Access to Energy via Digital Finance: Overview of Models and Prospects for Innovation

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Introduction

Globally, over 1.3 billion people lack access to electricity, and another 1 billion people have extremely unreliable connections to national electricity grids.[1] Without access to reliable electricity, these consumers turn to costly and unhealthy energy alternatives, such as kerosene and candles for lighting, disposable lead-acid batteries for torches, and diesel to run generators. Kerosene-based lighting products pose significant health and environmental risks at the household level, including indoor air pollution, suppressed visual health, severe burns, and poisoning due to accidental ingestion of fuel.[2] Fuel-based lighting is a significant cause of structural fires in the developing world and produces over 90 million tons of carbon dioxide emissions each year.[3]

Energy poor consumers—people whose well-being is negatively affected by very low consumption of electricity, use of dirty and polluting fuels, and excessive time spent collecting fuel to meet basic needs—are forced to spend a significant amount of their income on costly and inefficient alternatives. Off-grid consumers in Sub-Saharan Africa spend $70–110 annually to meet their lighting needs, primarily on kerosene and disposable batteries for torches.[4] Because of low and irregular income patterns, rural energy poor consumers often have to buy kerosene in small quantities, paying a premium of approximately 46 percent over urban consumers who are able to buy in larger quantities.[5]

In the past decade, dozens of companies have developed high quality, solar-powered solutions targeting the needs of the energy poor. New distribution models developed by these companies are bringing these products to off-grid areas around the world. Yet, affordability remains a significant barrier to mass adoption. For most people living off-grid, lack of access to financing options—loans, leasing, payment mechanisms, and so on—is a primary barrier to adopting modern solar solutions.[6] Those end-users can't afford to buy most modern energy products on a cash basis, while energy product and distribution companies are often unable to finance customers directly and formal finance providers have shown limited appetite to design products that meet the financing needs of the energy poor.[7]

A number of startup energy enterprises are now leveraging digital finance—especially mobile payments—to deliver modern energy to the poor, sold on a pay-as-you-go (PAYG) basis. PAYG pricing holds the potential to disrupt the energy sector in many of the same ways it helped to fuel the growth of mobile communication in the developing world. The energy poor earn and spend money on inefficient energy alternatives such as kerosene in a similar manner—through small, user-defined increments as and when cash is available. Designed to be flexible, PAYG services could then fit well with the existing economic realities of the energy poor consumer.

Based on currently available data, there are at least 25 companies actively deploying a PAYG solar solution across Africa, Asia, and Latin America. To date, at least 150,000 PAYG solar

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1 International Energy Agency; United Nations Development Programme

2 'Health impacts of fuel-based lighting,' Evan Mills, Lawrence Berkeley National Laboratory, University of California, 2012.

3 United Nations Environment Programme, en.lighten Country Lighting Assessments, 2013.

4 Lighting Africa Market Trends Report 2012. International Finance Corporation.

5 The Cost of Kerosene, Lighting Africa. International Finance Corporation. 2012.

6 Lighting Africa Market Trends Report 2012. International Finance Corporation

7 Based on industry interviews

products have been sold globally.[8] Another 100,000 customers will access modern energy through a PAYG solar product by the end of 2014.[9] In the next five years, at least 3 million PAYG solar systems will be sold globally, demonstrating the potential for such models to disrupt the energy access sector.[10]

While the business model and customer offerings can vary widely among companies, PAYG solar approaches do share a few common elements. First, energy poor consumers are required to make a small down payment or deposit, typically 10–30 percent of the fully financed cost, to receive the solar product or to have it installed at their premises. Second, customers are required to prepay for the ability to use the solar product via mobile money or through a mobile-based energy credit model. Technology within the product denies energy service if the customer's prepaid balance has been used or expires, enabling access again when the customer adds prepaid credit to their account. In some models, the customer pays off faster and ultimately owns the energy asset through a rent-to-own or lease, while others deliver prepaid energy as an ongoing service, pushing the equipment financing upstream to the energy enterprise. In many ways, this end-customer transaction structure dictates other aspects of the PAYG solar business model, such as sales and distribution channels, after-sales service, and agent network requirements.

In the past five years, a number of converging trends have made it possible to combine PAYG pricing and innovative end-user financing to small-scale solar energy:

- The cost of solar panels, batteries, and light-emitting diodes (LEDs) has dropped significantly in the past five years, and research indicates these trends will continue. Solar panels today are about half the price they were in 2008 and are expected to reach a delivered price of less than $1 per watt in the next two years.[11] IFC estimates that the average portable solar lighting product sold in 2020 will have twice the battery life, five times the brightness, and cost 33 percent less than similar products on the market in 2012.[12]
- The small-scale solar product market has experienced dramatic growth in terms of units sold and new market entrants in the past five years. Since 2008, over 100 new companies have entered the portable solar lighting product market. In Africa alone, over 4 million solar lighting products were sold from 2009 to 2012, with annual sales growth at almost 100 percent per year.[13]
- Significant advancements have been made in the past decade to improve the reliability and life of solar products and related appliances, increasing consumer trust in the product category in key markets. Average battery life has increased by over 20 percent in the past four years. High-quality solar products targeting the energy poor today often boast a useful life of over three years with minimal maintenance. Several leading manufacturers now offer a three-year standard full warranty covering full product replacement.
- Technological changes have made it easier to design, prototype, and program microcontrollers that regulate the use and functionality of solar devices. Low-cost

[8] Based on sales estimates obtained through industry interviews

[9] Based on sales estimates obtained through industry interviews

[10] Based on sales estimates obtained through industry interviews

[11] PV Pricing Outlook 2014: Value Chain Trends, Global Drivers and Regional Dynamics. GTM Research

[12] Lighting Africa Market Trends Report 2012. International Finance Corporation

[13] Ibid

GSM/GPRS modules and machine-to-machine (M2M) [14] chips make it easier to remotely monitor solar devices via the telecom network.

- The rapid adoption of mobile phones and network coverage across most off-grid areas makes it easy to communicate with customers and other players in the value chain. There is a massive market that's now very familiar with the prepaid, PAYG pricing model. In fact, mobile network operators (MNOs) are seeing the huge potential in delivering phone charging and other energy-related services to their clients. In Africa, the number of off-grid mobile subscribers is expected to reach 400 million by 2015.[15]
- Mobile money services make it easier to digitize and process micropayments, often eliminating the need for door-to-door payment collection.

This paper provides an overview of the digitally financed energy access sector, highlighting advancements in business models and product offerings. The focus is on businesses deploying PAYG solar photovoltaic products using digitized payments and unique hardware to control the use of energy services. While there are experiences combining digital finance with a wide range of energy technologies, PAYG solar photovoltaic (PV) products have by far the most market traction in terms of total units sold, amount of time deployed, and number of countries with active sales.

The report has six sections: (1) segmentation of PAYG solar energy technology, (2) current experiences with digital payments and off-grid solar energy, (3) segmentation of PAYG solar business models, (4) details on current financing and pricing models used by leading PAYG solar providers, (5) sales and distribution channels for reaching off-grid consumers, and (6) analysis of trends and the future of PAYG solar.

1) Segmentation of solar energy technology used by PAYG companies

A solar solution targeting the energy poor includes a PV module, a low-voltage direct current (DC) battery, a charge controller, wiring, sockets, and small appliances, such as lights, radios, televisions, and fans. In this section, we provide a basic segmentation of solar energy technologies. PAYG solar products on the market today can be initially categorized as (a) portable solar lights, sometimes referred to as solar lanterns or solar lamps, (b) small solar systems or plug-and-play systems also known as pico, and (c) solar home systems.

[14] M2M refers to technologies that allow both wireless and wired systems to communicate with other devices of the same type.

[15] Lighting Africa Market Trends Report 2012. International Finance Corporation

Table 1. PAYG Solar Product Categories

Product Type	Product Examples	Product Details	Company Examples
Portable Solar Lights	 SoLite3 (Angaza Design)	$15–60 0.5–3 Watt Solar Panel Internal lithium-ion battery Single LED lantern, mobile charging on some models	**Angaza Design** (Kenya, Tanzania) **divi Power** (Namibia, Kenya, Ghana, Somaliland, Peru)
Pico Solar Systems	 d.light d20 system (M-KOPA)	$100–250 4–25 Watt Solar Panel Internal lithium-ion battery Plug-and-play system, 2–6 LED lights, radio, mobile charging	**M-KOPA Solar** (Kenya, Uganda) **Azuri Technologies** (East and West Africa)
Large Solar Home Systems	 Mobisol 30Wp system (Mobisol)	$150–1,000 30–200 Watt Solar Panel External lead-acid battery Technician installed multiroom energy system: 4–10 LED lights, mobile charging, radio, fans, TV, refrigerator	**Mobisol** (Kenya, Rwanda, Tanzania) **Simpa Networks** (India)

Portable Solar Lights

Most solar products on the market today targeting energy poor consumers fall in the portable solar light or pico solar system categories. Portable solar lights include a small fluorescent or LED light with a rechargeable battery in a case that is easy to carry for outdoor lighting needs, and they are often designed to both stand on a table as a task light and hang from the ceiling or a wall for room lighting. Some include a small built-in solar panel, others are designed to be plugged into a roof-mounted solar panel of less than 3 Watt-peak[16] (Wp) size for charging and then detached for use, and are often sized to provide 4–6 hours of lighting each day. A majority of portable solar lights on the market today use lithium-based batteries (lithium-ion, lithium ferrous phosphate) that are well established in other consumer electronics applications, such as mobile phones and laptops. These batteries can be rapidly charged, perform well in extreme conditions in rural areas, have a high energy density—ability to store more energy per unit weight/size—and a longer life than most other types of batteries, making the technology well-suited to portable solar products such as portable solar lights and pico home systems.

[16] PV modules are specified by their Wp rating, which is the power generated under standard conditions, equivalent to bright sun in the tropics (they still work at lower light levels, though).

Portable solar lights typically retail at $15–60, with higher-end models also offering the ability to charge a mobile phone. For an off-grid household in Africa spending $7-10 per month on lighting and mobile charging, the simple payback period for purchasing a median portable solar light ($40) is 4-5 months. [17] While tremendous progress has been made on portable solar light distribution in the past four years, these products remain out of reach for a large portion of the off-grid market that is unable to afford a $15–60 price on a cash basis due to limited savings and access to financing. Research by the IFC Lighting Africa initiative has consistently cited access to downstream financing for end-consumers as one of the three biggest barriers in the portable solar lighting market.

Angaza Design (Kenya, Tanzania) and divi Power (Namibia, Kenya, Ghana, Somaliland, Peru) are two companies that have recently developed portable solar lights that off-grid consumers can pay off over 3–12 months through a combination of point-of-sale financing, mobile payments, and PAYG pricing. These and other portable solar light examples will be analyzed in the following sections.

SoLite3 PAYG light
(Angaza Design, Inc.)

Oolux PAYG light
(Oolux/Antenna Technologies)

diviLite PAYG light
(divi Power)

While portable solar lights can be an excellent replacement for kerosene lanterns and the first step on the energy ladder—transitioning toward cleaner and more efficient energy sources as incomes increase—for millions of consumers, there are some disadvantages to this product category. Designed as a single portable light, portable solar lights do not offer the ability to light multiple rooms/areas simultaneously, and they often are unable to charge multiple phones per day. Portable solar lights cannot meet major entertainment (TV/DVD) and productive energy requirements, and they often have a limited useful life.

Pico Solar Systems

Solar pico systems offer the ability to simultaneously light 2–6 rooms in a home or business. They often include the ability to charge multiple mobile phones at the same time and can also

[17] Lighting Africa Market Trends Report 2012. International Finance Corporation

power small DC appliances, such as a radio or an efficient fan. These products come standard with an external solar panel of 4Wp–25Wp in size, and they often use lithium-based battery technologies. A central battery pack with standard DC outlets allows users to customize the use of a pico system to fit their needs, shifting between lighting, mobile charging, and running other appliances as required in ways that are not possible with an individual solar lantern.

Solar pico systems can be described as “plug-and-play” because the end-customer does not require any specialized tools to connect, disconnect, or move the system and its appliances, and they are often self-installable by the end-customer. They are small in size and sold out of a single product container typically the size of a shoebox. These qualities make it possible to push pico systems through consumer electronics retail and fast-moving consumer goods distribution channels in much the same way solar lanterns are now distributed. Typically retailed at $80–150, these products are roughly the equivalent of one year’s expenditure on kerosene and mobile charging fees for an average African consumer. However, uptake has been slow due to limited financing available to energy poor consumers. In East and West Africa, M-KOPA Solar and Azuri Technologies sell pico solar systems on a PAYG basis, financed over 12–18 months, which include 3–4 lights, mobile charging capabilities, and the ability to power one or more small DC appliances.

‘Indigo Duo’ (Azuri Technologies)

M-KOPA III (M-KOPA Solar)

While it is a significant improvement over a single solar lantern, pico solar systems do have some limitations. Most products in these categories have a potential useful life of more than three years, but a 1-2 year warranty is the most common offering extended to end-customers in this product category. The relatively small battery size in pico kits can make it difficult for end-consumers to use all energy appliances simultaneously for long periods of time – i.e. running 3 lights and charging a phone simultaneously for 4 hours a day – particularly during rainy seasons. Pico systems are not yet able to easily meet higher-end energy requirements such as television and refrigeration because of the smaller battery capacity, and they do not yet offer consumers the ability to easily replace the battery themselves to extend product life.

Large Solar Home Systems

Larger solar home systems can be thought of as products with a solar panel above 30 Wp in size and often use deep-cycle, lead-based batteries that are more dependable and less expensive (cost-per-watt) than lithium-based alternatives used in solar lanterns and pico systems. These products offer energy poor consumers the ability to use up to 10 lights (LED or compact fluorescent) simultaneously and to use a wide range of 12V DC appliances, such as powering televisions and direct-to-home satellite systems, ceiling and pedestal fans, refrigerators, computers, and many microenterprise energy needs. The battery and solar panel in large solar home systems is often oversized to allow consumers the ability to run multiple lights and appliances simultaneously for longer run-times. Higher-end solar home systems can be sold with an inverter that converts the DC output of the solar panel into alternating current (AC), allowing consumers the ability to use many off-the-shelf 220–240V AC appliances. These products are installed by trained solar technicians who often customize the system to each consumer's energy requirements and home/business structure. With proper maintenance, these larger systems can often last for more than five years.

End-user financing is particularly important for large solar home systems targeting the energy poor given the higher retail price as compared to pico systems—$200–400 for large DC-only systems and $500–1,000 for versions that include an inverter to use AC appliances. Over 3 million large solar home systems have been sold in Bangladesh in the past 10 years, predominantly through 3–5 year loans to off-grid consumers offered by microfinance institutions (MFIs) and nongovernmental organizations. Two companies delivering large solar home systems on a PAYG basis leveraging digital finance are Mobisol (Kenya, Tanzania, Rwanda) and Simpa Networks (India). Both companies offer up to 2–3 year financing to end-consumers sold through a network of sales and service points.

Mobisol 80Wp PAYG Solar Home System (Mobisol GmbH)

Although large solar home systems offer a much wider range of energy uses and often larger battery capacity, there are some limitations. Lead-based batteries are large and heavy, making it

difficult to push through fast-moving distribution channels. These batteries sometimes require routine maintenance, forcing some companies to pay for door-to-door visits 1–2 times per year throughout the period in which the product is being financed. Customizing each system to a particular customer's needs can be time consuming for technicians and expensive to businesses. These factors can influence where a company can sell such products as prospective customer needs to live within a geography easily serviceable by a trained technician—challenges that solar lanterns and pico solar lanterns don't face to such a degree.

2) Use of Digital Payments by PAYG Solar Companies

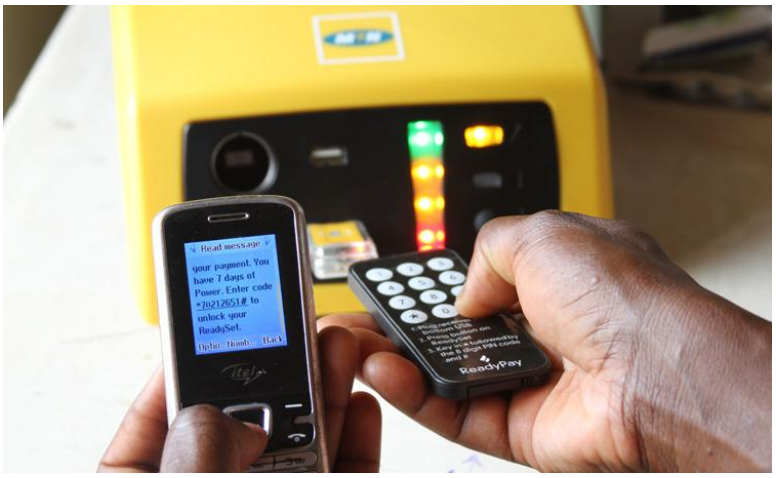
PAYG solar solutions on the market today generally have three basic parts to how digital payments are used (a) end-customer payments are digitized, either via formal mobile money channels or, in the absence of mobile money, through proof-of-payment codes sent via SMS; (b) proprietary hardware is used to tie the usage of energy services to payments; and (c) software that processes digital payments and manages automated communication with products, end-customers, and agents.

(a) Digitizing payments at the end-customer

PAYG solar customers prepay for the ability to use the product through formal mobile money transfer channels, or digitized energy credits through a form of agent banking in markets where these options are not yet available.

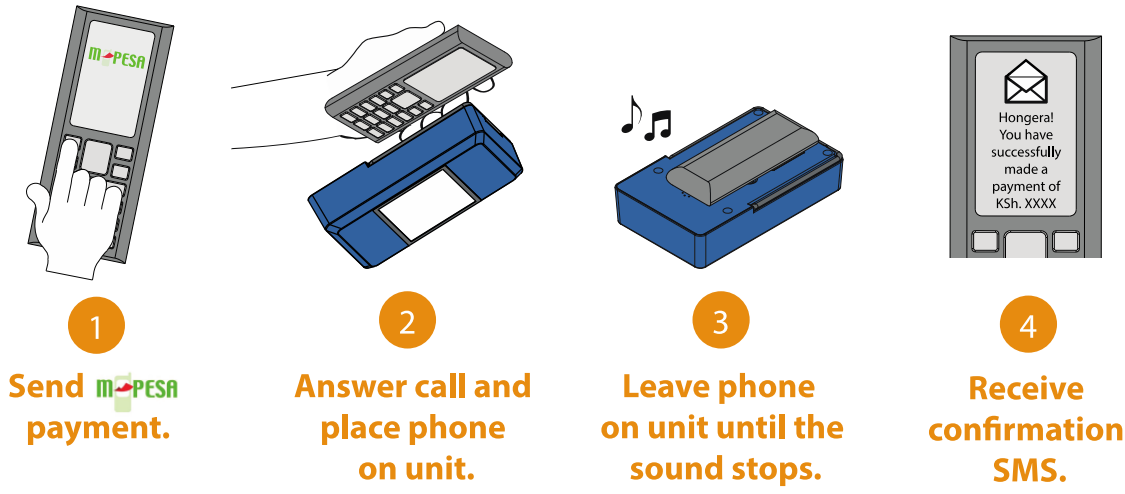
Mobile Money

PAYG companies operating in East African countries overwhelmingly use existing mobile payment platforms to accept payments from end-customers (Angaza Design, Fenix International, M-KOPA, Mobisol,). These and many other PAYG companies have developed a software platform that integrates with mobile money platforms to receive payments, update customer accounts, and deliver proof of payment data that is transferred to the solar device to unlock for the prepaid usage, often via direct data or SMS messages. M-KOPA Solar and Mobisol send proof of payment data directly to the solar devices over the cellular network to unlock services, and also receive product performance and customer usage data from each unit. In Uganda, Fenix International sends an SMS, which includes a unique code that is then transferred to the solar device through a hand-held keypad, to the end-user upon receipt of a mobile payment.



Unlocking the Fenix 'ReadyPay' product (Fenix International, Inc.)

For some Angaza Design products, upon receipt of a mobile payment, the company's software initiates a voice call to the end-customer's registered mobile number, which the customer then holds next to the PAYG product to communicate proof-of-payment and usage authorization data via audio tones.



Loading proof-of-payment to the SoLite3 product (Angaza Design, Inc.)

Energy Credits

In the absence of mobile money, other PAYG companies also deploy an "energy credit" agent model whereby end-customers prepay for energy services without a formal mobile money transfer service (Azuri Technologies, Simpa Networks). Under this model, customers pay cash to an agent appointed by the PAYG solar company to vend prepaid energy credits in the form of unique 8–12 digit numeric codes that are later entered into the solar product. Table 2 summarizes two examples of the prepaid energy credit model.

Table 2. Prepaid Energy Credit Examples

Prepaid Energy Scratch Cards	Prepaid Energy "Recharge"
Azuri Technologies (East and West Africa) prints and distributes energy credit scratch cards, similar to prepaid mobile airtime scratch cards used by most African MNOs, which are sold to end-customers by local agents.  Azuri prepaid energy scratchcard (Anne Wheldon, Ashden UK) • Customers scratch a panel on the back of each scratch card to reveal a unique numeric code. • Customer sends scratch card code to Azuri's software via SMS along with the product/customer ID. • Azuri's software platform verifies the initial code and product/customer ID. • Azuri's software generates a new single-use unlock/usage code, which is sent back to the end-customer's registered mobile number via SMS. • Customer then enters the final numeric usage code into the solar device via a keypad. • Solar device unlocks use of the lights and mobile phone charging services for the prepaid amount of time.	Simpa Networks (India) also sells prepaid energy credits through appointed agents, but deploys a "Recharge" model without scratch cards—a common way to purchase and process prepaid airtime in India.  Simpa Easy Recharge (Simpa Networks, Inc.) • Microenterprise registers as a Simpa energy credit agent, registering his/her name, address, mobile number in Simpa's software. • Simpa Agents buy a bundle of prepaid energy credits from Simpa via local bank deposit. • End-customers pay cash to the agent. • Agent sends an SMS to Simpa with the end-customer's unique ID, the agent's ID, and payment data. • Simpa's software validates the transaction based on the customer and agent's registered data, and sends a unique, single-use use numeric code back to the end-customer via SMS. • Customer enters usage code into his or her own solar system via the embedded user interface. • Solar device unlocks use of the system for the prepaid amount of time.

Angaza Design and divi Power also deploy a version of the energy credit model that uses a smartphone to process the proof-of-payment data transfer directly to portable solar lights. Under this model, customers can pay via mobile money or pay cash to an appointed agent who has a smartphone with an app from one of the PAYG providers. The agent can record cash payments via this app, which then communicates via the internet to the PAYG provider's software to update the customer's account. The smartphone can then communicate proof-of-payment to the portable solar light via a data cable (Angaza) or wirelessly via Bluetooth protocol (divi Power).

These forms of digitizing payments allow companies to sell PAYG solar products in markets that may not already have an active mobile money facility. However, the energy credit model often

requires PAYG companies to organize and manage a network of authorized agents in areas where customers live or work to collect cash and digitize payments via SMS or through a GSM-conneted device. For some companies, this model may also require issuing smartphones to authorized agents collecting cash payments and/or unlocking portable solar lights.

(b) On-network vs. off-network payment hardware on the backend

Once the proof-of-payment is transferred to the PAYG solar device, either through a direct message to the product's GSM chip (M-KOPA, Mobisol), a unique numeric code entered by the customer using a keypad (Fenix, Simpa), or data transfer from an agent's smartphone (divi Power, Angaza), technology within the product regulates the usage. This is typically done by a circuit board within the solar device with software designed by the PAYG solar company to govern how and when electricity is sent from the battery to the end appliances, such as the lights and mobile phone charging port. If this product-embedded PAYG hardware does not receive a proof-of-payment message, electricity is not sent to the end appliances.

PAYG hardware can be initially divided into two groups based on whether or not the solar device is directly connected to the cellular network. The specific PAYG technology approach is heavily influenced by the prevalence of mobile money services among target customer segments and the likelihood of reliable cellular coverage in off-grid areas of the target market. If the majority of off-grid consumers in a particular market do not have reliable cellular coverage, a PAYG company is likely to pursue an off-network approach. A company's research and development budget and the target cost of the energy asset also play a major role in this decision. Reliable GSM/M2M chips are currently more expensive on a per-unit basis than off-network hardware, though these prices continue to drop. For lower-cost products such as solar lanterns, it is not yet cost effective to add a GSM/M2M chip to allow for two-way communication via the cellular network.

Table 3. Comparison of Payment Technology Approaches

	On-Network	Off-Network
Summary	• Solar products are connected directly to the cellular network via embedded M2M module + SIM. • Customers pay via mobile money, software sends a message directly to the solar device to "unlock" prepaid services via the cellular network. • Typically requires a tight partnership with a MNO for SIM cards and access to discounted data/SMS/mobile money.	• PAYG hardware does not connect with the GSM network. • Customers pay cash to appointed agents for prepaid energy voucher/credit/scratch card, which is validated via SMS. Software generates unique usage code manually entered into solar device. • Does not require a formal relationship with an MNO.
Companies	• Econet Solar (Zimbabwe) • M-KOPA Solar (Kenya, Uganda) • Mobisol (Kenya, Rwanda, Tanzania)	• Azuri Technologies (East and West Africa) • Off-Grid:Electric (Tanzania) • Quetsol (Guatemala) • Simpa Networks (India) • Sun Transfer (Ethiopia, Kenya)
Advantages	• Ability to communicate with solar devices in real-time, accessing data on usage/performance. • Remotely disable services anytime. • If partnered with an MNO, can leverage its agent network and product distribution channels.	• Can be deployed in areas where end-customers do not have cellular coverage. • Can be sold in markets without active mobile money services. • Off-network PAYG technology development cycle is often shorter and lower cost than on-network. • Not tied to a particular MNO; higher degree of autonomy in designing customer transaction and distribution.
Disadvantages	• Requires some formal partnership with MNOs. • Somewhat limited in where you can sell to areas with reliable cellular coverage; may require customers to carry devices to areas with stronger cellular signal to sync/update. • Often limited to selling in countries with high mobile money penetration. • M2M technology development cycle is typically longer and more expensive than off-network.	• Lack of direct connectivity with solar devices makes it difficult to obtain real-time usage/ performance data and identify theft or tampering. Typically collect this information in-person at customer's premises, adding transaction costs. • Unable to disable energy services in real-time • Often requires building out a proprietary agent network for vending prepaid energy credits/vouchers/scratch cards.

On-Network

M-KOPA Solar, Mobisol, and Econet Solar are examples of companies that deploy PAYG products with networked hardware via embedded M2M modules. This technology approach typically requires a close partnership with MNOs as each device requires a registered SIM card. On-network PAYG solar software platforms integrate with partner MNOs or mobile money platforms to accept and process incoming payments from end-customers and send messages directly to solar devices via the mobile network. Networked hardware can track information such as battery and panel status and customer usage, and it can identify when tampering occurs. On-network PAYG solar companies often leverage MNO partner brands, airtime agents, authorized dealers, and product distribution channels.

Off-Network

The majority of current PAYG solar products on the market today use off-network hardware. Most PAYG solar products deploying off-network hardware typically include an embedded microcontroller with one or more electrical switches to enable/disable usage based on entry of a valid 10–12 digit “unlock/usage” code that customers manually enter into the device through a product-integrated keypad (Azuri Technologies, Off-Grid:Electric, Quetsol, Simpa Networks, Sun Transfer) or a handheld remote control unit with short-range infrared (Fenix International, Lumeter).

Off-Network PAYG Hardware – Off-Grid:Electric, Tanzania

A number of other PAYG companies have pursued other off-network hardware approaches that do not require SMS-based usage codes. Angaza Design’s audio tone technology is unique in that it does not include M2M tech, but relies on the cellular network to communicate proof-of-payment data directly to the solar product via the end-customer’s phone using digitally modulated audio tones. Stima Systems and Oolux are two companies that have experimented with PAYG portable solar lights that receive proof of payment data via USB-sticks/dongles.

Under these models, customers pay cash to an appointed agent, who then enters a special USB stick/dongle into the customer's energy product, communicating payment data to the device via the USB data capability.

Hybrid

Several PAYG companies are now deploying what can be described as a hybrid between the On- and Off-Network hardware approaches described above. These companies are often focused on entry-level portable solar lights that typically retail for $8-20. At this retail price level, it is currently difficult to integrate on-network M2M hardware into entry-level portable lighting products as the additional cost of PAYG hardware could almost double the product price to end-users. As such, a number of PAYG companies have designed a technology and business model that enables the solar light to remain off-network and leverages a GSM-enabled device (smartphone, tablet) to communicate with cloud-based software.

Under this model, end-customers are often required to bring their portable solar light to an appointed agent's place of business to unlock the device for the prepaid amount of usage time, though it is possible for an agent to visit customers door-to-door to conduct this activity. For divi Power, payments made via mobile money or cash given to an appointed agent are processed by a smartphone app which connects to the divi software platform via internet connection on the agent's phone. The smartphone's Bluetooth capability is then used to wirelessly unlock the divi portable light for the amount of prepaid time paid by the customer. Angaza Design deploys a number of data transfer technologies to process such a transaction including the audio tone model described in section 2a. In another model, customers are also required to bring their portable light to an appointed agent whose smartphone is used to unlock the device for prepaid usage time. Angaza's app on the agent's smartphone connects to the company's cloud software via the GSM network to record the customer's payment and, when connected to the portable solar light via a data cable, transmits instructions to unlock usage for the amount of prepaid time.

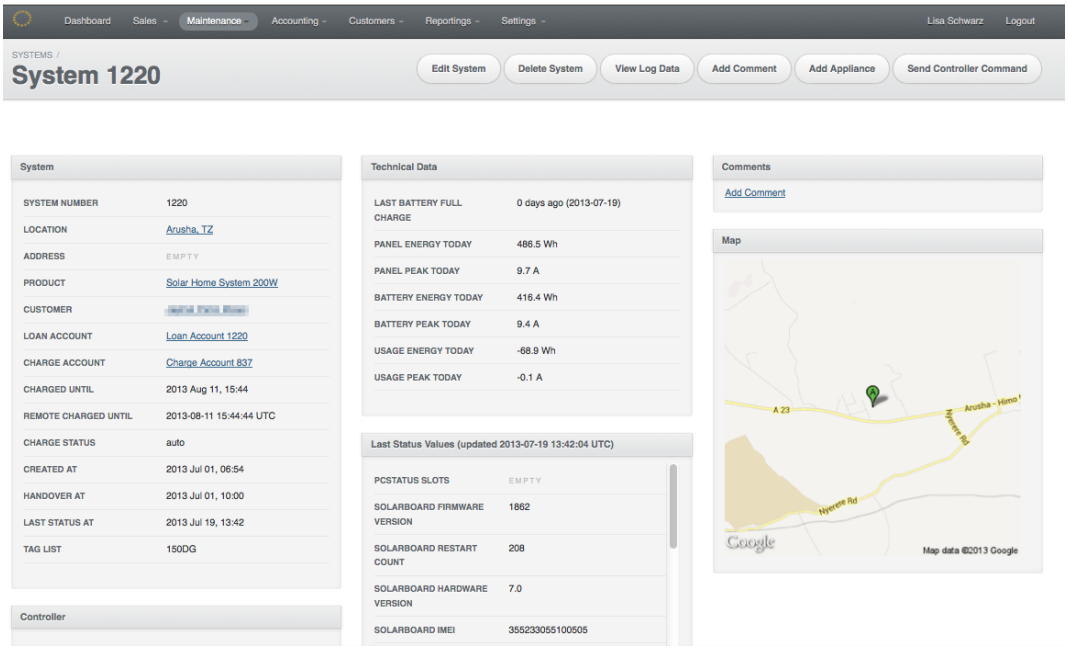
These hybrid approaches are particularly attractive for entry-level portable solar lights as the data transfer and payment enforcement hardware can be extremely low cost as compared to M2M technologies or other off-network hardware that requires a keypad interface on the solar product itself. However, these hybrid approaches require the identification and training of agents to accept cash payments and unlock each product via local data transfer, and can often require the PAYG provider to purchase and distribute smartphones with the right data transfer capabilities to these appointed agents. For end-customers, this model enables short-term financing of portable solar lights regardless of mobile coverage at their home or place of business, but also require travel to an agent with network connectivity on a regular basis to unlock the solar light.

(c) Software Back-End

Data plays an important role in PAYG solar businesses, with many companies collecting hundreds of data points weekly from each customer. All PAYG solar companies have developed

proprietary software, often hosted in the cloud, to track data related to end-customers and payments. These software platforms often include an SMS or data gateway for automated communication with products, customers, and agents, and some integration with a digital payment platform to receive mobile payments from customers. Some PAYG solar products (M-KOPA, Mobisol) track information on product performance (i.e., solar panel and battery voltage) and customer usage, sending data back to the central software hub on regular intervals via the GSM network.

Mobisol Software Platform: System Map (Mobisol GmbH)



Mobisol Software Platform: System Overview (Mobisol GmbH)

Proprietary software algorithms and reports help PAYG solar companies make sense of usage and payment data, identifying what appliances are used the most frequently, informing when and how to upgrade customers to larger systems, and coming up with the basis of future product

development efforts. Trends in payment and usage data can help PAYG companies develop pricing models customized to particular customer segments, taking into account seasonal variability in expenditures, and can improve initial risk assessment processes.

To date, most PAYG solar companies have developed their own software platform and payment enforcement hardware from scratch, often requiring a significant investment of limited startup capital. A number of companies are now deploying hardware and/or software on a business-to-business (B2B) basis to enable other companies to deploy PAYG products. For example, Angaza Design has developed a platform for pico solar systems and portable solar lights with the ability to tie into a number of data transfer approaches (M2M, data cable + smartphone, keypad, audio tones) and multiple customer payment options (mobile money, energy credits). Lumeter Networks takes a similar approach, offering both software and low-cost prepaid meters to enable PAYG functionality for portable solar products and microgrids. M-KOPA Solar and technology partner Eseye also recently began to license the core platform that connects the M2M technology in each M-KOPA solar system with application servers and mobile money platforms. These B2B offerings hold the potential to dramatically reduce the initial product development cost and time to market for new entrants and could lead to additional specialization along other areas of the value chain. These platforms could also be leveraged to deliver PAYG functionality to other non-energy products targeting low-income consumers.

3) Business Model Segmentation

The combination of flexible, PAYG pricing and product-embedded hardware enable energy enterprises to directly extend a range of product financing and energy service options directly to end-customers. PAYG solar businesses can structure the transaction with end-customers as a product financing relationship, where the customer is paying off and ultimately owns the solar device, or energy-as-a-service, selling prepaid electricity on a use-basis. In many ways, this end-customer transaction structure dictates other aspects of the PAYG solar business model. This section presents a summary of the most common variables found in a PAYG solar transaction with an end-user and implications on the overall business model: (a) Asset ownership vs. energy-as-service; and (b) time-based versus usage-based pricing.

(a) Asset Ownership vs. Energy-as-a-Service

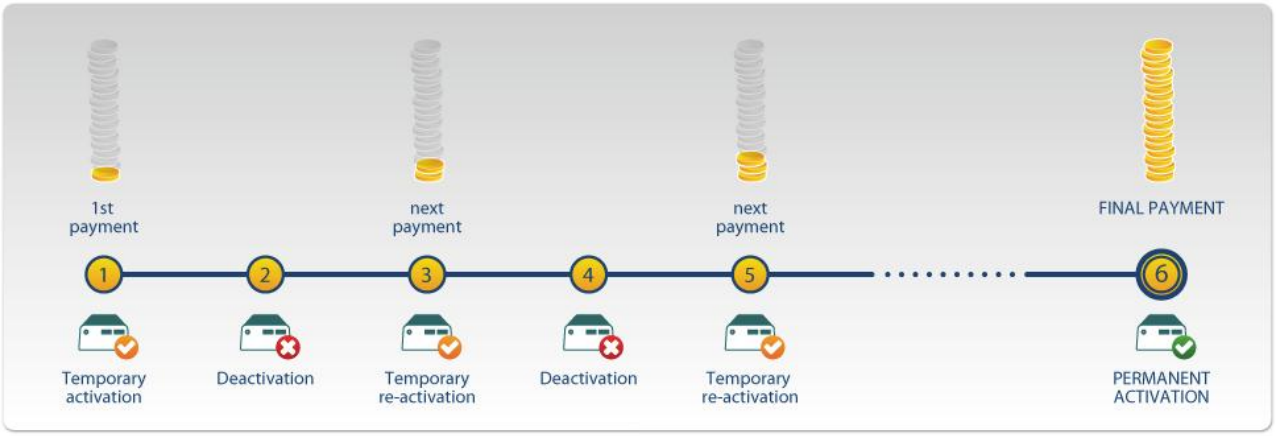
Broadly speaking, PAYG solar companies deploy two types of end-customer transactions: rent-to-own, where the end-customer ultimately owns the solar device through a series of usage payments; and energy delivered as a service, where the solar device remains as an asset owned by the PAYG company through the life-cycle of the customer relationship.

Asset Ownership

More than half of PAYG solar companies offer a rent-to-own or lease transaction with end-customers whereby ownership of the asset is ultimately transferred to the end-customer (Fenix,

M-KOPA, Mobisol, Simpa). Under this model, end-customers are required to make an initial payment in the form of a deposit or down payment, and pay off the remaining outstanding balance over time through prepaid usage. Legal ownership of the asset typically lies with the PAYG company until the end-customer has completed the leasing term and “earns” the right to own the system—sometimes through a closing payment. In many markets, a solar product purchased over 12–36 months through a rent-to-own transaction can be the first time some customer segments achieve a formal payment history.

This model offers consumers the opportunity to turn what was a perpetual expenditure—ongoing purchase of kerosene fuel and fees paid for mobile phone charging—into ownership of a clean energy asset that can deliver free energy once the product is paid off. The ownership aspect of rent-to-own models can be particularly attractive to end-consumers with a desire to add asset value to their home or business. For some consumers, the promise of ownership at the end of the payment term might be a strong incentive to better maintain the solar device, potentially leading to lower after-sales service costs for PAYG providers.



Rent-to-own model for Oolux PAYG portable solar light (Oolux/Antenna Technologies)

There are some disadvantages to the rent-to-own model. The nature of the credit/lease transaction requires energy companies deploying this model to build out a full in-house credit/finance function, complete with risk assessment and portfolio management staff and processes one might see at a financial institution. These additional activities, sometimes handled by a third-party financing partner, such as a rural bank or MFI, add costs to the business that may need to be passed to the end-consumer. Because this model requires an explicit repayment term, PAYG solar companies have the difficult challenge of determining a price and term such that it covers their costs and is competitive with existing energy alternatives. This delicate balance between competitive ongoing pricing and repayment term is particularly challenging for companies selling larger solar home systems on a rent-to-own basis, forcing most to extend the repayment term beyond 24 months. There is insufficient experience with such models to determine the actual impact longer repayment terms has on customer payments, but it is likely to increase repayment risks as PAYG companies extend the term beyond 24 months.

Rent-to-own models can be particularly challenging for end-customers who are uncomfortable committing to a long-term financing relationship and who generally have a low appetite for testing new technologies. Uptake of rent-to-own products in markets or customer segments with a negative opinion of or a social stigma toward being in debt or formal financial commitments is likely to be very low, even if pitched as a lease. With an explicit down payment, term and ongoing cost (price per day or week), end-customers might negatively react to what they believe is the inherent interest or cost of financing for a PAYG solar product, particularly in markets with subsidized or low-cost financing available for non-energy purposes. The rate of technology change within the portable solar market could also limit uptake of rent-to-own models, particularly for repayment terms over one year, as potential consumers may fear that competing products will hit the market with higher value at lower costs during the payback period.

Energy-as-a-Service

Another business model made possible by advancements in digital finance can be described as Energy-as-a-Service being used by Off-Grid:Electric (Tanzania), Persistent Energy (Ghana), and Econet Solar (Zimbabwe). Under this model, customers pay an ongoing usage fee to the energy company in exchange for prepaid days or weeks of usage without the option of ultimately owning the solar device. This model has the advantage of removing most of the financing and technology risk from end-customers as compared to a rent-to-own model.

Companies deploying energy-as-a-service are typically focused on maximizing concentration of subscribers in targeted geographies, spending a relatively low amount of time and resources assessing payment risk before approving a new customer. As such, these companies might begin to sign up customers that might otherwise be seen as high risk under a rent-to-own model because the products can often be easily redeployed to new customers in case of long periods of non-payment, or if an existing customer drops out. Similar to direct-to-home digital television companies (Tata Sky in India, Zuku TV in Africa), these PAYG solar companies often aggressively sign up new subscribers to get their own hardware in a customer's home, taking a long-term bet that the service is so valuable that consumption will happen. By targeting high connection rates in each area of operation, these PAYG solar companies may be able to achieve a large subscriber base relatively quickly, and could end up with a healthy mix of low and high usage customers in each region.

From an end-customer's perspective, energy-as-a-service can be a much lower risk transaction as compared to a rent-to-own offering. Without a fixed term, the financial risk to potential customers is much lower as they are typically able to discontinue the service at any time with minimal penalty. This model also addresses the potential consumer fear of technology obsolescence, as new devices can be easily added as technology advances without the need to first pay off the original equipment. Once signed up, an energy-as-a-service customer can typically upgrade—add additional battery capacity, solar panels, lights and appliances—without much hassle, with the PAYG company swapping out the systems and often redeploying the original assets to a new subscriber. For the customer, the primary change is that he/she will be paying a higher tariff with the bigger system.

While it may effectively remove most financing risks from energy poor consumers, energy-as-a-service models have some notable challenges. For consumers using pico solar systems, energy-as-a-service could be more expensive than a rent-to-own option over a period of three plus years particularly as the average useful life of such products increases. Without the potential to own the device, energy-as-a-service consumers may have less incentive to take care of the solar product and might be inclined to push the system to its limits, leading to higher after-sales service requirements.

It's not yet clear whether energy poor customers value ownership-based models over service models. As described previously, energy poor consumers with a very low tolerance for debt and/or long-term financing relationships might gravitate toward service-based models. Customer segments motivated by asset ownership and the potential to achieve free energy services might prefer rent-to-own models. Customer usage patterns and maintenance of the products could also influence the viability of one model over the other. For example, energy-as-a-service might not work in markets known for pushing products to their limit as frequent maintenance visits could increase costs beyond acceptable thresholds.

It's also early to tell what market conditions will facilitate or limit these options. In some markets, financial regulation might dictate which transaction model is appropriate. For example, a governing body might view rent-to-own and leasing models as falling under the existing financial sector regulation, requiring all companies interested in delivering such a transaction for solar products to be a registered financial institution. Depending on the market, this could require a PAYG Solar company to launch their own, purchase, or merge with a financial institution to meet regulatory requirements. Alternatively, existing energy regulation could dictate the price of electricity sold as a service—even via distributed DC systems—and could also restrict the provision of electricity services to formal utilities.

(b) Time-Based vs. Usage-Based Pricing

Time-based

In the PAYG solar sector, it's common to see end-customers paying for prepaid usage in increments of time—days, weeks, and months (Fenix, M-KOPA, Mobisol, Off-Grid:Electric, Simpa). Under this "time-based" pricing, end-customers are typically able to use the solar device and related appliances (i.e., lights, radio, phone charging outlets) as much or as little as they want in a given time period (e.g., a 24-hour period), within the limitations of the product's battery capacity. In other words, using a product for 10 minutes in a 24-hour period is considered the same thing as using it for 5 hours in a 24-hour period under time-based pricing—both count as a "day of use."

For most PAYG solar applications, time-based pricing offers a number of advantages. First, it simplifies the requirements and lowers the cost of the embedded payment technology as it does not necessarily need to meter actual energy consumption. An internal digital clock and simple time display can keep customers informed of their remaining balance. In many markets, a price-

per-day might be easier to communicate with energy poor consumers who may not be familiar with energy units like watt- and kilowatt-hours. It also often eliminates the possible price comparison with grid-connected electricity tariffs, which can sometimes limit sales. On the other hand, time-based pricing requires PAYG solar companies to carefully calculate the price-per-day weighing a number of moving variables: cost of the device, operating and financing costs, repayment term, anticipated variability in payments, portfolio management and payment processing costs, etc. Time-based pricing holds the potential to be more costly to some consumers if they do not use the device to its full battery limit on a consistent basis. Under most time-based pricing models, a consumer is also charged for a day of use if they don't use the device at all in a particular day. Under both scenarios, the product's timer counts down one day every 24 hours, regardless of actual use.

Usage-based

Angaza Design and Simpa Networks have some experience deploying energy, or usage-based pricing in PAYG solar products where end-customers are buying increments of energy. Usage-based pricing is the predominant pricing model used in national electrical grid billing systems where customers are typically charged in pre- or post-paid kilowatt-hour units. Usage-based pricing is also used in decentralized, mini, or microgrid scenarios where standard AC electricity services are delivered to individual consumers via distribution lines. Under the usage-based pricing models sometimes used by Angaza and Simpa, customers exchange cash for the ability to use a product for a number of watt- or kilowatt-hours.

For many energy poor consumers, usage-based pricing can be very attractive because it more closely matches variability in income and expenditures. Under this model, consumers are charged only for actual energy used, potentially increasing trust in the brand associated with the offering. However, PAYG solar companies deploying this pricing model have a number of challenges. First, their embedded payment hardware must meter actual energy consumption, adding costs to the product to accommodate this functionality. Second, it can be difficult for consumers to understand and manage their prepaid balance in energy units if they have not been exposed to the concept in the past. If the product includes a user interface that displays the prepaid energy units available and decrements from this balance in real-time, the consumer might use the device or certain appliances more conservatively than they would under a time-based pricing model where the outstanding balance decreases only once per day.

4) End-User Financing Terms

In this section, we detail the end-user financing terms across all combination of models discussed in previous sections—rent-to-own, energy-as-a-service, time-based, and usage-based—and consider products being deployed.

Specific financing terms vary among companies, and are often dictated by the size and type of PAYG product—i.e., portable solar lights/ pico-solar products versus larger solar home systems. PAYG companies that deploy a rent-to-own or leasing model share a number of characteristics

with more traditional equipment financing vehicles. Customers are required to provide a down payment/deposit before the system is delivered or installed, typically 10-20 percent of the total financed asset price. PAYG solar companies use this as an initial risk assessment tool, sometimes increasing or decreasing the initial payment requirement for interested customers, depending on risk level. These models also often have a fixed term, explicitly communicated to customers upfront in terms of a total time commitment or a target number of payments before the system unlocks. The length of the financing term is often determined by the average useful life of the energy asset, with most companies offering a warranty for the full financing term. It is also common for these companies to require a weekly or monthly minimum payment, and often deploy penalties when a customer exceeds a certain amount of days of consecutive nonuse.

A key objective of all PAYG solar companies is to deliver energy at a price that is competitive with alternatives. The financing term and per-unit pricing are often designed such that the estimated monthly expenditure for the PAYG product are in total cheaper than existing expenditures on alternatives like kerosene and mobile phone charging.

The Table 4 and Table 5 outline components of the PAYG financing options for both pico solar systems and solar home systems.

Table 4. Financing Terms for PAYG Pico Systems

Product/ Company	Solar Panel	Energy Applications	Initial Payment	Payment Increment	Payment Term	Price/ Week	Total Cost (Est.)
M-KOPA III (M-KOPA Solar)	8 Wp	3-Lights + Radio + Mobile Charging	$34	Daily	365 days	$3.22	$201
Indigo Duo (Azuri)	2.5Wp	2-Lights + Mobile Charging	$10	Weekly	80 weekly payments + $5 unlock fee	$1.50	$135
Based on exchange rates as of July 2014. US$1 = Ksh 87							

The financing terms for pico solar systems are often structured such that the initial payment is lower than the cash price of a portable solar light, and the total term is no longer than 18 months. The low upfront cash commitment can often make the PAYG solar system more attractive to consumers who might otherwise consider a cash-and-carry alternative. Companies deploying pico systems have a strong desire to keep the repayment period short because these products are relatively small in size, easily movable, and often sold through fast-moving distribution channels with minimal post-sales support. At a cash retail price point of under $150, it's typically easier for PAYG solar system companies to simply replace an entire product when customers face a problem, rather than invest in building out a complex service network to diagnose and address individual component-level issues.

PAYG pico solar systems often have a useful life of two years or less, primarily due to battery life and normal wear-and-tear in off-grid markets. Though some pico solar systems on the market can last beyond two years, it's common for companies to limit the financing period to at least six months shorter than the average useful life. This combination of low upfront commitment and

ongoing pricing competitive with alternatives is difficult to deliver with larger solar home systems that have a higher capital cost and often require ongoing routine maintenance.

Table 5. Financing Terms for PAYG Large Solar Home Systems

Product/ Company	Solar Panel	Energy Applications	Initial Payment	Payment Increment	Payment Term	Price/ Week	Total Cost (Est.)
Mobisol 80Wp system (Mobisol)	80Wp	5-lights + mobile charging business kit + Radio + TV	$45	Monthly Installment	36 months	$5.25	$801
Spark 40 system (Simpa)	40Wp	4-lights + mobile charging	$33	Daily, weekly	36 months	$2.33	$368
Based on exchange rates as of July 2014. USD 1 = INR 60							

Solar home systems above 20Wp can deliver more power and longer run times as compared with pico systems and often have a standard useful life beyond three years. On the other hand, device costs are much higher, and the product installation process is more time consuming and typically requires a trained solar technician. These products typically use standard lead-acid batteries with a useful life of up to five years and decades of experience as a technology in off-grid markets. The relatively long battery life and low product movability risk can give PAYG solar companies some confidence in extending the financing term beyond a year.

Both Mobisol (Kenya, Tanzania, Rwanda) and Simpa Networks (India) offer up to 2–3 year financing to end-customers for larger PAYG solar home systems, influenced by a desire to deliver a weekly/monthly cost that is competitive with alternatives. If these companies were to shorten the financing period to 12 months, the ongoing monthly cost to a consumer could be 2–3 times current expenditures on alternatives such as kerosene and mobile phone charging services. Reducing the term could somewhat reduce customer payment risk, but would also likely have an adverse impact on sales as many customer segments find it difficult to mobilize additional resources for energy beyond what they are already spending on alternatives. There are consumers willing to spend more on modern energy solutions, but the trend in the sector to date has been to design the financing so the PAYG solar solution is price competitive with existing options to maximize sales potential. It is not yet clear how large the market will be for PAYG energy solutions priced at above the average ongoing price for existing alternatives.

Risk Management

Companies deploying a rent-to-own model often develop risk assessment and ongoing customer portfolio management practices similar to the methods used in the microfinance industry, but with a twist. For example, PAYG companies often take potential customers through a risk assessment process similar in many ways to credit evaluation procedures undertaken in microfinance, complete with visits to the prospective customer's home and review of publicly available credit data; they often require a signature from an influential member of the community. PAYG solar companies might also collect and analyze energy-specific data to inform risk

assessments: expenditures on energy alternatives, access and/or distance from the electricity grid, ownership of electricity-consuming appliances, etc.

Once a system is installed, PAYG solar companies shift attention to driving customer payment behavior. Some companies require customers to achieve a minimum monthly payment amount, but offer a certain number of “grace days,” or days of nonuse, each month. If a customer goes over his or her grace day’s balance between payments, a penalty is assessed to the next payment. Several PAYG companies assess a financial penalty in situations where customers exceed a predetermined limit of nonusage. This gives end-customers the ability to forgo use if they choose, and delivers a strong incentive to keep these periods of nonuse short. Under most PAYG models, the energy enterprise reserves the right to repossess the solar device in cases of extended periods of nonuse/nonpayment.

Unlike many banks and MFIs, PAYG companies typically have a strong interest in promoting early repayment, and often offer discounts on the total financed price to encourage this behavior. For example, M-KOPA Solar and Mobisol offer a 10-20% discount to customers who prepay. Most PAYG companies offer free product usage (days or Wh) to existing customers who refer other new customers. This benefit is typically processed in much the same way as a normal PAYG payment, but at no charge to the end-customer. This digital economic good—prepaid energy credit—can be used to positively and negatively incentivize customers and other members of the value chain. For example, prepaid credits might also be used as way to incentivize agents to meet and exceed monthly targets or deliver timely service to customers.

5) Sales and Distribution

While PAYG pricing and end-user financing can make solar products more attractive to energy poor consumers, building out strong distribution channels that reach the customer’s doorstep efficiently remains a key challenge. Energy-as-a-service businesses such as Off-Grid:Electric and Persistent Energy Ghana aim to maximize penetration in targeted geographies, with sales and operations focused on signing up a high concentration of subscribers in select areas. Rent-to-own businesses, on the other hand, often require the design and management of large sales and product distribution networks because the rent-to-own sales process is long, and customers are often spread out geographically.

Last-mile distribution – Off-Grid:Electric, Tanzania

Most PAYG companies generate sales leads and deliver products through a network of commission-based agents, often with some form of physical presence in or near target off-grid areas, such as retail shops, supermarkets, cafes, and mobile phone shops. These agents play a number of roles depending on the company, but they generally serve as an initial marketing point where customers can learn about the products and pricing, fill out an initial application and make a down payment/deposit, and in some cases receive their product and bring it back for servicing. In markets where mobile money is not yet prevalent, these agents also often collect cash from customers and process proof-of-payment with the PAYG energy company via SMS. These agents also act as a distribution point, receiving products from the PAYG company, delivering to the end-customer, or installing at their premises, and might maintain a small inventory to reduce delivery times.

Given the logistical challenges of reaching deep into rural areas, it's common for PAYG solar companies to establish partnerships with for-profit and not-for-profit organizations to facilitate sales and product distribution. M-KOPA Solar (Safaricom) and Fenix International (MTN) partner with MNOs on sales and distribution, each co-branding its products with the mobile operator, and leverage its authorized product, mobile airtime and mobile money agent networks for sales and distribution of the PAYG solar products.

Fenix/MTN co-branded ReadyPay poster (Fenix International, Inc.)

M-KOPA/Safaricom co-branded M-KOPA III poster (M-KOPA Solar)

PAYG companies borrow multiple marketing tactics from the prepaid mobile sector. Above-the-line marketing activities for PAYG solar often involve painting buildings/homes with the energy brand/offering. Below-the-line marketing and promotions are facilitated by commission-based payment agents, field-based staff, and customer referrals. PAYG solar companies are also starting to deploy a range of direct marketing activities via SMS, phone calls, and targeted customer incentives. As with prepaid mobile airtime and mobile money services, smart agent incentives are critical to both drive signup of new customers and, more importantly, grow usage of PAYG energy services.

Simpa ad: Uttar Pradesh, India (Simpa Networks, Inc.)

Mobisol ad: Heshima Centre, Kenya (Mobisol GmbH)

The distribution-focused social enterprise SunnyMoney has played a lead role in promoting the development of PAYG technologies for entry-level portable solar lights, working with product manufacturers and PAYG providers including Angaza Design, Azuri Technologies, and divi Power. As the largest distributor of portable solar lights in Africa, SunnyMoney works closely with education authorities in four African countries to distribute solar lights through rural schools, leveraging the reputation of head teachers for marketing to students and their families. PAYG products from divi Power and Angaza Design are sold through SunnyMoney's school program, often leveraging the head teacher as an agent to collect payments and/or unlock the solar lights using a smartphone.

6) The Future of PAYG Solar

The core value proposition of PAYG pricing—flexible, user-determined increments with the ability to forgo usage without facing a penalty—is a strong match for energy poor consumers whose economic situation is often unpredictable. The emerging businesses reviewed in this paper are delivering significant energy improvements to largely underserved markets, leveraging mobile payments and M2M technologies to unlock new ways to extend end-user financing and deliver prepaid energy services.

These business models are young, but already highlight a number of opportunities for improving the provision of essential services to underserved consumers.

- Balancing Flexibility and Predictability—One of the truly exciting features of PAYG in the energy sector is that you can deliver payment flexibility that more traditional financing options can't offer, such as allowing customers to choose the amount and frequencies with which they top-up their account, as opposed to a schedule of fixed installments. On the other hand, most sources of energy asset finance are accustomed to steady, predictable cash flows. This constraint that consumer's face is forcing social enterprises to innovate, and PAYG solar companies are leading the way. As mentioned earlier, pricing models are being customized to segments of the market in ways that have never been done before, and new ways to monitor repayments and portfolio performance are under development. PAYG solar companies are developing new metrics and incentives to monitor customer portfolios that could one day prove useful to other industries financing assets on a PAYG basis. For example, a customer whose prepaid balance expires might be allowed multiple days or even weeks of nonuse under his/her contract before the account is considered an at-risk asset. This particular example might require a PAYG solar company to focus on the customer's cumulative payment performance rather than a particular month, or continuously compare his average monthly payment against other customers with similar characteristics.

- Facilitating Other Financial Services—PAYG solar businesses are often serving customers who don't currently have access to other forms of formal finance. For many

off-grid consumers, paying off a PAYG solar product might be the first formal credit history in their life. In the future, this data can be used to fulfill prerequisites for the same consumers to obtain other financial services that typically require a formal credit history. Energy payment data from PAYG solar customers are already being used by these companies to inform future solar financing transactions, and could be used to extend other financial services to energy poor consumers who have limited access to formal finance. For example, another asset such as a television or water pump can be bundled with the PAYG product and the entire product package value paid off through digital payments, with the energy services disabled if/when customer misses a payment. The digital energy credit itself could also be used as a vehicle to facilitate financial services. For example, a customer can store excess cash in their prepaid solar account as a form of digital savings, and could theoretically use the prepaid energy credit for other purposes in exchange with another PAYG solar customer or agent.

- PAYG Solar Driving Growth in Digital Finance—PAYG solar companies are delivering the first exposure to digital finance for many off-grid consumers. In markets where mobile money exists but has yet to achieve significant traction in rural areas, PAYG solar companies are already helping to build out these services as most require interested customers to register for a mobile money account to qualify and sometimes assist in identification and training of agents. In markets where mobile money has yet to take off, PAYG solar companies are building out an energy credit agent channel that often mimics the activities of mobile money agents in other countries, and can be leveraged by MNOs in the future.

- Leveraging Data—PAYG solar businesses are collecting and analyzing thousands of data points on each customer, already using this information to better understand customer requirements and usage, customize pricing, and improve future products. Yet we have only scratched the surface when it comes to exploring how to make use of this data. For example, this data can be useful to governments, investors, and donors financing rural electrification. Data from PAYG products can give investors and donors financing the assets significant insights into performance and usage, improving efficiency of rural electrification financing. This data could be used by governments and regulators to better direct energy subsidies to target populations. In countries where significant government budgets are spent on fuel-based subsidies, new programs could offer digital transfers direct to consumers to be used on energy services of their choosing—and could be used to prepay for PAYG solar services. PAYG solar companies could potentially sell rich data on energy needs and preferences to consumer electronics companies searching for a better way to serve the off-grid market.

- Energy Access is Becoming “Bankable”—To reach scale, the PAYG solar sector will need significant capital to both support new business development and initial market experience, and to scale existing models. To date, most PAYG solar companies have funded product development and initial sales through a combination of grant capital and equity through mainly impact-oriented investors. Only a handful of companies have

accessed debt to finance the energy assets, and even fewer have leveraged local sources of finance. However, recently announced funding rounds by M-KOPA Solar[18] and Off-Grid:Electric[19] demonstrate that delivering energy access through PAYG solar is becoming bankable. M-KOPA's $10 million syndicated debt facility fronted by Commercial Bank of Africa is a strong signal that PAYG solar can be attractive to local finance providers, and the innovative use of future M-PESA payments as collateral for the facility should serve as a model for future funding to the PAYG solar and other sectors leveraging digital finance.

[18] http://www.gsma.com/mobilefordevelopment/m-kopa-solars-new-funding-a-landmark-for-off-grid-energy-service-companies

[19] http://venturebeat.com/2014/03/21/off-grid-electric-gets-7m-to-light-africa-in-a-decade-exclusive/