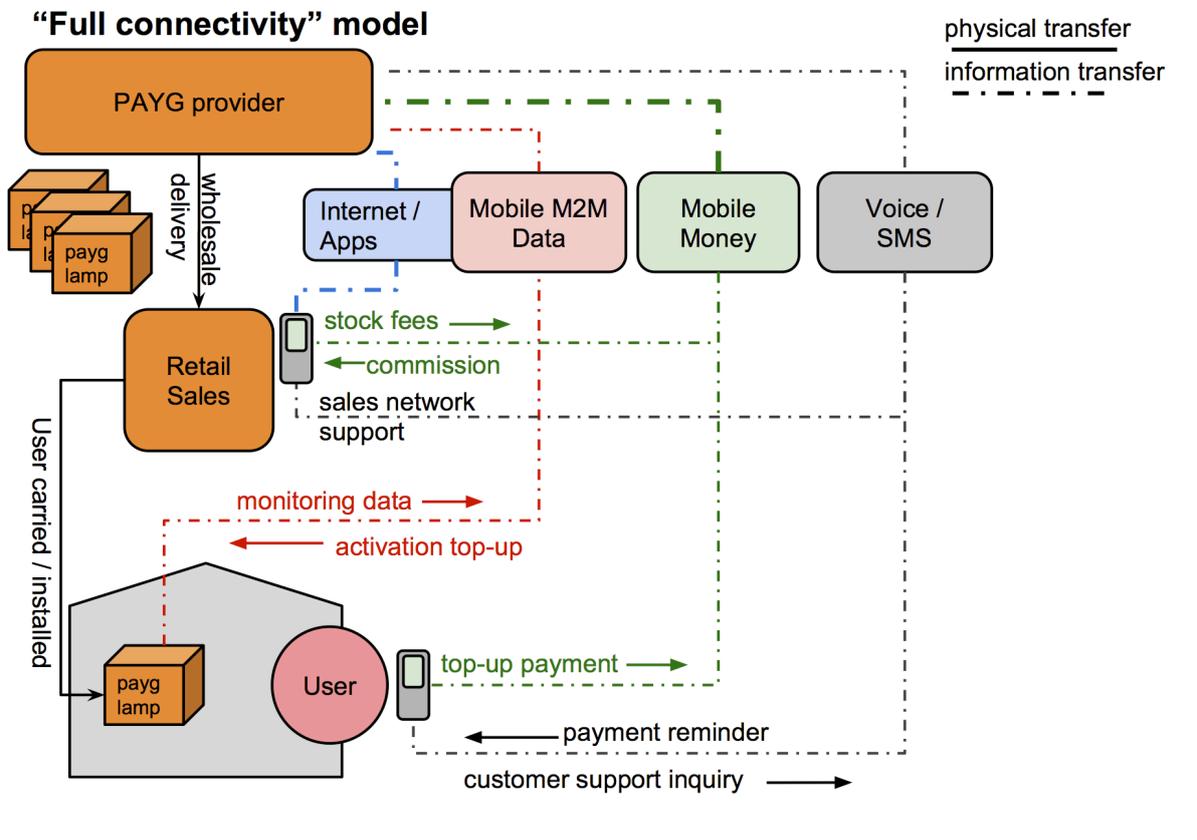


Fig. 10. Flow of goods, information, and money for “full connectivity” PAYG

The two study lamp pico-solar products that were part of our study--those developed by Angaza and Divi Power-- utilized a **periodic connection with smart phones** to verify payment and unlock the solar device. In this case, unlocking was accomplished by connecting the device to a dealer’s smartphone, where a proprietary application accounted for customer credit, supplied an unlock code to the solar device, and facilitated a temporary bidirectional data transfer. All performance data is stored on the device until an internet connection is established, at which point it is downloaded from the device and sent to the central office via cellular network. The payments in this case can alternatively be made through mobile money or through a cash payment to the dealer, as is shown in the figure below.

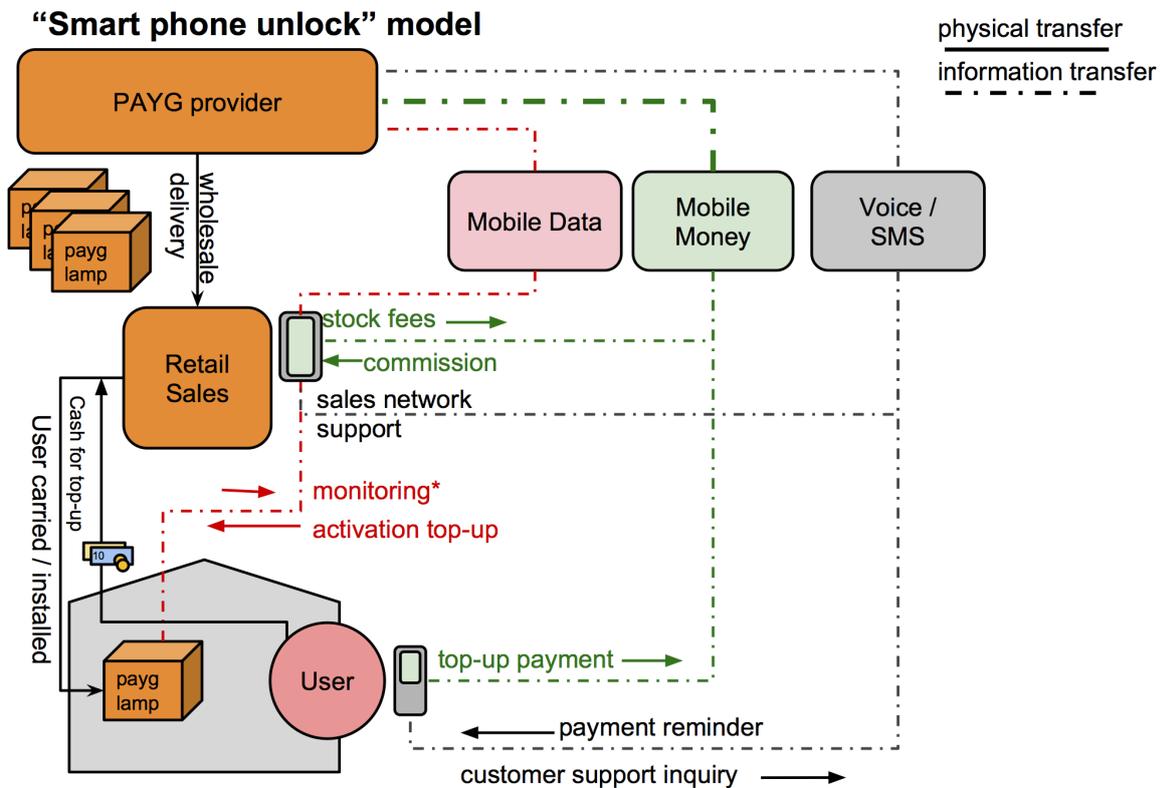


Fig. 11. Flow of goods, information, and money for “smart phone unlock” PAYG

Other PAYG systems such as the Simpa Networks Progressive Purchase device or Azuri Indigo Duo are activated by keypad--using a **scratchcard** or SMS-generated codes--and no direct connection is ever made between the solar devices and a central server. Such systems only have lock and unlock capability and no data transfer. To prevent codes from being used multiple times, the typical sequence of operations begins with the purchase of a scratch card, then the code from that card is sent via text message by the customer to an automated system along with their account number (or it is linked with their mobile phone number). That system verifies the scratch card number, matches the payment to a customer account, and sends back a unique unlock code for entry on a keypad connected to the solar device. An onboard microprocessor in the solar device recognizes valid unlock codes and independently tracks progress towards full repayment. An alternative to this model is directly selling keypad-ready codes at the retail level, where retailers use their smartphones (or standard phone) to generate a code for customers who pay for them in cash.

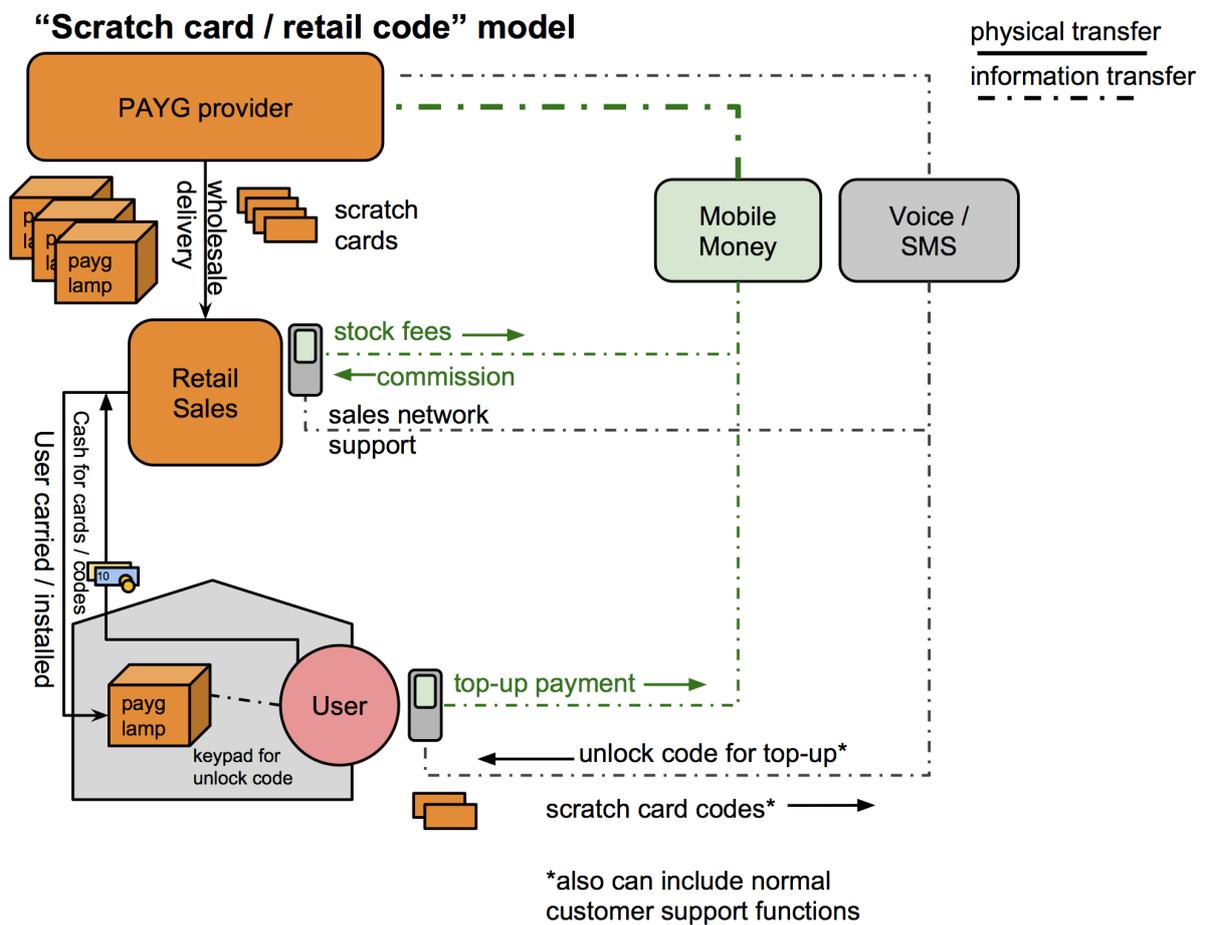


Fig. 12. Flow of goods, information, and money for “scratch card / retail code” PAYG

STUDY METHODS AND CONTEXT

Our mixed-methods study of the off-grid lighting market combines end-user research (surveys and focus groups), in-country supply chain observation (surveys at retail shops, with distributors, and supporting organizations), and analytics of global dynamics (spread of mobile money, trends in underlying technology and policy context). The focus of the end-user and supply chain research is Kenya, concentrating in particular on towns where our partner organizations have been active. This strategy was adopted to capture an in-depth view of the dynamics for the emerging PAYG marketplace to bolster broader analytics of current market trends or issues. Our effort builds on past work by the Lighting Africa program, other institutions, and a growing set of researchers focused on understanding and shaping the off-grid power market.

Kenya is a special case for solar and off-grid power in general, and particularly for PAYG, where the early success of M-KOPA was burgeoned by a growing pico-solar market and by Safaricom's dominant and near-ubiquitous M-Pesa mobile money platform. Most other markets have earlier-stage pico-solar and mobile money marketplaces, making Kenya either a special case, an indication of things to come, a learning experience, or some combination of those.

Our work:

This report is based on years of experience in the broader off-grid power market and focuses the analysis on insights gathered in 2014, during 2 months of field research in Kenya and approximately 4 months of data gathering that followed.

Our work in Kenya included surveys of 132 local retailers and wholesale traders, 15 national distributors, and 6 finance professionals. We worked closely with in-country partners SunnyMoney, M-KOPA, Angaza Design, and Divi Power to conduct 215 customer phone surveys, as well as 4 customer focus groups in 2 locations. In addition, our team collected publicly available information on 30 PAYG providers operating in 32 countries, which included system size, total number of customers, total investment per company, etc.

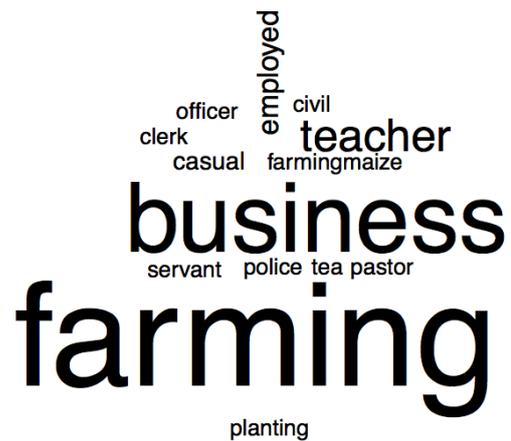


Fig. 13. The main source of income for PAYG customers in our surveys (N = 215), interpreted through a word cloud.

Research partner organizations:

In this section we summarize general information on the research partners in our study. With each partner we worked to understand their business model in depth and also executed a telephone survey of customers. In addition to these deep dives, brand-agnostic research in the Kenya retail market for off-grid solar significantly augmented these case studies in developing our findings. The methods included structured interviews with a range of stakeholders and experts in the supply chain for off-grid energy and PAYG firms along with retail-level surveys of the Kenya market.

M-KOPA is the largest PAYG firm in the early market, passing 100,000 systems in June 2014 during our field study and having reached over 150,000 and expanded beyond Kenya by 2015. In June 2014, **M-KOPA** sold a d.light-manufactured solar home system (5 W solar) that included 3 lights and a radio, the D-20g. The offer is detailed in the Table below along with others. Prior to our study M-KOPA sold the D10, a slightly lower-service system, also made by d.light, for a lower price point, 40 Ksh per day. At the conclusion of our study period, M-KOPA launched a new version of their product, the M-KOPA III (8 W solar), produced and sold solely under an M-KOPA brand (i.e., no longer co-branded with d.light). The price on the new system has also been reduced, to 40 Ksh per day.



Fig. 14. The M-KOPA Customer Care operations center, and the M-KOPA branded d.light d20g circa June 2014, in Nairobi.



Fig 15. PAYG lamps sold by SunnyMoney circa June 2014, the SunKing Eco with Angaza PAYG platform and divi light.

SunnyMoney and SolarAid are the commercial and charitable arms of an organization that has sold over 1.5 million solar lights (as of early 2015), the vast majority of which are not PAYG. Selling through institutional partnerships with schools and a retail agent network, the approach has driven fast growth in the early-pico solar market. **SunnyMoney (SM)** was working with two integrators of PAYG study lamps during our research period, both of which supported independent PAYG pilots through the SunnyMoney schools campaign in Kenya. The first, **Angaza**, is partnered with **Greenlight Planet (GLP)** to offer PAYG-enabled “Easy Buy” SunKing Eco lamps. SunnyMoney specified a pay-off period of approximately 10 weeks using M-Pesa for the Angaza lamps. The pilot was the first deployment for the Eco Easy Buy. The second partner, **divi Power**, offered a PAYG study lamp known as the *divilite* (similar in performance and features to the Eco). Its pay-off period was 5 weeks, with cash payments (in the pilot tests we observed). As a benchmark, the standard Eco has a normal cost through the SunnyMoney Kenya supply chain of 1000 Ksh (~ 12 USD).



Fig. 16. Informational meeting for head teachers who will offer PAYG study lamps to families at their schools

Table 1: Summary information on PAYG systems that were the subject of our research focus.

System:	M-KOPA / d.light D10	M-KOPA / d.light D20g	SM / Angaza / GLP Sun King Eco	SM / divi / Divilite
Form Factor	Pico-SHS	Pico-SHS	Study lamp	Study lamp
Branding	M-KOPA / Safaricom	M-KOPA / Safaricom	SunnyMoney / Angaza / Greenlight Planet	SunnyMoney / divi
PV Power Rating	4 W	5 W	0.5 W	0.5 W
Accessories	USB phone charging	USB phone charging, includes a radio	NA	NA
Down payment	2500 Ksh (USD ~29)	2999 Ksh (USD ~35)	200 Ksh (USD ~2.30)	200 Ksh (USD ~2.30)
Recurring payment	40 Ksh + ~5 Ksh M-Pesa fee (USD ~0.52)	50 + ~6 Ksh M-Pesa fee (USD ~0.65)	110 Ksh + 22 Ksh M-Pesa fee (USD ~ 1.30 + 0.26)	200 Ksh (USD ~2.30)
Recurrence period	daily	daily	weekly	weekly
Number of periods	365	360	10	5
Total outlay	17,100 Ksh + 100's-2000 fees** (USD ~200 + 20)	21,000 ksh + 100's-2000 fees** (USD ~240 + 20)	1300 Ksh + up to 220 fees** (USD ~15 + 2.60)	1200 Ksh (USD ~14)
Payment Mechanism	M-Pesa Paybill	M-Pesa Paybill	M-Pesa Paybill	Cash Payment (collected by the Agent / HeadTacher)
“Unlock” mechanism	GSM / M2M	GSM / M2M	SmartPhone App + cable connection	SmartPhone App + Bluetooth connection
Lighting Global QA Verified?	No*	Yes	Yes, for the “standard” Eco	No*

* While these are not verified by Lighting Global there were no obvious quality issues with these lamps that we were able to observe in the field or other informal settings. Note that this is not meant as an endorsement or declaration of nonconformance with respect to the quality of the product on behalf of Lighting Global. It is an observation by the field research team based on limited field-based observation, in support of this analysis.

** The sum total fees for cash transfer depends on the frequency and size of consumer payments. More frequent, smaller payments incur higher fees as a fraction of the total and larger transfers typically achieve lower transfer fees.

OVERCOMING ENERGY ACCESS BARRIERS WITH PAYG

Pay-as-you-go provides a technological platform that addresses many of the factors that impede the widespread adoption of off-grid solar. Not only does PAYG supply necessary financing for poor consumers, but also allows last-mile distributors to stock more inventory, signals quality to the end consumer, reduces the cost of monitoring and after-sales service, and improves visibility in the market so businesses and supporting institutions can adapt to consumer needs more dynamically. Concurrently, new barriers related to implementing more complex, linked technology and human resource systems arise that should be addressed by manufacturers, distributors, and supporting organizations to ensure the greatest impact and reach.

UP-FRONT COST

The typical purchase price of a solar product can range from nearly \$10 for low-end pico products to \$200-300 for mid-range low-power solar home systems. In either case, such amounts are prohibitively expensive for some or many of the off-grid poor who may only have cash income of \$1-\$2 per day. PAYG addresses this barrier by amortizing the high upfront capital cost of products over a time period that the off-grid poor can much more easily accommodate. By reducing the size of cash outlays required, the payment stream for PAYG systems more closely aligns with status quo spending patterns for the incumbent energy services (kerosene and fee-based

mobile phone charging). Figure 1 illustrates how the effective daily costs during repayment are similar to typical costs for kerosene for households in Kenya, with vertical lines indicating the daily cost for the SunnyMoney (19Ksh/day – roughly \$0.25) and M-KOPA (50 Ksh/day – roughly \$0.60) systems that were sold during our 2014 field study.

While the daily costs for repayment are slightly higher than the average spending on kerosene, it is important to note that the service levels are orders of magnitude better, providing valued service beyond the kerosene that is replaced. The repayment period is not in perpetuity for these two examples, which are both micro-loan models.

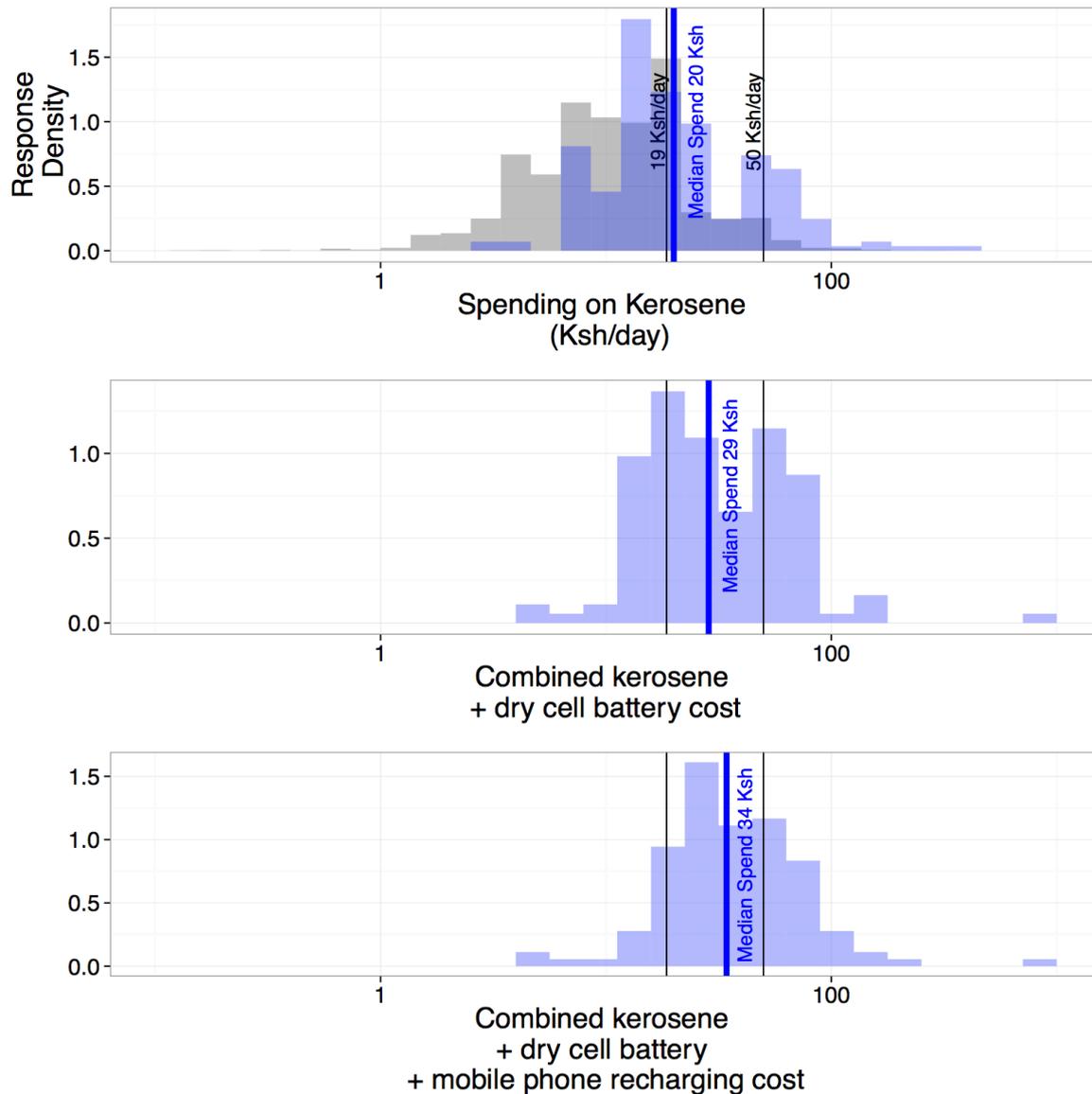


Fig. 17. Comparing the status quo daily spending on kerosene, batteries, and mobile phone charging to the effective daily charges for the two PAYG systems we studied in depth (~19 Ksh/day for 10 weeks for the SunnyMoney study lamps and 50 Ksh/day for one year for the M-KOPA pico solar home system). In panel [A], the distribution kerosene spending for lighting is shown. The M-KOPA solar home system provides substantially more lighting service than kerosene lighting and also valued radio and phone charging, so the comparison on cost of kerosene is incomplete. For a better comparison we include spending beyond kerosene in the other panels, including [B] dry cell batteries (normally purchased to power radios) and [C] with mobile phone charging fees. The spending data displayed in grey in the first panel are from the Kenya Integrated Household Budget Survey for a benchmark reference (2005, $n = 9,432$ responses) and have been adjusted to 2014 values using the Kenya Consumer Price Index. The spending data displayed in blue in all panels are self-reported estimates from the survey our team deployed to individuals who purchased a PAYG solar system (2014, $n=205$). The values are what they recall spending per day on kerosene, dry cell batteries, and mobile phone charging before purchasing the system.

TRUST

Building trust in clean energy technologies remains a great concern in these emerging markets, and PAYG can instill trust along two distinct dimensions: trust in the quality of the products and trust in the match between a product's performance and household needs. Customers in the focus groups made a clear link between PAYG finance and trust in quality, pointing out that by shifting more early failure or underperformance risk to the manufacturer, there are added incentives to ensure quality and meeting customer expectations. One of the focus group participants said, *“If you see someone giving you a lamp to pay slowly, that means they have confidence with their product.”*

Strengthened trust in performance value derives from PAYG allowing a consumer to test the product for some time without paying the full cost, giving the consumer the opportunity to stop payments if product performance is not as advertised. Some customers have the ability to pay full cost and use the opportunity to try products at home for a relatively low outlay, paying in full following a short initial period of use.

We can observe how for some customers, overcoming this initial performance trust barrier behavior leads to fast repayment (if they did not also need financing to overcome cost barriers). The pattern emerges from payment data we analyzed from Sunny Money customers (see figures

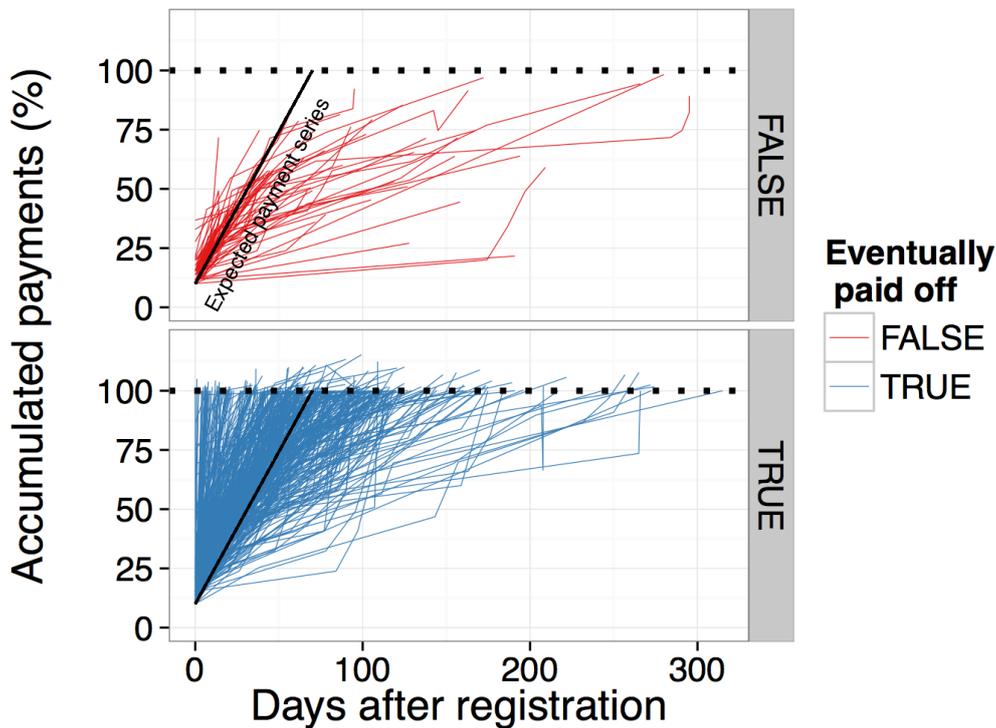


Fig. 18. Diverse paths to repayment (or not) for lamps in a SunnyMoney pilot. These plots trace the repayment behavior of a sample of anonymous individuals in SunnyMoney pilot tests, who pay over the course of 10 weeks. The range of paths in repayment indicate diversity in behavior for those that both did and did not eventually pay off the lamps (indicated with split plots and colors). The dotted line indicates 100% repayment for the study lamp, and the solid lines represent the “ideal” repayment behavior, i.e., the trend that occurs if an individual makes each payment exactly on the timeline suggested in the advertising and marketing literature.

below). Out of the ~80% of customers in the trials that eventually completed the repayment cycle, there is a clear subset of customers (about 15% of those who paid fully), who made a full repayment in the initial 30 days following deposit. While it is possible that some of these customers were able to pay off their products early with windfalls of cash (e.g., from either their employer, remittances, or another source), we have reason to believe based on qualitative data from focus groups and surveys that this repayment behavior illustrates that for some customers.

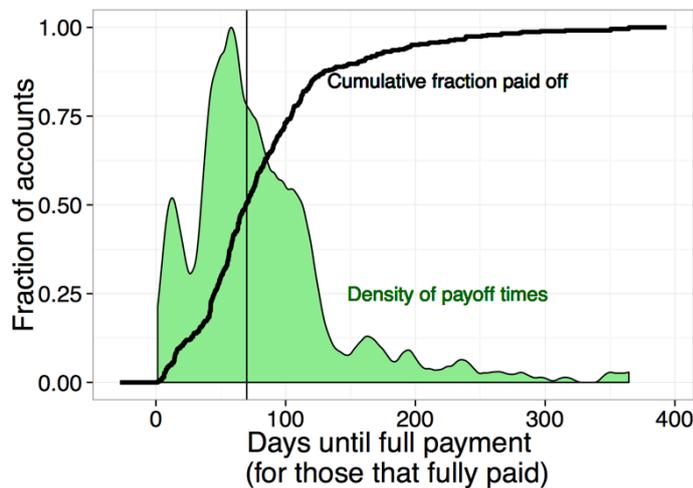


Fig. 19. For those who eventually pay off a study lamp (from the previous figure), the number of days until the lamp is fully paid. A vertical line indicates the expected repayment date based on product literature (10 weeks after purchase).

RETAILER RESOURCE CONSTRAINTS

Retailers and potential sales agents in Kenya may be as resource constrained as consumers, which limits their ability to purchase sufficient inventory. During our retail surveys, many of the interviewees commented on their inability to fulfill customer demand, often due to their own resource constraints and the requirements of manufacturers to have products paid-in-full upon delivery. PAYG providers typically require retailers to only pay a

deposit amount up-front (i.e. the PAYG company retains the majority of default risk), which is a fraction of the total unit price and lower than typical wholesale prices. When incorporated into the retail market, PAYG financing thus allows retailers to carry a larger inventory of the PAYG product with reduced needs for retail-level working capital (the working capital debt is essentially taken on by the PAYG organization). Our team heard from retailers about the dynamic of getting extended credit for stocks after repeated good business with their supplier. In an off-grid and remote town in southwestern

Kenya, an M-KOPA saleswoman was so successful in her first three months of sales that she was given the opportunity to double the number of systems stocked in her store. Depending on the structure of retail incentives and business relationships, PAYG can essentially offer credit to both end-users and the retail network by restructuring payments for both.

AFTER SALES SERVICE

Product after-sales service has often been a significant barrier for solar providers in developing countries and is in many ways related to the aforementioned concerns about quality. The retail surveys our team conducted confirmed this as a continued source of concern. In the case of permanently and intermittently connected PAYG, overcoming this barrier can be supported through real time feedback to manufacturers regarding product performance and use (typically in the form of voltage, current, runtime, charging, etc. data). Since there is risk split between buyers and sellers, there are stronger-than-normal incentives for firms to more rapidly honor warranties and conduct

maintenance that reduce payment stream interruption. Firms with capabilities for monitoring (either the payment stream or remote monitoring of system performance) can act proactively, contacting users when products begin to malfunction in order to prevent system failures. In turn, an improved after-sales service model may attract skeptical consumers who previously perceived the risk of investing in unknown or poorly understood technology as too high.

MARKET INTELLIGENCE

By collecting significant data around consumer behavior, PAYG firms also have strong advantages over traditional players in understanding the performance of their product and shifts in consumer behavior. In particular, home system PAYG firms can more rapidly respond to changing consumer consumption patterns and provide users with upgraded products (e.g. larger batteries or new converters and connectors), new appliances and loads, or entirely new and expanded systems. As the market shifts, PAYG providers are better able to respond by releasing new products and services. Furthermore, system monitoring and customer data allow companies to gather real-time feedback related to product performance in the field to inform product improvement for the next iteration. The direct connectivity enabled by some of the PAYG systems also facilitates more fluid communication with customers. In short, the information that can be collected related to device performance, consumer preferences, and payment history could

form the core of streamlined models for market monitoring, regulation, and support with appropriate levels of transparency and access to data.

These customer data may be particularly useful for supporting expansion in system capabilities. The figure below shows the category of improvement that is mentioned by customers we surveyed. For users of study lamps without mobile phone charging (SunnyMoney) the key priority is obtaining that recharging feature. Other high priority services are brighter lights, radio, and television. The majority of customers spoke about system expansion in terms of service, rather than technical expansion along engineering terms (e.g., the size of solar module, battery, and other components). While an expansion in service may entail expanding both the energy side of the system and adding appliances, it is the service that is a key priority. Thus combined packages of expanded system capabilities should include both to improve their appeal. These offers could be targeted based on repayment and the use of the current system, identifying customers with spare capacity for additional appliances, and/or the ability to pay for an expansion. Targeted and customer-specific data that would have once been difficult or impossible to track and use for supporting expanded access are now built-in to many PAYG business models. We expect a range of approaches to managing these new organizational capabilities for improving service offerings and expanding the reach of off-grid solar.

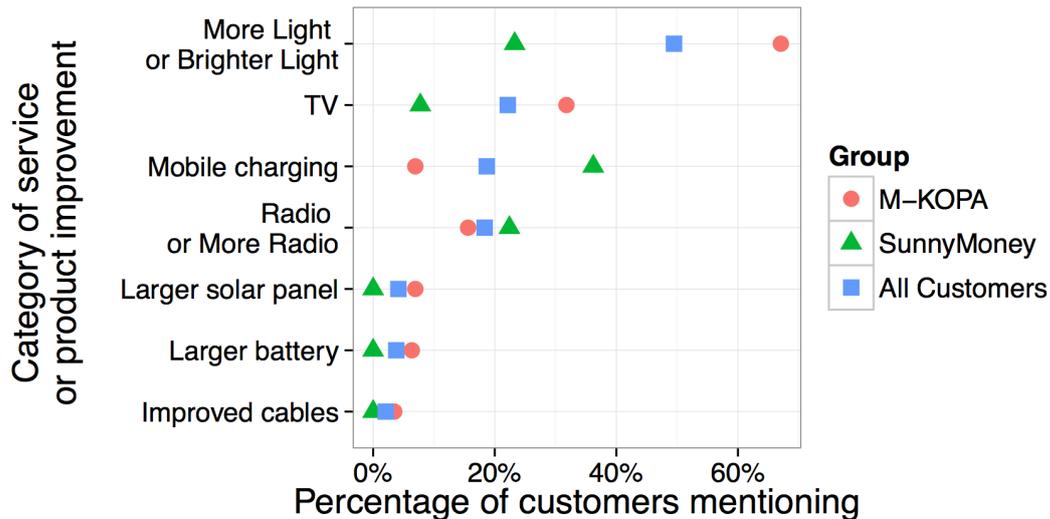


Fig. 20. The highest priority for system improvement or expansion among PAYG customers. The data are shown separately for M-KOPA (mkopa) and SunnyMoney (sm) customers, along with the aggregate.

NEW INTERFACES AND CHALLENGES

While PAYG is an effective approach for reducing many typical barriers to supplying solar products for energy access off the grid, new barriers and frictions not present in a cash-sales market are created through the integration of PAYG technology. In this section we identify some of these emergent issues at the interface between customers and businesses and opportunities to address them.

PAYMENT AND VERIFICATION

In the early PAYG market there are a variety of approaches to payment collection and verification (i.e. controlling whether devices in the field are unlocked or are deactivated due to lack of payment). Every firm we have observed has a slightly different combination of technologies, which could lead to a degree of customer lock-in by introducing a cost to switching platforms based on the time needed to familiarize and learn a new system. For example, M-KOPA accepts mobile money payments using the SafariCom “Paybill” system for a central account, and the system automatically verifies payment using a GSM chip embedded in the product. The SunnyMoney pilot we observed tested two approaches with unique payment methods, both requiring the lamp to be transported to a central

location to verify the payment. The Angaza/Greenlight Planet system used the same M-Pesa utility account payment system—Paybill—as M-KOPA and used a cable-based connection with an agent’s smart phone to verify. The *divi* pilot test combined cash payments to the agent and a Bluetooth connection to their smart phone for verification. Another model in Kenya (exemplified by Azuri) employs scratch cards or remotely-generated unique codes and an agent network as a way of distributing them, with a two-step verification process that does not require connectivity at the premises where the device is located. Other approaches can involve a range of payment platforms and verification steps. These clusters of collection and verification systems used in Kenya and globally are indicative of a market undergoing significant growth, where creativity in new approaches is

accommodated with fresh markets and uninitiated users. This is enabling a robust environment for learning what mix of approaches can best meet the needs of sellers and buyers using PAYG systems.

Overall the PAYG customers we surveyed were happy with the payment and verification systems (nearly 90% reported that the process was “easy”, while others indicated that it was okay or that the payment process was hard to understand).

TRANSACTION COSTS

While PAYG reduces the upfront cost for consumers through the extension of a micro-loan or a fee-for-service model, the currency used for repayment often comes with a fee structure that can significantly impact overall cost to the consumer. Depending on the system size and payment type (for example, in Kenya, M-PESA has 3 types of payments, each with different tariff structures), mobile money fees can reach upwards of 25% of the total system cost to the consumer over the course of repayment, often equal or greater to the financing fees (i.e. the difference in simple cost between a PAYG product and a cash-sales equivalent system).

FEATURE REQUESTS

While overall the users of PAYG systems did not express significant concerns over the usability of PAYG devices, the following requests for features represent opportunities for growth in the PAYG sector. These come primarily from the in-depth focus groups we conducted, along with other surveys and conversations.

- 1) **Expanded ability to activate non-GSM lamps** through a range of channels, not solely through direct agent contact. While the majority of customers reported no issues with the process, some reported difficulties in accomplishing the activation logistics for lamps where a specified dealer agent must activate the lamp. This was in part due to the occasionally complex logistics of locating the agent, traveling long distances (several km in some cases), or the frequency with which users had to take the trip. This was particularly challenging when the agent was not centrally located. As the market grows and a larger agent network is established, the challenges of logistics could be reduced. Non-GSM PAYG lamps are important because currently GSM chips are cost-prohibitive in some applications (like entry-level study lamps) and network coverage is not universal in many rural areas.



Fig. 21. Power and mobile communication infrastructure in Western Kenya

The payments made by *PAYG customers* have other transaction costs as well, including the costs associated with

conducting diligence on small loans, often through phone or in-person surveys; the cost of the software and hardware required to allow for PAYG, and in cases where agent networks are active participants in fee-payment or verification there are additional costs incurred.

- 2) **New features and options for interfacing with their micro-loan payments:** A set of extensions on the capabilities of payment systems were suggested by the users:
 - a. **Notification services** (e.g. payment being due): several people in focus groups expressed a desire for an improved notification system that acts as a reminder, urging payment a day or two before it is due. We note that these systems were in place for the pilots, but some focus group members expressed that they would like an improved system (or they did not get the notifications, e.g., because the phone attached to the account may be different than the one they regularly use).
 - b. **Balance checks:** Some focus group participants expressed that they would like a simple system to check the current balance, allowing them to reduce the effort for remembering when and how much to pay.
 - c. **Ownership transfer:** There were lively discussions in the focus groups about the desire for secondary markets where partially-paid systems could be transferred by the original owner to a new owner who would take over the loan payments (allowing them to recoup part of their investment). Two necessary conditions were mentioned for this: balance checks (see above), and a way to verify and transfer the account from person to person.
 - d. **Theft protection:** People were interested in the idea that stolen PAYG systems could be reported by them and remotely shut off to reduce their value to thieves. Theft is a key concern for off-grid solar customers: our survey showed 40% of PAYG customers actively manage their solar module (moving it inside at night), with security being the most commonly cited reason.

PAYG ECONOMICS

PAYG combines market fundamentals from several intersecting areas: global supply chains for electronics, rural distribution networks, mobile money payments, and international financing. Bringing together insights from the broader market with focused effort on understanding PAYG we identified a number of core features that should be understood by entrepreneurs, policymakers, regulators, and supporting organizations.

RISK PROFILES

PAYG provides a reduction (and in some cases elimination) of some of the risks that are often cited as barriers to off-grid power, but it also leads to other shifts in the overall risk profile of the market. Many PAYG firms face a number of additional risks that require unique management strategies for sustainable business in these markets.

Currency exchange risk can become a significant concern for any business model that provides credit to consumers.. Some companies in other sectors often chose to mitigate the effect of local currency value by only borrowing capital from local banks. However most PAYG providers have been unable to exclusively source local capital. Furthermore, when inventory is ordered long in advance of

sale, currency risk remains a problem, as prices are typically negotiated in US Dollars. Therefore, PAYG companies need to price the expected changes in currency into the retail prices charged to customers in order to maintain sustainable revenues and make debt and equity payments to investors, or face potential losses.

In the foreign exchange figure we show a range of representative currency exchange rates from countries relevant to PAYG solar. While the majority of fluctuations have been small and require little effort from companies, the three year period ending in 2013 demonstrates the potential for shocks in foreign exchange markets (FOREX). Furthermore, not all PAYG providers will be equally affected by such changes in exchange rates. Providers of lower-cost (and lower power / service) products, with short repayment terms (in

the weeks-months range), would be least affected and can easily incorporate the expected currency fluctuation into the product price. For firms with product loan tenors exceeding a year, the risk becomes greater but still manageable through price adjustments or through the use of a debt service reserve account in the case of short-term extreme currency fluctuations. For developers of large household level or community mini-grid projects with PAYG components, the risk of significant currency exchange rate fluctuation during the life of the project is fairly high. In this case, debt service reserve accounts, currency hedges, and other mechanisms may be necessary to reduce the risk of losses.

As with any financed product, PAYG providers face **potential consumer default**. Through our research, we identified three key factors that affect default risk for PAYG companies:

1. Quality of technology: For PAYG products, the quality of lighting technology becomes critical in avoiding consumer default. If the product fails before the loan is fully repaid, the

consumer will cease payments until the item is replaced. Furthermore, if the time to replace a failed product exceeds expectations, customers may refuse to pay and move to a different product or a different provider. Finally, if product failure occurs after the loan is repaid but before the official warranty period ends, the consumer may lose trust in the provider and may decide not to purchase other products from the same company. Thus, product quality becomes paramount not only in generating revenue but also in the ability of the PAYG provider to scale past the initial product offering.

2. Changing ability to pay: Most PAYG providers conduct an informal credit check of every consumer, either at the point of sale or by phone following an initial inquiry. Such surveys often include self-reported information about income, property ownership, housing type, family size, level of education, and other factors. While this information is very useful to eliminate customers who clearly lack an ability to fulfill debt obligations, the majority of credit checks are yet unable to accommodate or predict the impacts of

Foreign Exchange over 3-year period

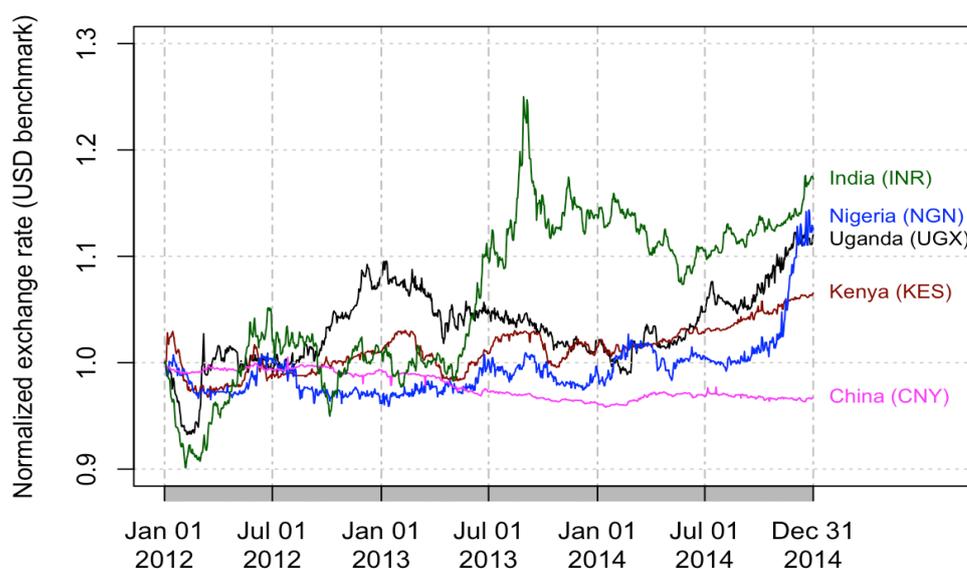


Fig. 22. FOREX for representative currencies, normalized so the ratio with USD at the beginning of the series is 1.

seasonal or unexpected fluctuations in income for all customers. For example, if part of the consumer base of a PAYG product is involved in coffee farming in Kenya and global commodity prices drop like they did in 2013, then a large proportion of paying customers may lose the income they need to finish repayment on their loan.

3. Tampering and theft: PAYG technology is relatively new, and while most products attest to being tamper-proof, experience with other measures such as DRM on DVDs or manufacturer locks on mobile phones suggests that tampering can occur among widely used IT-enabled services. However, it is important to note that none of the providers we interviewed indicated that this was a significant risk to their business based on early experience with the market.

Many PAYG providers have cited concerns around **policy risk**, like mobile currency regulations in the markets in which they currently operate or target countries for expansion. While Kenyan PAYG companies have seen a lot of success, it is unclear whether or not they will be easily able to adapt to new country regulations as they expand. This is particularly true for models that depend on a specific type of mobile currency, such as M-Pesa, which although widespread, has not seen the same level of global penetration as it has in Kenya.

As with any business that is not vertically integrated, there are **partner risks for most PAYG firms**. Thus far, most PAYG providers of GSM-enabled systems have created strong partnerships with mobile telecommunications giants to support their efforts. Fenix International and Nova Lumos both work exclusively with MTN in Uganda and Nigeria, while M-KOPA has partnered with Safaricom in Kenya. While this model has certain

advantages, the potential risks are worth noting.

Since PAYG providers are relatively small entities thus far, they may have little bargaining power when it comes to determining transaction costs for mobile money transfers. Thus, if an operator chooses to raise rates--with significant implications for the overall price a customer will have to pay for a PAYG product--the PAYG provider can do little to avoid the resulting losses in customers or margins. Furthermore, if the single partner telecommunications company experiences technical issues resulting in dropped or delayed payment transfer and the PAYG provider is dependent on the network for payments, there can be losses incurred and customer confusion if no other means of payment are available and products become disabled.



Fig. 23. Pico solar powers rural households in Ethiopia (Alstone, 2015)

While partnership with a single telecommunications provider in a country like Kenya, where Safaricom holds significant market share, can be acceptable initially, the limitations become more serious when scaling or when operating in a more diverse market.

Being limited to a single telecom partner can limit market penetration and potentially deny access to willing and able consumers. Furthermore, depending on the mobile money service, it is possible that there is some self-selection bias amongst different income tiers of consumers, thus limiting the total socioeconomic impact that a PAYG provider has.

DOWN PAYMENT

While consumer financing reduces the up-front cost barrier significantly, the initial down payment that many PAYG companies charge can still be prohibitive for marginal consumers. With the M-KOPA system, the ~3,000 KSH deposit that is currently charged for the M-KOPA III system is equivalent to the monthly income of many off-grid consumers. These deposits protect the firm from losses and are a barrier to entry that limits the participation of poorer customers. Improvements in the scoring approach that PAYG firms employ to select potential customers (based on the valuable data generated by a growing number of repayment data streams) could lead to a reduction of the down payment from improved views on default risk and even



Fig. 24. One of the ubiquitous M-PESA agent locations in Kenya

further improvements in market access.

COMPETITION AND MOBILE MONEY MARKET SHARE

Mobile money fees play a role in the ability of any individual product to compete in the market. For example, in Kenya, many PAYG providers employ M-Pesa Paybill (the dominant mobile money system) for all of their payments. It is advantageous to use Paybill because it is a service that offers the ability to have unique accounts associated with a repayment stream, enabling users to pay for multiple accounts using the same phone number. Paybill fees are negotiated individually with each firm (without standard fee structures), providing space where firms can gain retail cost advantages over competitors. This friction in the market can create distortion. The mobile money fees also present the opportunity for exercising a degree of retail market power by telecom providers that process payments and also co-brand or offer a PAYG system through their business (this has not been identified in the market thus far; it is raised here to provide clarity to the dynamics between mobile money and digital financing more broadly). The paradox is that it is attractive from one perspective to enter a PAYG market where there is a single, dominant, widely adopted mobile money platform to reduce the up-front cost in IT system setup and integration. However, a single telecom operator also exposes firms to risks from fee changes (depending on the agreement structure) and potentially competitive disadvantage in fee negotiation if the telecom is partnered with another firm or offers its own PAYG product for sale.

UNIFORM PRICING

Beyond payment platforms, the harmonization of pricing across regions or nations (i.e. you pay the same regardless of whether you are in an urban center or a

rural village) has important implications for reaching outlying areas. Since pricing and margins are fixed, the sales agents cannot charge more in rural areas to cover the additional (and real) transportation costs to reach them. For rural consumers, however, this also has an upside of preventing double marginalization (i.e. raising prices to maximize retail-level profit) by resellers or agents who may hold a local monopoly on distribution in an area. Providing support to rural sales agent networks in support of distribution in sparsely populated areas could be an area of focus for market transformation efforts to ensure PAYG reaches both the rural and urban poor.

ACCESS TO WORKING CAPITAL

Like the broader off-grid solar market, one of the core barriers to scaling PAYG is access to working capital financing. Access to working capital allows PAYG providers to stock more product in country, supply larger inventory to retailers and agents, and extend better loan terms to consumers. All of these factors ultimately contribute to higher levels of access. At this point, investment in the PAYG sector has been insufficient to fulfill capital needs for providers. Although more than \$70 million of equity, debt, and philanthropic investment in PAYG firms has been publicly announced (originating from over 60 unique investors), a recent report by the Global Off-Grid Lighting Association (in 2014) cited a sector-wide need of over \$1.5 Billion of investment to support consumer finance over the next 2 years.¹³ Bridging this gap will be crucial for growth in PAYG and the broader market.

SOCIAL AND FINANCIAL RETURNS

There is still a no common framework for assessing the performance of PAYG firms providing service to the market, particularly for investors and organizations trying to measure social

impact and the financial profile of PAYG investments. In some cases the lexicon of the mobile phone industry is borrowed, with average revenue per unit reported. In other cases the descriptions are along financing lines with default or total repayment rates for systems offered as a loan (i.e. the fraction of expected payments received). Conversations with PAYG firms thus far have revealed that about 90% of the expected payments are eventually received, and higher rates are often reported publicly (e.g., M-KOPA reports a 95% repayment rate^{14,15}).

There is an important distinction however between the micro-loan repayment rate and system activation rate (in other words, the fraction of solar home systems that are not deactivated). While the repayment rate is important for financial returns, it is the system activation rate that determines the degree of energy access provided, and it is inevitably lower than repayment rates due to system deactivation after partial payment. As an example of how the difference plays out in practice, consider the overall results from repayment for roughly 650 customers in the SunnyMoney sales trial: For these customers, 90% of the expected payments were received but only 80% of customers were left with an activated lamp. That 10% gap represents customers that made some payments but did not fully repay. It is important to note here that those customers did receive energy service during the time when payments were made, so the loss is not complete (kerosene spending would have been offset during that time), but there is a missed opportunity to recover additional payments and put stranded solar energy assets to use.

One solution for companies to increase repayment and redeploy assets is to formalize and ease the transfer of stranded assets between consumers in

secondary markets. While in theory the PAYG firm can often repossess systems that are not fully paid, it may be cost prohibitive (depending on the size/resale value of the system) and difficult from marketing and communications perspectives to redeploy previously used systems in retail markets through normal sales channels. Focus group participants indicated that clear processes for ownership transfer on a secondary market would be valuable. They emphasized that a critical element to make the system work would be having easy ways to verify the remaining balance (so negotiation on a price to transfer could occur, potentially allowing the original owner to recoup some investment) and to verify the transfer of the account from one individual to another. With the proper controls around identity fraud, the new owner could repay the system and ownership could be transferred to that person at full repayment. Such a system could also benefit the retailers of PAYG products, who often make much of their commission only after the full repayment of the product.

DATA PRIVACY AND UTILIZATION

Data is a key component of many PAYG business models, with substantial improvements over the status quo in visibility on repayment behavior and often also system-level monitoring. People in the focus groups voiced reasonable concerns about their personal privacy while also recognizing the value in these types of data.

A clear distinction was made regarding when and how the data could be used: the people we heard from approved of operators using data to improve consumer experience or business operations but they disapproved of the data being sold to third parties wholesale, regardless of the intended purpose. As one focus group participant elaborated:

“It’s good when the company keeps track of the payments and charging...so the lamp can be improved. Recording that information is like being closer to users (and lets the company understand the experience)...but I would not advise the company to give out the information because it might be misused.” – focus group participant A (summarized from translation)

“If another party wants to have the data, they should sell their own lights, and get to know us.” – focus group participant B

Their concerns about misuse stem from a range of issues: One that came up in the groups was M-Pesa fraud, a confidence scheme where someone will defraud a person by “accidentally” wiring them a small amount of money, then asking for the money back...they then say that the refund was not received and ask for a retry or may raise the stakes. People had concerns that PAYG customers may be sensitive targets for scams that involve the system, if personal data are released.

Another potential misuse that was raised was those that obtain the data may use them harm the market share of SunnyMoney or create “fake” products. Customers in the focus groups felt a sense of connection with the PAYG offering firm (in this case SunnyMoney), and wanted to protect the organization. The people in the focus groups recognized that their market data were valuable, and expect confidentiality and security with them.

A final concern was over the potential for remote surveillance based, which could be used to identify the patterns of travel for people who use the system. Such a concern has been raised in the developed world with “smart” electric meters as well, where concerns include the potential for burglary of homes or other nefarious activity.

Customer concerns about data sharing do not necessarily preclude many of the ways PAYG operators are deploying them, but highlight the need for clearly communicated expectation. Consider the case of PAYG payment streams used to develop credit histories. This process is standard in many developed economies where most repayment streams on loans (and other bills) are provided to credit scoring companies, such as FICO, Experian, Equifax, etc. Credit scores are being used already in Kenya through the M-Shwari micro savings and loan service that is offered by SafariCom through the M-Pesa platform, which has been adopted by over 15% of the country (with 30% of those adopters using the loan features)¹⁶. While the practice of credit scoring is generally accepted for loans, utility bills are often not subject to reporting (at least, in the U.S.A. context)¹⁷. If PAYG is treated and viewed as a utility by the customer—consider firms offering a DESCO model or very long loan tenors—different expectations around the implications of non-payment on future offers or credit history could be appropriate. In either case, clear communication on the benefits and mechanism for access to additional finance with support from PAYG could prove to be sufficient.

As information and communication technologies (ICTs) are integrated throughout the energy system—both on and off the grid—there will be new opportunities and challenges around data management, privacy, ownership, and control. The status quo is for data to be protected and mined primarily by private sector system owners, operators, developers, and integrators, who may extract different value from the data by keeping it confidential and scarce (e.g. by encouraging repeat customers or improving their competitive position with product design improvements). Public uses of the data are important as well (e.g., better informed policy).

The full value from global data sharing and appropriate investment in data collection can only occur if sufficiently high fractions (or good samples and standardized aggregations) of data are available and sufficiently protected to prevent the need for over-aggregation and loss of value. Ownership of distributed energy usage data generated by dispersed global institutions, corporations, and citizens is a critical and unresolved legal and political issue that will continue to be important for the PAYG industry as it is with other IT-related firms.

SUPPORTING A ROBUST PAYG MARKET

Based on evidence from the field, we are optimistic about the potential for PAYG to accelerate energy access through a doubling or tripling of reach into the market (roughly the bump in sales of entry-level lamps by converting to PAYG). The amplification factor may be higher among more costly systems, where financing needs are larger. These vital services help the rural poor climb the household energy ladder toward more equitable and climate-friendly electricity¹⁸. Furthermore, the basic PAYG business model (with assets in the field that can back and enforce loans) could be a foundation on which to build access in other critical areas: higher-power appliances, clean water, health, and other areas where loans and technology investment can change lives.

Some key next steps and drivers of change we identified in our work are:

For Lighting Global and Lighting Africa:

- Support PAYG products with Quality Assurance verification that is appropriate to continue risk reduction from product quality issues, with emphasis on supporting verification of the special or added features of IT-connected energy systems (underway).
- Continued work to identify and support solutions to targeted market needs for the PAYG sector of off-grid power, like those listed below (underway).

For the Public Sector:

- Find ways to leverage the connectivity of PAYG systems for effective and inexpensive tracking of system reliability for conformance with service standards, carbon credits, project requirements, etc.
- Build support and outreach for PAYG firms into energy access plans.
- Integrate energy access planning with telecommunications and mobile money / financing, where possible.
- Reduce trade policy barriers that impact solar products broadly, such as value-added tax and import tariffs

For Investors:

- Provide low-cost appropriate capital, which is a limiting factor to growth in this important market. There are particular needs for debt funds to support loan and service offers.
- Work with companies to develop standard metrics, allowing for receivables-backed financing and a shift towards securitization

For the off-grid solar power industry:

- Provide high-quality solar power systems for a growing PAYG-enabled market with partnerships and new ventures.
- PAYG can be integrated in existing supply chains along side cash sales, growing and strengthening the connections with sellers and supporting communities with improved access.
- Adopt best practices in securing customer data while still making data available for effective use of insights that lead to better energy access. Clearly communicate how repayment and system use data are used and controlled.

For telecommunications and IT

- Provide standardized application programming interfaces (API) for integrating into mobile money systems to ease PAYG platform scaling.
- Reduce transaction fees for basic needs service payments and provide a standardized fee structure with easy start-up for new services.
- Find ways to support robust competition in the energy market to maximize the reach of off-grid power. Early connections to solar electricity provide basic needs service: critically important lighting and recharging for IT devices like phones and tablets.
- Continue supporting interdisciplinary research (e.g., through GSMA M4D) and collaboration across sectors to learn and support best practices.

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About Lighting Global

Lighting Global is the World Bank Group's platform to support development of commercial markets for modern energy services for the [more than 1.2 billion](#) people in the world without access to electricity. Through Lighting Global, IFC and the World Bank collaborate with the Global Off-Grid Lighting Association (GOGLA), the solar energy services industry and development partners to spur growth of markets for clean, affordable, modern energy services.

The Lighting Global product quality assurance program sets the global standard for quality off-grid solar devices and kits. The program presently lists over fifty [quality-verified solar products](#) from more than 25 manufacturers. The Lighting Global platform provides support to a broad portfolio of country-based regional market development programs - Lighting Africa, Lighting Asia and Lighting Pacific, which work along the supply chain to reduce market entry barriers and first mover risks in key off-grid solar markets.

Lighting Global is a key element of the Global Lighting and Energy Access Partnership (Global LEAP), an initiative of the Clean Energy Ministerial (CEM). The World Bank Group implements Lighting Global with support from the Africa Renewable Energy and Access (AFREA) grants program, Denmark, the Energy Sector Management Assistance Program (ESMAP), the Global Environment Facility (GEF), Italy, The Netherlands, and the United States of America. For more information, visit www.lightingglobal.org.

About IFC

IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector. Working with private enterprises in about 100 countries, we use our capital, expertise, and influence to help eliminate extreme poverty and boost shared prosperity. In FY14, we provided more than \$22 billion in financing to improve lives in developing countries and tackle the most urgent challenges of development. For more information, visit www.ifc.org.

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The World Bank, a member of the World Bank Group, is a vital source of financial and technical assistance to developing countries around the world. Our mission is to fight poverty with passion and professionalism for lasting results and to help people help themselves and their environment by providing resources, sharing knowledge, building capacity and forging partnerships in the public and private sectors. For more information, visit www.worldbank.org.

ANNEXES

NOTES ON M-KOPA APPROACH

The M-KOPA system, the D20g, at the time of this research had the following pricing strategy: 3000 Ksh down payment and 50 Ksh a day for 360 days—for a total of 21,000 Ksh, or about \$30 down, \$0.55 a day, for a total of \$230. After this period the system is owned outright. If someone fails to pay the system will not work until they begin payments again. Payments can be made with any frequency, but typically are done on a weekly or monthly basis by users due to income stream fluctuations and mobile money transaction fees.

The payments are made through M-Pesa mobile money and the systems have integrated GSM modules, allowing them to be activated remotely once a customer's payment processes.

M-KOPA has over 100,000 systems in the field since their inception and has a goal of 1 million by 2018. They started in Kenya and are expanding to Uganda.

The M-KOPA sales agents network has schemes for offering credit to agents for purchasing stocks, along with incentives that come on the initial purchase (600 Ksh) and on payoff (600 Ksh). The total margin is therefore 1200 out of 21,000, or 6%. This is on par with the margins reported by retailers for broader solar goods. It is important to note that the M-KOPA approach does not require the same level of working capital financing for retailers, who pay significantly less than a typical wholesale price to carry M-KOPA stock (only the down payment for each system) and can build trust (and a line of credit) through repeated good business dealings and sales. The commission is not paid in full until the device is fully repaid, which places some onus on the retailers to select credit-worthy and trustable customers.

The cash payment for the system is 17,000 Ksh – \$190.

NOTES ON SUNNYMONEY APPROACH

SunnyMoney tested two platforms for PAYG during our study period that accomplished essentially the same purpose: financing for an entry-level solar study lamp. The entire process was essentially integrated into a modified version of the “traditional” schools campaign model through their research/innovation unit, SunnyMoney “Brains”.

They chose to test two payment mechanisms (see information in main text) with total costs of 1200-1300 Ksh over a series of weeks. The payments were made either in cash to a sales agent or via M-Pesa, and allowed SunnyMoney to assess the logistics differences for each one. For both payment channels, the sales agent then connects to the lamp with a smart phone and "activates it", collecting commissions of 30 Ksh on the initial down payment and 70 Ksh on payoff (for a total of 100 Ksh for financing the lamp, or 10% of the 1,000 Ksh retail price for a cash-equivalent model without PAYG).

The smart phone activation approach avoids the need for GSM modules that would cost roughly \$10 on a wholesale basis³ – which would effectively triple the cost of entry-level lamps.

Through the pilot projects, SunnyMoney Innovation department (SunnyMoneyBrains) aimed to develop and test an affordable PAYG model for study lamps – combining ultra-low-cost PAYG technologies with entry-level solar products to build experience and iterate on PAYG approaches for this segment of the pico-solar market.

Exchange Rates: Our field work took place primarily during May and June 2014. The exchange rate we use in our analysis is based on the average rate during this period, **86 Ksh / 1 USD** (from Yahoo! Finance).

Datasets collected for this study: The datasets below were collected in support of this study and other related projects that were conducted in parallel. All the data were collected by or in collaboration with our research team. These datasets are supplemented by others that are publicly available or available through the Lighting Global program.

Scale	Name	Population	Sample size and description
End-user	Telephone survey (0-1 months after purchase)	Buyers of PAYG systems	55 SunnyMoney Customers.
End-user	Telephone survey (4-9 months after purchase)	Buyers of PAYG systems	160 M-KOPA customers 45 SunnyMoney Customers (all from initial survey)
End-user	Focus Groups	PAYG purchasers through SunnyMoney Pilot	~ 40 participants in 4 groups. 2 each in two separate towns.
Retail	Retail Survey	All retailers of off-grid lighting	~150 shops
National Distribution	Structured interviews	Managerial-level employees and executives at PAYG organizations	~ 5 each at M-KOPA and SunnyMoney / Angaza / divi. Non-disclosure agreements prevent release of sensitive aspects of the particular business models. Synthesized results in combination with the Global structured interviews are included in this study.
Global	Structured Interviews	Managerial-level employees and executives at PAYG organizations and other stakeholder firms (device manufacturers, telecommunications industry).	~ 15 interviews with anonymized and synthesized results reported that do not betray private details of particular business models.