



Unlocking Public and Private
Finance for the Poor

DIGITAL FINANCE FOR ENERGY ACCESS IN UGANDA:

PUTTING MOBILE MONEY BIG DATA ANALYTICS TO WORK

Mayank Jain, Robin Gravesteijn, Arne Jacobson, Emily Gamble, Nicola Scarrone





ABSTRACT

Access to clean energy is a basic need that directly supports people's livelihood, yet more than 30 million Ugandans live without electricity. Pay-as-you-go (PayGo) is a promising and innovative financing solution that can make clean energy affordable for low-income people. However, there remains significant knowledge gaps regarding the digital energy finance market's size, outreach, growth and impact. This study leverages anonymized mobile money data of PayGo solar energy users in Uganda to gain insight on digital energy financing in Uganda. It also draws from a customer phone survey that assesses solar product adoption and quality of life improvements. We find that the Uganda solar market is growing rapidly and currently has around one million active customers. Around 12 percent of the Ugandan households own a solar home system and there is opportunity for further market expansion, especially in areas with high levels of mobile money penetration. The clean energy market is becoming more inter-connected with the digital finance market. In fact, digital energy financing through PayGo has promoted wider financial inclusion for around 110,000 new mobile money customers. Likewise, when Uganda implemented a temporary mobile money tax it caused an immediate slow-down in PayGo uptake and new mobile money activations indicating it negatively impacted the country's access to clean energy and formal finance. The customer survey results indicate that poorer customers seem equally able to purchase larger solar systems as compared to richer customers because of mobile money financing. Mobile money transaction data confirms this pattern as PayGo customers are making smaller and more frequent transactions of around US\$2-3 on average indicating solar home systems are indeed becoming more affordable for low-income populations. There seem to be strong customer journeys as around half of the surveyed customers purchased at least one additional energy product within three years of their initial solar product purchase. Customers perceived various positive impacts on household's quality of life including a reduction in use of traditional fuels, increased savings, health, increased study hours and safety improvements. These results highlight the importance of using customer data in designing business strategies and policies aimed at achieving energy access targets in Uganda.

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ABBREVIATIONS AND ACRONYMS

DDI	Dalberg Data Insights
ESP	Energy Service Provider
GONGLA	Global Off-Grid Lighting Association
LCDs	Least Developed Countries
MNO	Mobile Network Operator
OGS	Off-Grid Solar
PayGo	Pay-as-you-Go
PV	Photovoltaic
SDGs	Sustainable Development Goals
SHS	Solar Home Systems
SHS	Solar Home System
SPL	Solar Portable Lamps
UGX	Uganda Shilling
UNCDF	United Nations Capital Development Fund
USEA	Uganda Solar Energy Association
USSD	Unstructured Supplementary Service Data
W	Watt
Wp	Watt-peak

ABOUT UNCDF

The UN Capital Development Fund (UNCDF) makes public and private finance work for the poor in the world's 47 least developed countries. With its capital mandate and instruments, UNCDF offers "last mile" finance models that unlock public and private resources, especially at the domestic level, to reduce poverty and support local economic development. UNCDF's financing models work through financial inclusion that expands the opportunities for individuals, households, and small businesses to participate in the local economy, providing them with the tools they need to climb out of poverty and manage their financial lives; and by showing how localized investments can drive public and private funding that underpins local economic expansion and sustainable development. By strengthening how finance works for poor people at the household, small enterprise, and local infrastructure levels, UNCDF contributes to SDG 1 on eradicating poverty and SDG 17 on the means of implementation. By identifying those market segments where innovative financing models can have transformational impact in helping to reach the last mile and address exclusion and inequalities of access, UNCDF contributes to a number of different SDGs.



UNCDF INCLUSIVE DIGITAL ECONOMIES: LEAVING NO ONE BEHIND IN THE DIGITAL ERA

The UNCDF strategy 'Leaving no one behind in the digital era' is based on over a decade of experience in digital finance in Africa, Asia and the Pacific. UNCDF recognizes that reaching the full potential of digital financial inclusion in support of the Sustainable Development Goals (SDGs) aligns with the vision of promoting digital economies that leave no one behind. The vision of UNCDF is to empower millions of people by 2024 to use services daily that leverage innovation and technology and contribute to the SDGs. UNCDF will apply a market development approach and continuously seek to address underlying market dysfunctions.



ABOUT UNCDF WORK ON ENERGY

The UNCDF programme focused on energy contributes to achieving SDG 7 on affordable and clean energy for all, and SDG 8 focusing on decent inclusive work, economic growth and, more specifically, financial inclusion. The Programme aims to improve access to clean energy finance for poor and low-income people. By partnering with energy and financial service providers and offering capital, data analytics, capacity building and policy advocacy services in the off-grid energy finance markets, UNCDF CleanStart has scaled energy business models for cleaner, efficient and more effective sources of energy for poor people. As of 2019, UNCDF digital energy finance activities have enabled over 375,766 low-income families and small-scale businesses to access renewable energy technologies (RETs) through micro- and PayGo financing.

ABOUT SCHATZ

The Schatz Energy Research Center (SERC) at Humboldt State University is located on California's northern coast. The Center engages in research and projects that support the establishment of clean and renewable energy in our society. Its areas of expertise include solar power, biomass energy, clean transportation, energy efficiency and access to energy in off-grid areas. For the past decade, the Schatz Center has been an international leader in efforts to promote quality assurance and consumer protection in markets for off-grid solar products and systems. The Center's work involves research and development, technology demonstration, laboratory testing, feasibility studies, resource assessments, energy planning studies, energy systems analysis and education and training. For the purpose of this study Schatz has conducted a demand side customer survey and supported with an analytical report.

The UNCDF programme focused on energy is supported by:



THE GOVERNMENT
OF THE GRAND DUCHY OF LUXEMBOURG



FOREWORD AND AUTHORSHIP

This working paper is part of a wider UNCDF partnership with the Uganda Solar Energy Association (USEA). UNCDF has supported the Association's members with technical and analytical know-how in using customer data for market scoping and customer-centric product development. Among other actions, the partnership created an 'online digital energy finance dashboard' using mobile money big data that offers real-time insights on the PayGo solar energy market in Uganda. We value the rich insights gained from a fresh new survey conducted with customers of SunnyMoney, Greenlight Planet, Solar Now and Fenix International. The project further trained energy service providers (ESPs)¹ in Uganda on how to gather and use data on product development and the customer experience. Finally, the joint UNCDF-USEA initiative collected and harmonized key performance indicators. In collaboration with Dalberg Data Insights (DDI), Schatz Energy Research Center (SERC) and USEA, the partnership and this working paper aim to fill critical information gaps so that businesses and policymakers can improve energy access in Uganda and help households make informed choices when purchasing solar products.

This paper was authored by Mayank Kumar Jain, Dr. Robin Gravesteijn, Emily Gamble and Nicola Scarrone (UNCDF); and Dr Arne Jacobson (Schatz Energy Research Center). We thank Dipti Varghese for editorial support, and Karen Lilje for layout and design. The views expressed in this publication are those of the authors and do not necessarily represent those of the United Nations, including UNCDF and Member States.

ACKNOWLEDGEMENTS

The authors of this report would like to thank those who reviewed and provided invaluable comments:

Joyce Nkuyahaga	CEO	Uganda Solar Energy Association
Rositsa Zaimova	Associate Partner	Dalberg Data Insights
Jerome Urbain	Associate Partner	Dalberg Data Insights
Lucio Melito	Data Scientist	Dalberg Data Insights
Dr. Nicholas Lam	Research Scientist	Schatz Energy Research Center
Chih-Wei Hsu	Research Assistant	Schatz Energy Research Center
Richa Goyal	Senior Insights Manager	Energy Savings Trust
Christopher Emmott	Product Portfolio Manager	Fenix International Inc
Jacob Winiecki	Director	BFA
Sjef Ketelaars	Project Manager Research	GOGA
Tae Yoon Lee	Intern	UNCDF
Jubing Ge	Intern	UNCDF
Sarmin Rauf	Intern	UNCDF

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This research publication was supported by:



¹ In this paper, we also refer to PayGo solar companies as Energy Service Providers

EXECUTIVE SUMMARY

Clean energy can improve people's wellbeing, health, and socio-economic status, yet today more than 30 million Ugandans live without electricity. Only 16 percent of Ugandan households are connected to a grid (Umeme, 2017) and they often have unreliable access (IFC, 2018)². Unelectrified households rely on traditional lighting fuels, such as kerosene lamps, which are 100 times more expensive than clean electricity (IRENA, 2016). Low-income Ugandans are particularly affected financially, spending 5 to 10 percent of their family income on lighting (Enclude, 2014; Harrison et al., 2016); they also experience severe health problems associated with the use of kerosene lamps (Mills, 2012). Energy poverty needs viable solutions as it remains a serious obstacle to the achievement of the Sustainable Development Goals (SDGs), including those for affordable and clean energy, good health and well-being, and quality education.

The Government of Uganda has set an ambitious goal of achieving universal access to electricity by 2040.^{3,4} With the current rate of grid expansion, the country seems unlikely to achieve its targets without the rapid deployment of off-grid solutions. Presently, 17.5 percent of Ugandan households are using off-grid solar (OGS) devices, with the majority of them owning pico-PV (Photovoltaic) lamps that provide few additional services beyond lighting. Only three percent of all Ugandan households currently use larger solar home systems⁵ (UBOS, 2017). The affordability of solar home systems, particularly for low-income households, is a significant barrier to improving energy access in Uganda. Pay-as-you-go (PayGo)⁶ solar allows customers to pay for their electricity use via mobile money payments that are more frequent and in smaller amounts than traditional financing systems.

While PayGo solar is seen as a promising and innovative financing solution to enable energy access in Uganda, its market growth is hindered by several barriers, including a lack of market information, limited customer targeting, market failures in the distribution chain, a lack of harmonization of product quality standards, capital constraints for product financing, and unclear tax policies. Most of these challenges are underpinned by a general lack of information that customers have about solar products, and the lack of information that companies have about customers and product demand. Other than insights from several demand-side surveys (for example UBOS, 2017) and supply-side surveys (for example IFC, 2018), there remains limited market information on the PayGo solar market in Uganda. In particular, poor households in remote areas are unfamiliar with solar products and remain unaware of the impact they can have on their lives, including financial and health benefits. Furthermore, despite the existence of several studies on digital finance in Uganda (FSDU, 2013; FSDU, 2018; Demirguc-Kunt et al., 2017), as well as on energy access (Goyal and Jacobson, 2018), there is little information on the relationship between the two.



16%
of Ugandan households are connected to a grid and they often have unreliable access.



17.5%
of Ugandan households are using off-grid solar (OGS) devices.



This working paper leverages anonymized mobile money transaction data to gain customer and market-level insights on digital energy financing in Uganda.

This working paper leverages anonymized mobile money transaction data to gain customer and market-level insights on digital energy financing in Uganda. The mobile money transaction data used for the period October 2016 to December 2018 represents around 75 percent⁷ of the PayGo solar market in Uganda as of 2018. The data contains 11.5 million PayGo transactions of more than 700,000 solar PayGo customers belonging to 20 energy service providers (ESPs) in Uganda. UNCDF and Dalberg Data Insights (DDI) jointly created the online digital energy finance dashboard that shows relevant insights by gender, transaction date, transaction type (for example PayGo, cash-in, cash-out, savings), mobile money activation date, location (by region, district and cell-tower area), and by ESP.

This study evaluates the geographic penetration and growth patterns of the PayGo solar market by district, province, provider, and number of new customers. By overlaying aggregated mobile money penetration⁸ and transaction data onto electricity-access maps we can identify geographic areas with potential PayGo customers. We further evaluate the ability of customers to pay for clean energy by examining their PayGo solar transactions over time. We test whether digital energy financing contributes to wider financial inclusion and apply this to measuring the effects of the (temporary) mobile money tax on the digital energy finance markets.

To understand solar product adoption patterns and quality of life improvements, telephonic surveys were conducted 424 off-grid solar customers in the Luwero and Pallisa districts⁹ of Uganda (Lam et al. forthcoming). Participating households had each bought at least one of the following in 2015: a small solar portable lamp (SPL)¹⁰ using cash, a mini solar home system (mini-SHS)¹¹ using pay-as-you-go financing, or a larger SHS¹² using micro-credit. By conducting surveys we tracked households' energy product purchasing behavior through late 2018.



The study estimates that the PayGo solar market is much larger than initially expected, with around one million customers as of 2018.

In summary, this project aims to fill some critical gaps in information about the solar market in Uganda, enabling businesses and policymakers to improve energy access and households to make more informed choices about solar products.

The study finds that Uganda is a niche PayGo solar market that is not only growing fast but also has the potential for further geographic expansion. Uganda's top four solar companies control the majority of the PayGo market (approx. 98 percent based on the Telco data), leaving little market share for small players. The study estimates that the PayGo solar market is much larger than initially expected, with around one million customers as of 2018; of whom 672,000 are accessing PayGo solar via MTN mobile money. Growth in new customers has been rapid: 138 percent in 2017 and 160 percent in 2018. The average PayGo penetration—meaning the number of active¹³ PayGo households as a percentage of a district's or province's total number of households—is 12 percent, and implies that there is a significant market opportunity to expand.

The study finds that a reasonable PayGo solar penetration is limited to only a few districts in Uganda. In fact, only 10 districts in Uganda have more than 5,000 active PayGo customers, and all of them are located in the country's Central and Eastern regions.¹⁴ Especially districts

with high rates of mobile money penetration can become the prime target areas for energy companies to accelerate off-grid solar usage.

For example, the districts of Masindi, Kriyandongo, Gulu, Lira, Busia, Mbarara and Hoima have more than 60 percent mobile money adoption but less than 20 percent of households have electricity access. Overall, the study estimates that an additional 3.5 million households can afford solar home systems in Uganda.

The study identified several market trends: PayGo solar customers are making more frequent and smaller transactions with average transactions reducing from US\$3.1 to US\$2. ESPs seem to have made their payment plans more flexible by extending the repayment period and reducing the minimum required transaction amounts. This made PayGo solar purchase more affordable for the lower income customers. For more than 110,000 new customers - 16 per cent of all new mobile money customers - PayGo was their first form of digital finance, as they activated their mobile money accounts 45 days prior to making their first PayGo payments. This suggests that the Paygo model may offer a good use case for wider digital financial inclusion.

We did see a significant drop in number of new mobile money activations due to PayGo during the period March to July 2018 as a result of the introduction of a (temporary) mobile money taxes. Equally so when the mobile money taxes on bill payments was proposed for cancellation in later-July the market quickly recovered. This shows that mobile money taxation policies can have a severe and immediate impact on not only rates of financial inclusion in Uganda, but also on people's ability to access energy.

The demand-side survey showed strong customer journeys: 50 percent of existing solar home system customers purchased additional energy products after their initial purchase, thereby gradually increasing their energy usage over the period 2016 to 2018.¹⁵ This demonstrates a



110 000
new mobile
money customers
use PayGo as
their first form of
digital finance.



@ Fenix International



Only 9%
of the customers
using PayGo are
below the 1.9US\$
poverty line as
compared to
42% of Uganda
population.

significant opportunity for market growth in solar home products among existing customers. Customer satisfaction is generally high, in particular for larger solar home systems that can power more devices. Yet only 29 percent of the solar products sold in 2018 were above 20Wp (USEA and GOGLA 2019, forthcoming) indicating both the affordability concerns for bigger devices and unserved market. Most customers who used flexible financing, including PayGo and micro-credit loans, mostly viewed these schemes positively.

The customer survey finds that PayGo is serving low-income people rather than the poorest of poor as only 9 percent of the customers are below the 1.9US\$ poverty line as compared to 42 percent of Uganda population. The income poverty distributions of households that purchased small solar lamps with cash were similar to those who purchased larger solar home systems using PayGo financing. This indicates that PayGo may be a flexible financing tool (in terms of smaller and more frequent transactions) that makes solar systems more affordable for low income households (see also Goyal and Jacobson, 2018). While we find no indication that solar home systems themselves directly contribute to poverty reduction, customers reported various positive impacts on the household's quality of life, including a reduction in the use of traditional fuels (57 percent of the customers), increased savings (26 percent), improved health (24 percent) and perception of safety (20 percent) and increased study hours for children (10 percent). These socio-economic benefits were more substantial for larger solar products.

RECOMMENDATIONS

RECOMMENDATIONS FOR THE GOVERNMENT AND OTHER INSTITUTIONS SUPPORTING FINANCIAL AND ENERGY ACCESS POLICIES:

- **Facilitate partnerships among mobile network operators (MNOs), aggregators and energy service providers (ESPs) and remove regulatory cost constraints to accelerate digital energy finance in Uganda.** For example, the partnership between Fenix International and MTN Uganda allows customers to pay for off-grid electricity using mobile money services and it has resulted in 110,000 new mobile money and energy customers since the partnership began in 2013. Small solar companies, however, find it difficult to afford such partnerships since integration with mobile money platforms requires a significant investment in time and resources. Recently, several payment aggregator companies have emerged in Uganda offering integration services that are fast and come with technology and customer support. These payment aggregators can play an important role in connecting off-grid households, energy service providers and MNOs, leading to the much-needed expansion of digital energy finance for small ESPs in Uganda. But the high regulatory costs that come with activating an Unstructured Supplementary Service Data (USSD) based payment platform are hindering the ability of aggregators to facilitate PayGo solar transactions.
- **Decrease mobile money fees on small PayGo solar transactions.** Our study has shown that PayGo solar service providers are creating a substantial new customer base for mobile money companies, with 16 percent of new customers (around 110,000) setting up mobile money accounts for the first time to make their PayGo payments. Yet these payments are subject to high transaction costs by MNOs. Most of the PayGo solar transactions



Customers
reported
positive
impacts of
solar products
on household
quality of life,
including a
reduction in
the use of
traditional
fuels, increased
savings,
improved health
and safety.

range from UGX 5,000 to UGX 15,000, with an average amount of UGX 8,000. Such low-value transactions are levied a mobile money fee of nearly UGX500, which is relatively expensive for low-income households and discourages them from purchasing PayGo solar products and making digital payments. Reducing transaction fees will likely lead to more people opening mobile money accounts to access clean energy and other digital financial services. The lower fees will also result in a higher number of mobile money transactions that can easily recover the foregone revenues for MNOs.

- **Investigate effects of mobile money taxes on digital payments and wider economic sectors.** Our research shows that taxing mobile money withdrawals may be a hindrance to Uganda's goals around financial inclusion and energy access. The use of mobile money for payments and remittances drives the financial sector's growth in Uganda, and its taxation may compel low-income people to resort to informal finance. For example, fewer people purchased PayGo systems when the 2018 temporary mobile money tax that also affected PayGo solar market was first announced. Likewise, we find PayGo purchases quickly recovered when the tax for digital payments was canceled. The Uganda case illustrates that if countries aim to expand PayGo renewable energy, it is better to avoid mobile money taxation on bill payments because it can have rapid effects on the market, with consumers switching back to cash options. This study demonstrates negative effects of the taxes on energy markets, but taxing mobile money is also likely to affect other mobile money use cases including for example payments for education loans, health, MSME finance, International remittances, etc. Countries who want to implement mobile money taxation policies have to carefully consider how to design such policies before launching them.¹⁶
- **Implement favorable tax policies for achieving energy access targets.** Beyond mobile money taxes there remains a range of other taxes charged for solar home systems. Taxation on solar products, including value-added tax, import and excise duties, influence the affordability of solar products especially for low-income and more rural customers. Sudden changes in tax rates also affect the sector's ability to estimate costs and pricing of solar products, creating an uncertain business environment. Following the introduction of new taxes and tariffs on the standalone solar sector in Uganda, energy providers are faced with uncertainty as to how much solar home systems will be taxed. There is also inconsistency in how taxes are being applied, with different companies facing different tax rates and some companies are even experiencing different tax rates on individual consignments of the same product. The government of Uganda should consider to constructively engaging in a dialogue with energy associations such as USEA and GOGLA on the taxation of solar home systems, components, and appliances.

RECOMMENDATIONS FOR ENERGY AND FINANCIAL SERVICES PROVIDERS:

- **Expand PayGo solar in geographical locations with high rates of mobile money penetration.** Our analysis showed that districts with high mobile money penetrations have better access to off-grid electricity. Districts such as Masindi, Kriyandongo, Gulu, Lira, Busia, Mbarara and Hoima have more than 60 percent of the households using mobile money but less than 20 percent of households have access to electricity. These districts could be primary target areas for energy companies seeking PayGo solar markets with a high potential for growth. On the other hand, districts such as Yumbe, Bukomansimbi Bududa and Kotida



60% of the households in Districts such as Masindi, Kriyandongo, Gulu, Lira, Busia, Mbarara and Hoima are using mobile money but less than 20% have access to electricity.

have extremely low levels of mobile money penetration (10 to 20 percent) and may require agent-led digital energy financing for improving energy access. Districts in the Karamoja region, including Napak, Moroto, Nakapiripirit and Amudat, show low rates of mobile money penetration but have relatively high ability to pay for electricity. Such locations may first require improved access to digital finance to expand clean energy usage.

- **Use customers' transactional data to develop user-centric financing for PayGo solar home systems.** Our analysis showed that Ugandans make frequent energy transactions and in small amounts; it also revealed that half of the surveyed customers purchased additional energy-related products and appliances after buying their first solar products. Analyzing information on people's financial behavior and products adoption over time can enable financial institutions to design user-centric and low-cost product financing methods that enable energy access, particularly for Uganda's last mile customers living in rural areas. Existing PayGo payment plans can be better tailored to the customer's needs; for example, solar product financing for farmers can be based on crop production. Several fintech firms, including Ant Financial and Kreditech, are using mobile money transactional data to build credit histories for unbanked customers as a way to provide them with customized financial services.
- **Continue the use of the digital energy financing dashboard to identify target customers and expansion areas.** The dashboard can monitor Uganda's Energy Access goals and market growth in real-time, broken down geographically by province, district and even areas covered by cell towers. Finally, the dashboard can support in tailoring financial services and solar products to the needs of local markets and help plan electrification projects. For the purpose of this study, we used anonymized mobile money transaction data to identify districts and regions with high levels of mobile money and solar PayGo penetration and then superimposed the results with maps showing energy access and electrical grids. Similar analytics can also be done at a more micro-level (for example, using a map that shows mobile money at mobile tower level) to identify potential PayGo solar customers based on factors like income levels, distribution channels, and mobile money adaption rates.

RECOMMENDATIONS FOR THE UGANDA SOLAR ENERGY ASSOCIATION:

- **Use mobile money data to monitor Uganda's off-grid solar energy market.** The digital energy finance dashboard can monitor the progress of PayGo solar sales and penetration in Uganda at cell tower, district and national levels on a weekly basis. The dashboard provides granular data that can supplement USEA's semi-annual sales data collection for tracking the overall solar market growth in Uganda. In addition, USEA and the Government of Uganda can use the dashboard to better plan energy access improvements in both the rural and urban areas.
- **Train energy service providers on how to use customer data for better understanding clients' needs, improving products and services, and expanding market outreach.** UNCDF, in partnership with USEA, organized a three-day data analytics workshop of more than 20 solar companies in Uganda. The training guided ESPs in using supply and demand data for market scoping, product development and improving customer experiences. Furthermore, the training discussed the implementation of PayGo technology for digitizing operations and

open-source platforms for managing and reporting data. Furthering this work, USEA can collaborate with its members, particularly small solar companies, to collect and use data and build tools for effective monitoring and growth of the off-grid solar market in Uganda.

- **Collaborate with MNOs to create digital campaigns for improving public awareness of PayGo solar.** As the Uganda PayGo solar market expands, awareness raising is crucial. Although nearly 86 percent of Ugandans are aware of solar products, there is limited awareness on purchase channels, financing and benefits for households (Enclude, 2014). In all, 73 percent of Ugandan households own a mobile phone (UBOS, 2017), providing an opportunity for USEA to improve public awareness about solar technology, its use, and its health and monetary benefits via digital campaigns. This, for example, could include launching a targeted SMS and automated calling campaign to inform people about PayGo solar products.

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- 2 It is estimated around 70 percent of those households with electricity access have unreliable electricity access.
 - 3 https://www.seforall.org/sites/default/files/Uganda_AA_EN_Released.pdf
 - 4 <http://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/UGANDA%29%20Vision%202040.pdf>
 - 5 A small autonomous PV system with capacity 10Wp to 350Wp and consisting of one or more solar panels, a battery and several appliances. These systems provide clean and affordable electricity to households having nil or unreliable access to the grid electricity.
 - 6 Pay-as-you-go (PayGo) is a digital financing technology that allows end-users to digitally pay for solar energy in instalments on a daily, weekly or monthly basis. For example, rather than paying a large solar system in one time up front cash purchase of 400 US\$, low income people could stretch out the payment of the system gradually over the course of 3 years using an installment of US\$ 11 per month or 2.5US\$ per week. Often the solar home system devices are being financed through leasing, loans or rental contracts and the devices can be switched off remotely to ensure proper usage and (re-)payment, thereby reducing the risk for the energy service provider, the financial service providers and ultimately also the customer.
 - 7 Calculated based on 76 percent mobile money market share of largest telco in Uganda and 25 percent of PayGo solar products are purchased in cash or through microcredit (USEA, GOGA 2019, forthcoming).
 - 8 Mobile money penetration is measured as the percentage of people who use mobile money as a percentage of the total adult population (Goyal & Jacobson, 2018).
 - 9 These districts were chosen because they differ in terms of socio-economic indicators, infrastructure and presence of off-grid energy industry players, and had a relatively high sales of number of solar products. For further details on geographical scope, please refer to https://mailchi.mp/4df554badf5b/energy_ladder.
 - 10 Solar module with a capacity ranging from 0.3 to 3 watts, with large solar lamps offering the ability to charge mobile phones. The products were purchased through the distribution channels of SunnyMoney and Greenlight.
 - 11 Solar modules ranging from 10 to 34 watts. Depending on the system size, these products included three to four LED light points, a radio, ports for charging mobile devices, and a TV. These products were purchased from Fenix.
 - 12 Solar modules with a capacity of 50 watts or more. The systems could power multiple lights plus appliances such as TVs, radios and mobile phones. These products were purchased from SolarNow.
 - 13 “Active PayGo customers” refers to households that have purchased a PayGo solar home system and are still paying off their system.
 - 14 Kampala, Wakiso, Mukono, Luwero, Kamuli, Budaka, Mbale, Manafwa, Tororo and Busia.
 - 15 This includes customers who purchased products additional solar home systems, solar panels and solar batteries to increase solar-powered electricity, as well as those who purchased electrical appliances like TVs and refrigerators.
 - 16 <https://www.uncdf.org/article/3892/understanding-the-consequences-of-mobile-money-taxes-in-uganda>

INTRODUCTION

This working paper leverages anonymized data on mobile money transactions from October 2016 to December 2018 to gain customer and market-level insights on digital energy financing in Uganda. The data we collected included customer gender, transaction dates, transaction types (for example PayGo payments, cash-in, cash-out, savings), mobile money activation dates, location (by region, district and cell tower area), and which energy service provider (if any) a customer is using. With this information, this study evaluates the geographic penetration and growth patterns of PayGo solar market by district, province, provider and number of new customers. By overlaying aggregated mobile money penetration¹⁷ and transaction data onto electricity-access maps we can identify geographic areas with potential PayGo customers. We further evaluate the ability of customers to pay for clean energy by examining their PayGo solar transactions over time. Finally, we test whether digital energy financing contributes to wider financial inclusion and apply this to measuring the effects of the (temporary) mobile money tax on the digital energy finance markets.



This working paper is part of a wider development project that established a data partnership with DDI, SERC and USEA.

This working paper is part of a wider development project that established a data partnership with the Uganda Solar Energy Association (USEA) and supported its members with technical and analytical know-how in using customer data for market scoping and customer-centric product development. In collaboration with Dalberg Data Insights (DDI), Schatz Energy Research Center and USEA, the project aims to fill some critical gaps in information about the solar market in Uganda, enabling businesses and policymakers to improve energy access and households to make more informed choices of solar products.

Section 2 describes the data and methodology used for the analysis. Section 3 presents findings of the supply-side energy and financial inclusion surveys and Section 4 showcases the demand-side analysis using the mobile money data. Section 5 demonstrates the use of readily available customer data for informing business and energy strategies in Uganda. Lastly, Section 6 provide recommendations to energy and financial service providers, USEA and government agencies for improving energy access in Uganda.

¹⁷ Mobile money penetration is measured as the percentage of people who use mobile money as a percentage of the total adult population.

DATA & METHODOLOGY

This study leverages the aggregated and anonymized mobile money transaction data to gain customer and market-level insights on PayGo solar in Uganda. In doing so it aims to stimulate customer-centric product development and inform the national energy policy on achieving universal access target by 2040. The study also explores the relationship between digital energy finance and wider financial inclusion, as well as the impact of mobile money taxation on digital finance, including PayGo transactions. We overlay the supply-side mobile money data with demand-side insights from the energy ladder customer survey (Goyal & Jacobson, 2018), and the national financial inclusion survey (FSDU, 2018). This is further supplemented with semi-structured interviews of twelve ESPs and payment providers to better understand customers' energy and financing needs, behavior, and use of solar products. The project established data partnership with USEA and supported its members with technical and analytical know-how in using customer data for market and product development. In collaboration with DDI, Schatz Energy Research Center (SERC) and USEA the project aimed to fulfill the informational gaps that enable businesses and policymakers to improve energy access in Uganda and help households to make informed choices of solar products.

Following applicable data protection and data privacy norms, customer data was mined and processed at the MNO servers by DDI; only aggregated insights are shown in this paper. The study did not use any individually identifiable information such as phone numbers, names, addresses, bank account numbers and call records, and instead draws insights from monthly aggregated results UNCDF and DDI (the data mining firm) signed strict data non-disclosure agreements to protect data privacy and confidentiality as per the applicable national and international laws and regulations. All datasets were password encrypted and only a limited number of UNCDF CleanStart and DDI staff members had access to the aggregated data.

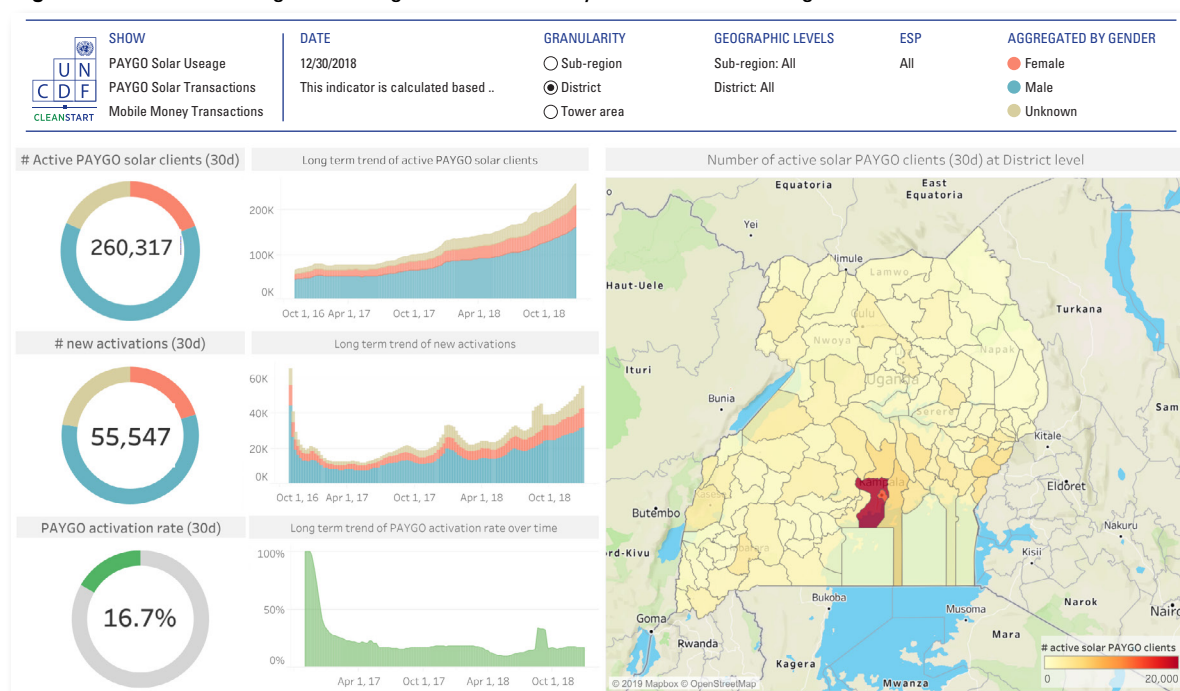
The mobile money data is accessed from MNO's servers and processed to display monthly aggregates on an online dashboard (see Figure 1). Different types of mobile money transactions are recognized such as solar payments, airtime top-ups and subsequently matched to other fields such as PayGo solar companies, geographic location, gender. The data utilized for the period Oct 2016- Dec 2018 has 11.5 million transactions of 672,236 customers, which covers around 75 percent of PayGo solar market in Uganda. These customers belong to the top 20 solar companies representing the majority of the PayGo market in Uganda. Overall data contains details on customers such as gender, transaction date, transaction type (e.g. PayGo, cash-in, cash-out, savings), mobile money activation date, location (region, district and cell-tower area), and transaction values (UGX) and ESPs.

The digital energy finance dashboard can help to identify target solar customers and expansion areas. It also tracks the PayGo solar uptake over time and can disaggregate



This study leverages the aggregated and anonymized mobile money transaction data to gain customer and market-level insights on PayGo solar in Uganda.

Figure 1: Dashboard Page Showing Active Solar PayGo Customers in Uganda



insights by location and over time. The dashboard provides granular data which can directly supplement USEA's semi-annual sales data collection to track the overall solar market growth in Uganda. The dashboard can monitor Uganda's Energy Access goals and market growth at different levels (province, district and tower level) on a weekly basis. USEA and the Ugandan government can use the dashboard to better plan energy access improvements equally in both the rural and urban areas. Finally, the dashboard can support solar companies in tailoring financial services and solar home systems to the needs of local markets.

First, we used mobile money transaction data to analyze penetration rates of mobile money and PayGo solar by regional, district, and—at the most granular geographic level—cell tower coverage area.¹⁸ Overlaying this data with Uganda's energy access maps¹⁹ helped us to identify areas that have no or unreliable access to grid electricity but have high rates of mobile money penetration. These geographic areas could become potential markets for ESPs to expand off-grid solar services (Nique, 2013).

Next, data on value (in UGX) and volume of PayGo solar transactions along with the total number of customers is examined to understand the historical growth of solar PayGo in Uganda from October 2016 to December 2018. Money spent per PayGo transaction can also be interpreted as the ability of consumers to pay for electricity, which is a key indicator for planning grid and mini-grid projects in Uganda. We then segment the PayGo solar market by different solar companies in Uganda. The mobile money transactions of PayGo users were analyzed to understand the impact of mobile money taxation on digital finance, and customers' mobile money activation dates were compared to their first PayGo transaction dates to conclude whether digital energy financing leads to digital financial inclusion.

To our knowledge, the data used for this study is one of the largest energy transaction datasets in Uganda covering 75 percent of the PayGo solar market. Nevertheless, the data has certain limitations. PayGo transactional data used in the study includes only customers from 20 ESPs and also excludes customers who paid for their systems with cash. Second, the MNO mobile money data does not offer insights on the type of solar products purchased, as well as how individual customers are adopting and using the product over time and what value the solar products create for customers.

To address these limitations the study draws from a series of telephonic panel surveys conducted with 424 solar product customers in the Luwero and Pallisa districts²⁰ between 2016 and 2018 (See Table 1). Results from two survey rounds completed between 2016 and 2017 were summarized in a previous report (see Goyal & Jacobson, 2018). A third round of surveys was completed in late 2018 in support of this study (Lam et al., 2019 forthcoming). These studies were led by the Schatz Energy Research Center (SERC) at Humboldt State University, and implemented by the Centre for Integrated Research and Community Development Uganda.

Surveys were performed on the same set of customers, and included an initial survey in 2016 (554 respondents); and two follow up surveys, the first in early 2017 (498 of the original cohort) and the second in December 2018 (424 of the original cohort). Attrition rates between the first and third survey was 30 percent (15 percent for each survey) and varied only slightly across customers who purchased smaller and larger products (28 to 32 percent), and low- and high-income groups. In-person interviews were conducted with customers who could not be reached over the phone and to gain additional field-level insights. Finally, the demand-side analysis also draws from field observations about market conditions and expert interviews conducted with seven representatives from ESPs and USEA.

Table 1: Overview of Solar Customers Sampled in Round 3 of Energy Ladder Survey

SOLAR PRODUCT CLASS (PURCHASED BY CUSTOMER)	CUSTOMERS REACHED IN ROUND 1 (2016)	CUSTOMERS REACHED IN ROUND 2 (2017)	CUSTOMERS REACHED IN R3 (NOV 2018)	ATTRITION RATE BETWEEN R1 AND R3	ATTRITION RATE BETWEEN R2 AND R3
Small (SPL)	226	200	171	32%	15%
Medium (mini-SHS)	166	148	129	28%	13%
Large SHS	162	150	124	30%	17%
Total	554	498	424	30%	15%

18 The mobile tower region (or polygon) is determined by a Voronoi partition such that the area corresponding to a given tower comprises all points that are closer to that tower than to any other tower (Martinez-Cesena et al., 2015).

19 UBOS 2014 Census

20 These two rural districts were chosen as they differ in terms of socio-economic indicators, infrastructure, and presence of off-grid energy industry players, and had relatively high sales of number of solar products. For further details on geographical scope, see https://mailchi.mp/4df554badf5b/energy_ladder.

SUPPLY SIDE INSIGHTS ON DIGITAL ENERGY FINANCE



The Ugandan solar PayGo market is growing rapid from 257,859 active customers in 2017 to 672,236 in December 2018.

TRACKING THE GROWTH OF THE PAYGO SOLAR MARKET IN UGANDA

The Ugandan off-grid solar market is a rapidly growing niche market. Our study shows that the number of active PayGo solar home system customers in Uganda using MTN mobile money has more than doubled from 257,859 in 2017 to 672,236 in 2018 (see Table 2).²¹ The total number of households owning solar home systems in Uganda is even larger than this number since 76 percent of mobile money users use MTN Uganda (UBOS, 2017) and some households purchase solar systems in cash. The number of PayGo transactions also grew rapidly, from 3,142,195 in 2017 to 7,688,269 in 2018, indicating that digital energy finance could act as a catalyst for accelerating wider financial inclusion.

Mobile money is the enabler of PayGo solar, and its wide adoption by customers and solar companies is the key to scaling the digital energy finance market²² in Uganda. Currently, the mobile money sector in Uganda is dominated by MTN, which has 76 percent of Uganda's mobile money users; the second largest is Airtel, followed by M-Sente, Africel, and M-Pesa (UBOS, 2017). Most of the PayGo solar companies in Uganda rely on mobile network operators (MNOs) to facilitate PayGo transactions. A few solar companies have developed partnerships with MNOs to provide energy access that can be paid using mobile money. Smaller solar companies, however find it difficult to afford such partnerships since integration with an MNO's mobile money platform requires significant time and resources; they also receive limited technological support from their MNO partners.

A few smaller solar companies are now using payment aggregator services to sell PayGo solar home solutions in Uganda. Payment aggregators started offering particularly smaller ESPs, quick integration to mobile money platforms and better technology and customer support. Yet high regulatory costs to activate their USSD based payment platform still hinders aggregators' ability to facilitate PayGo solar transactions. Payment aggregators can act as a bridge between unelectrified households, the energy service providers and the MNO in supporting the expansion of digital energy finance for small ESPs in Uganda.

Table 2: Summary of PayGo Solar Customers and Transactions

YEAR	NUMBER OF PAYGO TRANSACTIONS	NUMBER OF TOTAL SOLAR (ACTIVE AND INACTIVE) PAYGO CUSTOMERS	ACTIVE SOLAR PAYGO CUSTOMERS (END OF YEAR)
Oct to Dec 2016	716,482	107,904	77,486
2017	3,142,195	257,859	131,056
2018	7,688,269	672,236	260,317

Note: Active customers are those that made PayGo payments during a given month. 'Inactive' customers did not (have to) make a transaction in the particular month; these customers own the solar systems but for example either completed the full loan repayment, or pre-paid, or did not pay an instalment in the specific month.

Figure 2: Monthly Growth of Solar PayGo Home Systems in Uganda, 2016-18

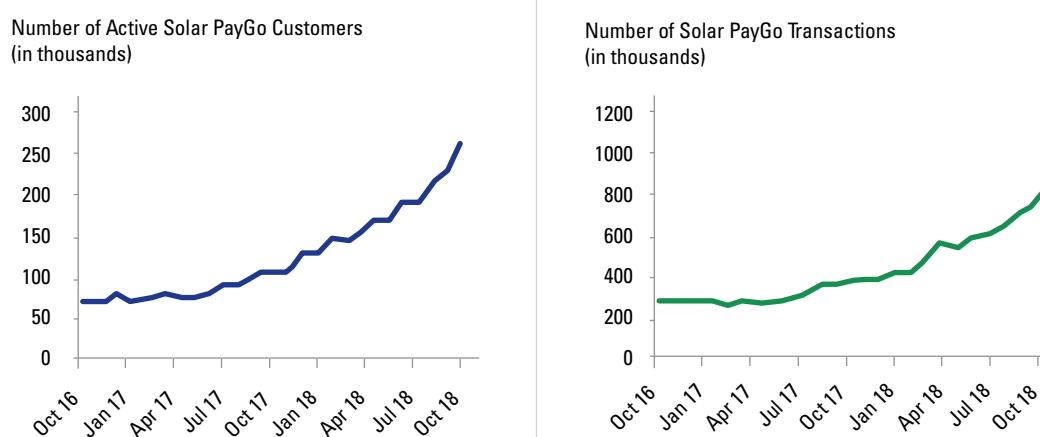


Figure 2 illustrates the monthly growth of PayGo solar customers and transactions in Uganda. From October 2016 to December 2018, the number of monthly active customers almost quadrupled from 68,168 to 260,367, and the number of monthly transactions increased from 234,345 to 986,141. This impressive growth was spurred by both the expansion of mobile money markets as well as the dissatisfaction with the quality of grid electricity (Goyal, Jacobson, Byoung Hwa Hwang 2017).²³

The Uganda Energy Association's Uganda Solar Products Sales Survey (USEA, GOGLA 2019, forthcoming) collected data from 23 solar companies and finds that in 2018 nearly 284,369 solar products were sold in Uganda, though only 36 percent were 11 watts or greater in size. This means the solar market in Uganda is driven mostly by the purchase of solar lamps and small home systems, with limited growth coming from larger systems that are unaffordable for most households.

The USEA survey also finds that around 69 percent of solar energy products were sold using PayGo financing. The number of active PayGo solar customers estimated from mobile money data (260,367) is higher compared to USEA sales data because the latter reports the direct sales being made to customers over the period January-December 2018. The digital energy finance Dashboard, on the other hand, shows the people actively paying off a system in December 2018, which may include products purchased before 2018 that are still actively being paid off.

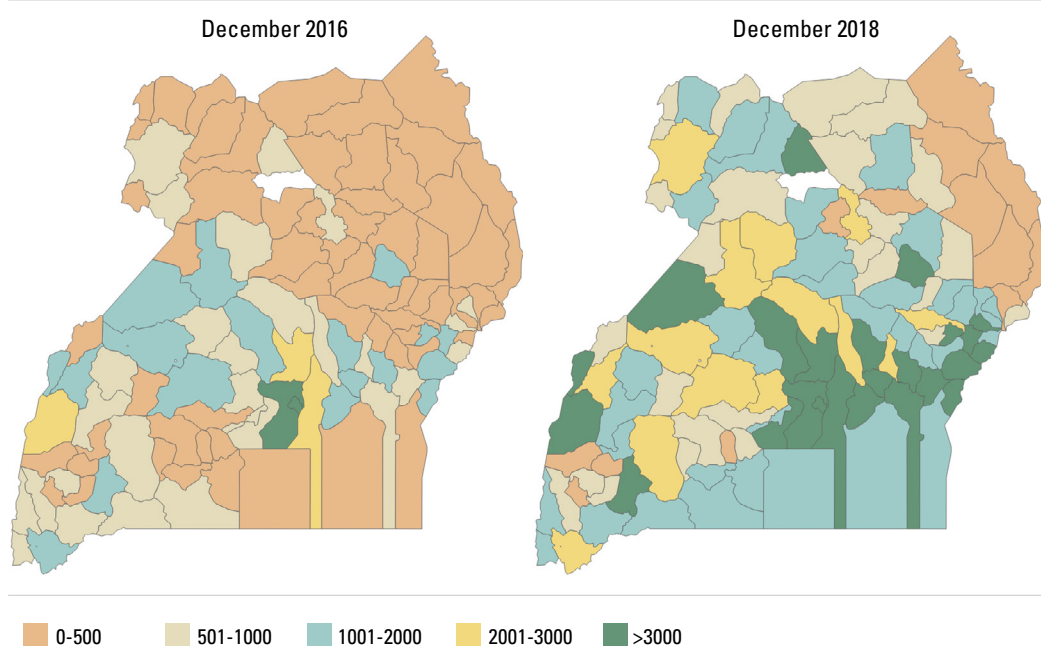
Flexible financing combined with increased mobile money adaption can trigger OGS market growth in Uganda, as even today nearly 6.7 million households have no grid connectivity (Umeme, 2017) and 70 percent of grid-connected households experience unreliable power (IFC, 2018). Penetrating this remote, unserved and financially excluded market will require a good understanding of who your customers are and where are they located. Companies engaging customers digitally and leveraging behavior data and analytics, such as building credit history on repayment transactions, are more likely to acquire larger market share and experience growth.

In terms of geography, our study showed that as of December 2018, most of Uganda's active PayGo solar users are located in the central region, followed by the eastern and the western regions.



6.7 million households in Uganda have no grid connectivity and 70 percent of grid-connected households experience unreliable power.

Figure 3: Number of Active PayGo Solar Customers in 2016 and 2018, by District



Though the northern region shows the lowest number of PayGo users, it has experienced the biggest growth in the number of customers between 2016 and 2018. However, the penetration rate of PayGo solar as a share of the population remains significantly low in all the regions.

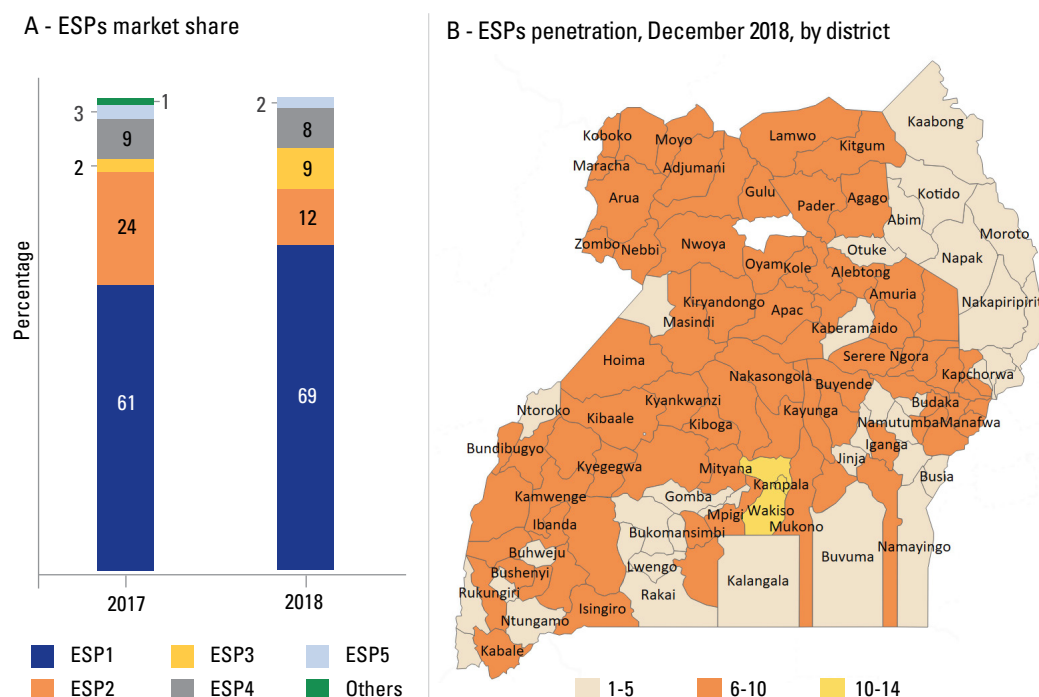


There is opportunity for further market expansion as only 10 districts in Uganda had more than 5,000 active PayGo customers in Dec 2018.

Figure 3 shows the geographic presence of active PayGo customers during December 2018 in different districts of Uganda. Districts in the central region have the highest number of PayGo solar users, followed by districts in the eastern region. Almost two-thirds of PayGo users in the central region are located in the four urbanized districts of Wakiso, Kampala, Mukono, and Luwero, where nearly 45 percent of the Central region's population reside. The districts of Napak, Kaabong, Moroto, and Amudat in Uganda's northern region have the fewest number of PayGo customers. Budaka district, in the eastern region, has the highest share of PayGo users (7%) while all other districts have less than 4 percent. In fact, there are only 10 districts²⁴ in Uganda with more than 5,000 active PayGo customers, all of which are located in the country's central and eastern regions.

Based on the MNO dataset, as of December 2018, the top four ESPs have 98 percent of the PayGo solar customers in Uganda, with only 2 percent of transactions originating from the remaining 17 ESPs (see Figure 4A). In other words, the Ugandan PayGo solar market is extremely concentrated partly because of limited partnership opportunities. Figure 4B shows that the penetration of a number of solar companies across all districts in Uganda. Kampala and Wakiso have more than 10 PayGo solar companies serving the market, while most of the other districts have six to ten companies. Several districts in the central region, including Rakai, Lwengo and Sembabule, have high rates of mobile money use, but few ESPs. These districts could become new expansion areas for PayGo solar financing. We also find that ESPs with fewer customers are only present in districts with high mobile money penetration, whereas the larger ESPs have a universal geographic presence in Uganda.

Figure 4: Market Share and Penetration of PayGo Solar ESPs



IDENTIFYING TARGET CUSTOMERS AND EXPANSION AREAS

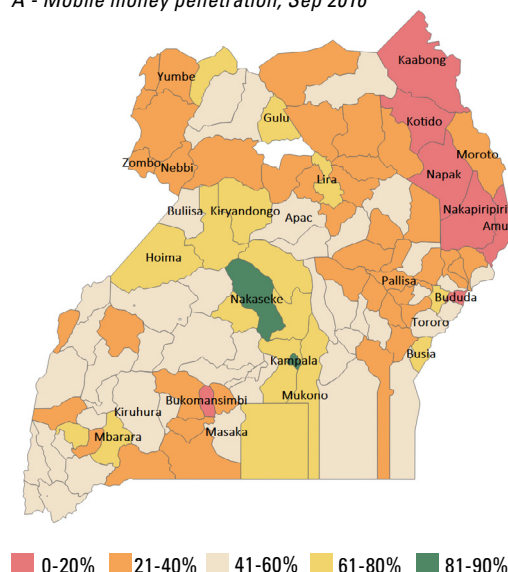
Geographic areas with high rates of mobile money use and with no or unreliable grid electricity are often seen as potential markets for ESPs seeking to expand OGS services using digital energy financing (Nique, 2013). Demand-side data (UBOs, 2017) demonstrated that most of the Ugandan adult population, including energy consumers, use mobile money for (utility) bill payments. Thus, readily available mobile money transactions data helped us to identify potential districts and regions for accelerating energy access in Uganda.

Figure 5A shows rates of mobile money penetration,²⁵ with red representing districts with the lowest rates of mobile money use, and green representing the highest. As of September 2018 the overall rate of mobile money penetration in Uganda was around 59 percent, with highest rates in districts in the central region (63 percent) and lowest in the Karamoja²⁶ area in the northern region (17 percent). The sub-regions of West Nile, Teso, Elgon, Lango Acholi and Western have mobile money penetration rates between 36 and 52 percent.

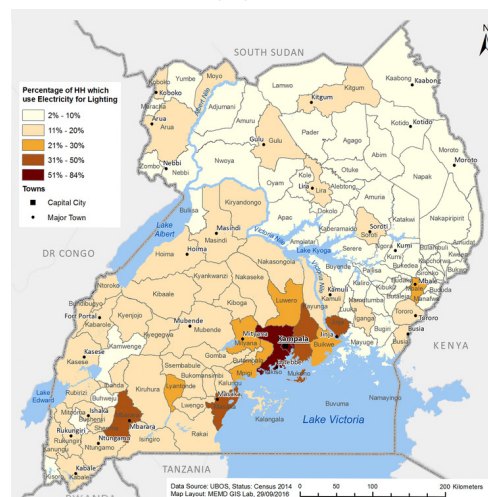
Overlaying the energy access map (Figure 5B) with a mobile money penetration map (Figure 5A), we show that districts with high rates of mobile money penetration also generally have better access to electricity. However, districts such as Masindi, Kiriyaongo, Gulu, Lira, Busia, Mbarara and Hoima have more than 60 percent mobile money adoption yet less than 20 percent of households have electricity access. These districts could be the primary target areas for energy companies seeking to accelerate off-grid solar use. On the other hand, districts such as Yumbe, Bukomansimbi, Bududa and Kotida show extremely low levels of mobile money penetration (10-20 percent) and require agent-led digital energy financing for improving energy access.

Figure 5: Household Rates of Mobile Money Use, Access to Electricity and PayGo Solar, by District

A - Mobile money penetration, Sep 2016



B - Access to electricity by District, 2014 (UBOS 2014)



C - PayGo solar penetration, Dec 2018

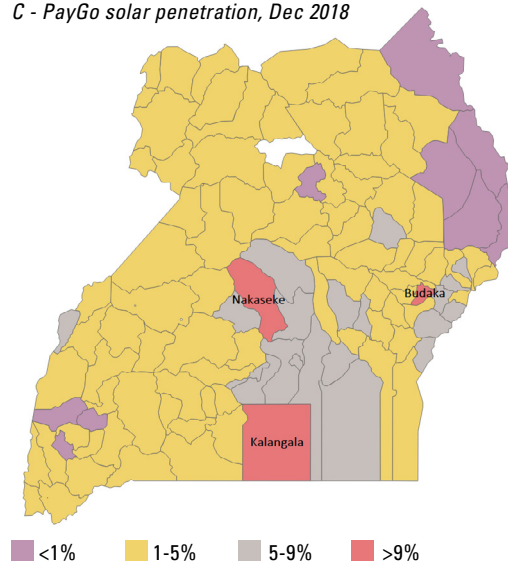
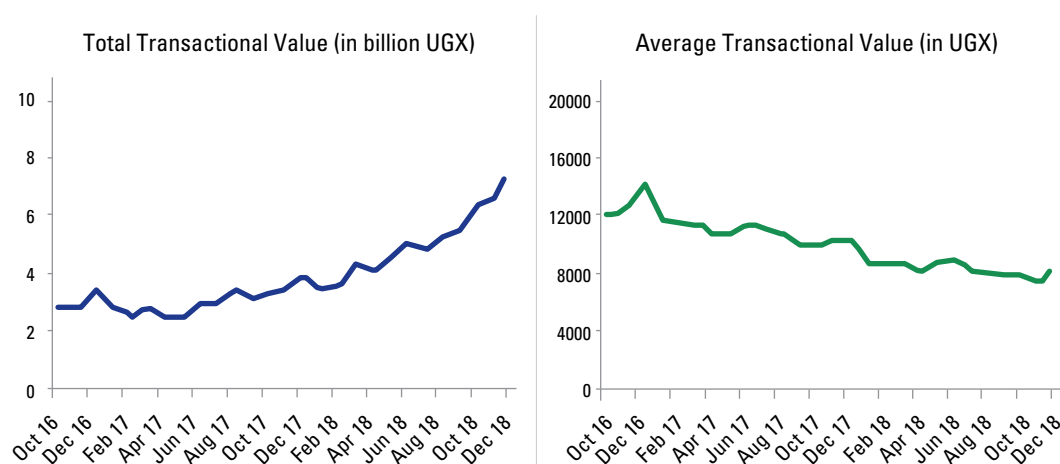


Figure 5C shows that the average PayGo solar penetration rate—defined as the number of households using PayGo financing as a percentage of the total number of households in the district or province—is around 12 percent. However, the PayGo solar penetration varies significantly among districts, and is higher in the central and eastern regions (5 percent) where there is widespread mobile money use. Only 2 percent of households in the northern and western regions use PayGo solar financing. At the district level, the percentage of household having adopted PayGo varies from 1 percent to 15 percent. Only a few districts such as Budaka, Nakaseke, Kalangala have a PayGo penetration of 10 percent or more, while 90 of the 112 districts have less than 4 percent PayGo penetration. This demonstrates a substantial scope for ESPs to expand their outreach, provided that PayGo solar home systems are made affordable for low-income people. Furthermore, sub-regions such as Acholi and Lango in the north have very low rates of PayGo penetration despite receiving high levels of solar radiation²⁷ and having good access to mobile money. Due to the low rates of mobile money use, the Kajamara sub-region has the lowest SHS penetration despite benefiting from one of the highest levels of solar radiation in Uganda.

TRACKING ENERGY EXPENDITURE OF SOLAR PAYGO CUSTOMERS

The analysis showed that the average payment per PayGo transaction decreased 36 percent from UGX 11,752 in October 2016 to UGX 7,805 in December 2018, yet the total overall value of payments grew 2.8 times, from UGX 2,754 million to UGX 7,697 million, during the same period due to an increased number of transactions (Figure 6). The decreased value per transaction is perhaps due to improved affordability on account of flexible loan repayment plans of

Figure 6: Average and Total Transactional Value in UGX of PayGo Solar Customers

the PayGo products. Another reason could be Uganda's growing mobile money network, which makes it easier for customers to access an agent and make smaller payments. Additionally, by extending repayment periods and reducing the minimum required daily commitment, ESPs are making payment plans more inclusive and reaching a higher number of low-income customers. For example, in 2015 the ESP Fenix offered a 10W solar home system at a daily commitment of UGX 1,100 for a loan period of 18 months, but recently made the repayment plan more flexible by offering a reduced daily payment commitment of UGX 1,000 for a loan period of 24 months.

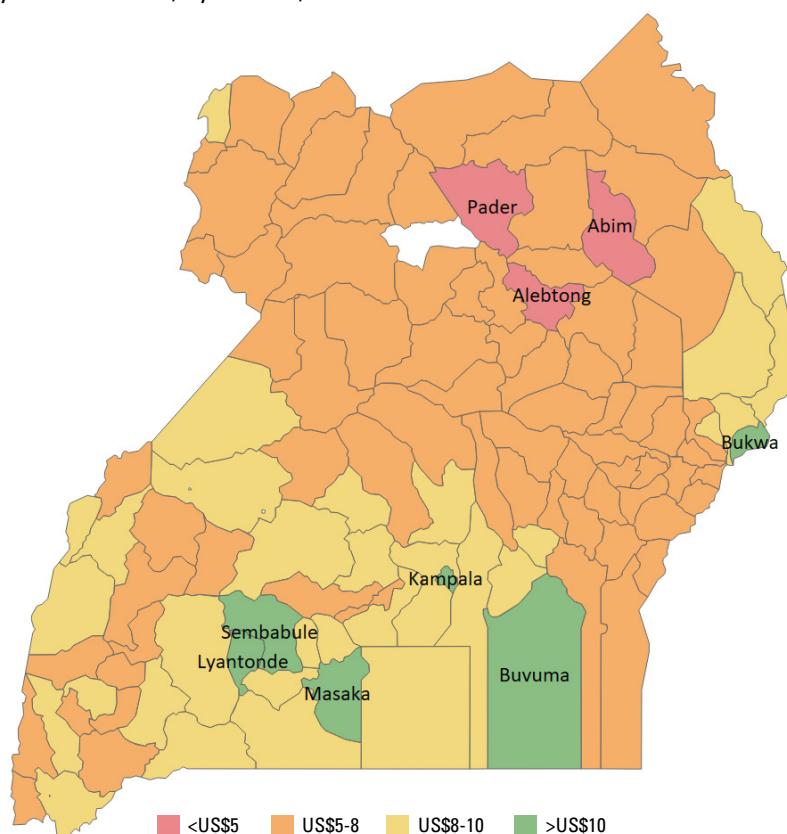
The data on number of monthly transactions per customer shows that PayGo users are making 3.5 to 4 payments a month at an average payment of UGX 7,900 per transaction. Four instalments totalling UGX 31,600 per month translates into a daily commitment of around UGX 1,000. This is consistent with the payment plans offered by ESPs for their 10W to 15W solar home systems, including the ones offered using PayGo financing. PayGo customers in the eastern region make more frequent payments at lower amounts as compared to other regions. Monthly payment frequency and value also vary significantly among ESPs due to differences in the size of the products and payment plans offered (Table 3). Most ESPs, including Fenix, M-Kopa and Dlight, offer daily or monthly payment options on their PayGo products, while others like SolarNow offer products only on monthly commitments.

Table 3: Payments Profile of PayGo Solar Customers by ESP, 2018

ESP*	AVERAGE MONTHLY TRANSACTIONAL VALUE (UGX)	NUMBER OF MONTHLY TRANSACTIONS PER CUSTOMER	TOTAL MONTHLY TRANSACTIONAL VALUE (UGX)
A	6,329	3.7	23,417
B	9,798	4.1	40,172
C	9,867	3.4	33,548
D	5,952	2.7	16,070
E	137,982	1.2	165,578
F	68,552	2.4	164,525

*ESP's names are anonymized to protect data confidentiality

Figure 7: Ability of Households to Pay for Electricity Based on Average Monthly PayGo Payment Amounts, by District, December 2018



The mobile money transactional data of PayGo customers provides accurate and timely insights about household electricity expenditure, which can be used for planning and optimising electrification projects in Uganda. The mobile money data can substitute costly household surveys for estimating household's ability and willingness to pay for electricity. Further benefits of mobile money transactions over household surveys include generating unbiased electricity expenditure data for all geographic locations up to cell-tower level.

Our analysis showed that a household's monthly willingness to pay for off-grid electricity varies among different districts in Uganda, from US\$4.70 in Alebtong to US\$12.8 in Bukwa. This variance is perhaps due to factors including the availability of mobile money agents as well as household income status, which in turn will determine what kind of solar home system a household can afford. The districts of Pader, Abim and Alebtong have the lowest (<US\$5) monthly electricity expenditure; they also have low rates of mobile money penetration (<40 percent). Thus, these districts may be the toughest market in which to expand energy services. Our estimations are consistent with previous surveys including NRECA (2018) finds that 40 percent of Ugandan households spend more than US\$3 per month for energy services, and IRENA (2016) estimates that off-grid households in Uganda spend between US\$12 to US\$16 per month on traditional lighting sources and mobile phone charging.

Interestingly, districts in the Karamoja region, including Napak, Moroto, Nakapiripirit and Amudat, have the lowest number of PayGo solar and mobile money users yet have a relatively

high (US\$8-10) monthly electricity expenditure. This may be because early PayGo adopters have a relatively higher propensity for clean energy, and that people in rural areas with limited access to mobile money agents are more likely to make fewer but larger payments on their PayGo solar products. As discussed earlier, growth in the Karamoja region is hindered in particular by low rates of mobile money penetration, and the Government and MNOs should make a collaborative effort to expand mobile money use there.

PAYGO SOLAR AND WIDER FINANCIAL INCLUSION

The percentage of Uganda adults with access to formal financial services grew from 28 to 58 percent during the period 2009 to 2018 (FSDU, 2018). This rapid growth in financial inclusion is mainly caused by mobile money access (56 percent adults), followed by savings (18 percent), credit (5 percent) and insurance (1 percent). Nearly 27 percent of the adults use mobile money for payments of goods and services, 23 percent for savings, 9 percent for borrowing money, and 8 percent to pay electricity and other utility bills. The number of people paying their electricity bills with mobile money is expected to grow significantly as Uganda undergoes expansion in the digitization²⁸ of grid electricity payments, including the installation of pre-paid energy meters. Previous research studies (see Winiecki, 2015; Waldron, 2016) in fact have suggested that PayGo may drive mobile money penetration while others (Goyal & Jacobson, 2018) did not find clear evidence to support this hypothesis. Does solar PayGo uptake increase digital financial inclusion? We answer this question using mobile money transactions of PayGo customers.

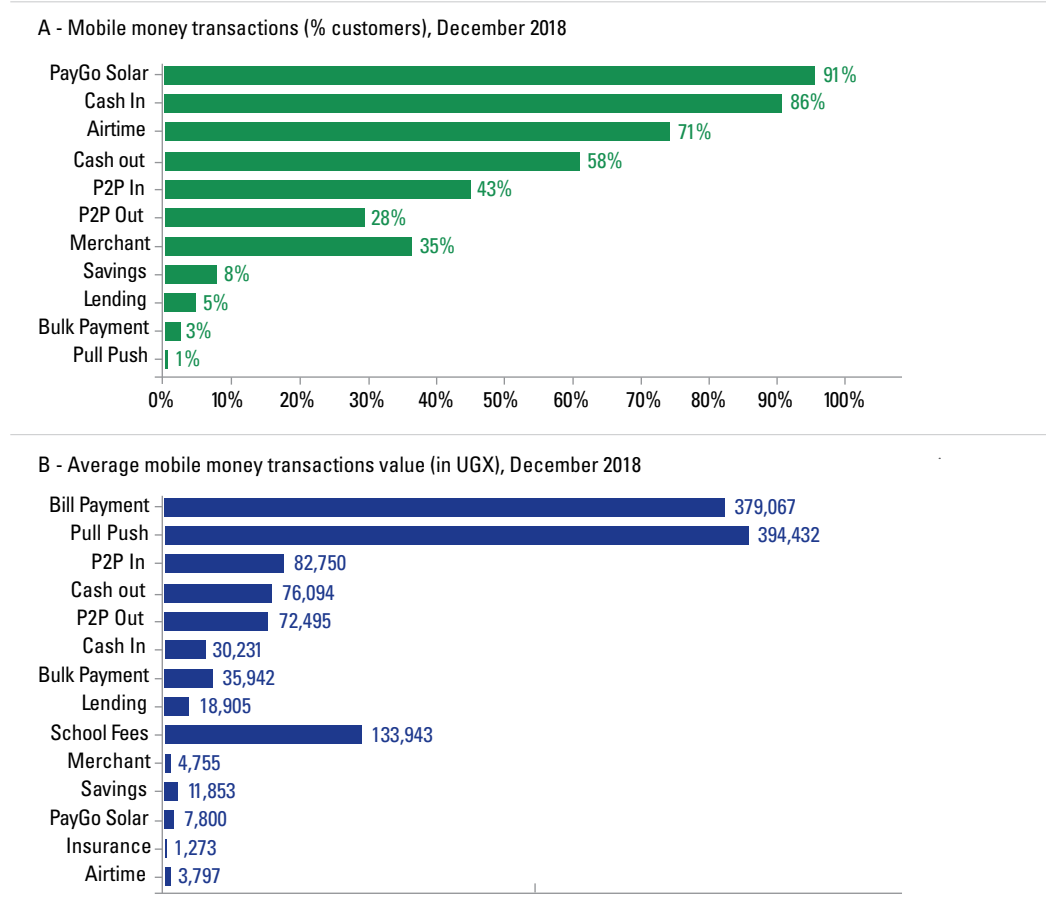


The percentage of Uganda adults with access to formal financial services grew from 28% to 58% during the period 2009 to 2018.



@ Fenix International

Figure 8: Mobile Money Transactions of PayGo Solar Customers, by Type and Amount, December 2018

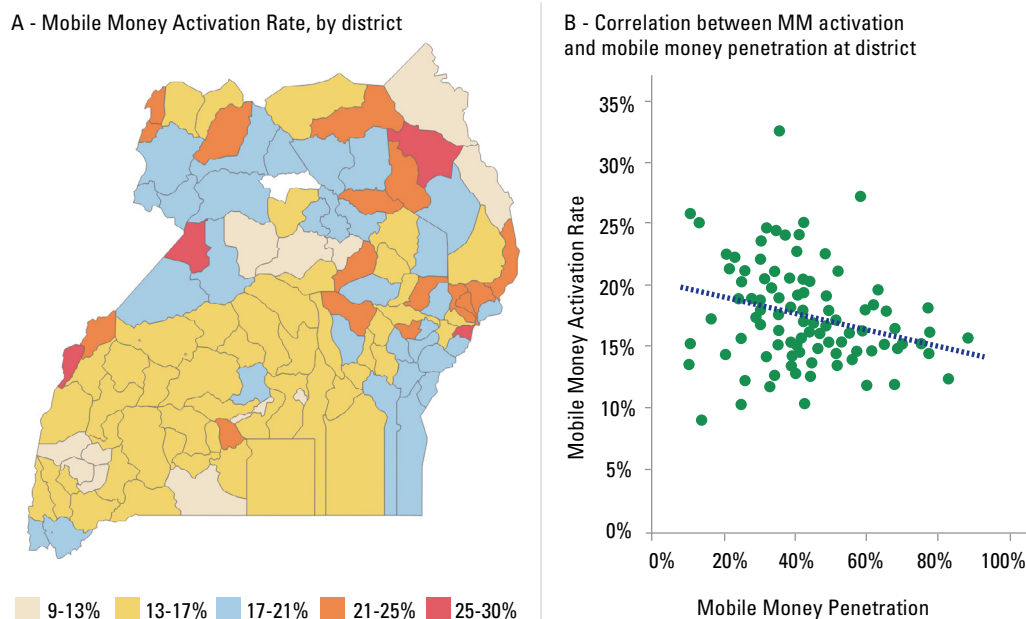


PayGo solar customers made close to 1.5 million mobile money transactions in December 2016, which increased more than three-fold to 5 million transactions in December 2018. Nearly 92 percent of PayGo customers used mobile money for a variety of financial transactions, including air-time top-up, remittance transfers, cash-in, cash-out and bill payments. Eight percent of PayGo customers also used mobile money for savings and 5 percent used it for lending. Figure 8B shows the money spent per transaction for different services and demonstrates a strong business case for MNOs to collaborate with PayGo providers. On average, PayGo customers spent UGX 22,694 (US\$6) per transaction in December 2018. The results demonstrate that the PayGo customers actively use mobile money for financial services beyond making payments for energy services.

To assess the causal relationship between PayGo and mobile money what needs to be researched is whether the mobile money activation happened after or before customers expressed interest in purchasing PayGo solar. Generally, the mobile money activation is needed prior to PayGo purchase and therefore any household survey will likely suggest that most PayGo customers had mobile money prior to adopting solar home systems. Based on our consultations with ESPs and payment providers in Uganda, we proxy that if the mobile money accounts are activated 45 days prior to the first PayGo payment then it is likely that the adoption of mobile money happened to purchase a PayGo solar.


5 million
 mobile money
 transactions were
 made by PayGo
 solar customers
 in December 2018.

Figure 9: Mobile Money Activation Rate of PayGo Solar Customers, December 2018



Using the collected mobile money data of PayGo customers, we compared the date of the first PayGo payment of new customers with their respective mobile money account activation dates. We find that nearly 16 percent of the new PayGo customers activated their mobile money 45 days prior to the first PayGo payment.²⁹ Thus, while the majority (84 percent) of PayGo customers already used mobile money before purchasing a PayGo solar product, for roughly 110,000 mobile money customers PayGo was their introduction to digital finance in Uganda. We also find that the mobile money account activation rate varies from 9 percent to 33 percent across different districts in Uganda (Figure 9A) and that districts with low rates of mobile money penetration are more likely to have high mobile money activation rates (Figure 9B). This further confirms that PayGo solar drives the uptake of mobile money and demonstrates business opportunities for MNOs in areas with high rates of PayGo solar use (see Section 3).

21 “Active PayGo customers” means these households have purchased a PayGo solar home system and are still paying off their system. The number of active PayGo customers data is based on data from one MNO in Uganda. Other PayGo users might be using mobile money services offered by other MNOs.

22 Energy consumed is paid via digital means such as mobile money

23 See <https://spark.adobe.com/page/ipuqiDQY7qBzV/>

24 24 Kampala, Wakiso, Mukono, Luwero, Kamuli, Budaka, Mbale, Manafwa, Tororo, Busia

25 Mobile money penetration is measured as the percentage of people who use mobile money as a percentage of the total adult population.

26 Karamoja area comprises of districts such as Kaabong, Kодо, Moroto, Napak, Nakapiripirit, and Amudet.

27 [hVps://solargis.com/maps-and-gis-data/download/uganda](https://solargis.com/maps-and-gis-data/download/uganda)

28 <https://www.gsma.com/mobilefordevelopment/programme/m4dutilities/an-update-on-umemes-smart-energy-solutions-how-ugandas-electricity-utility-has-been-tackling-losses-in-the-last-3-years/>

29 This is in line with a Fenix survey that found 13 percent of its PayGo customers signed up for mobile money after they purchased a solar home system (GSMA, 2015).

DEMAND-SIDE INSIGHTS ON DIGITAL ENERGY FINANCE

CUSTOMER SATISFACTION AND SOLAR PRODUCTS ADOPTION

This section draws from the demand-side survey of 424 PayGo solar customers that was conducted in 2016, 2017 and 2018 to track their long-term solar product adoption patterns (Lam et al., forthcoming). Most of the surveyed customers (68 percent) expressed satisfaction with the solar products they had purchased to date. Small portable lamp (SPL) owners had the highest dissatisfaction rate (31 percent), and they also reported the highest rate of technical issues such as system malfunctioning or complete damage. The most common reason for dissatisfaction among solar home system customers was related to battery and overall system performance.

The overwhelming majority of customers (86 percent) who used flexible financing, including PayGo and micro-credit loans, generally viewed these schemes positively, regardless of their past experiences with it. Among households that had completed payments of PayGo systems, 83 percent viewed flexible financing positively. PayGo customers that failed to complete payments had, as expected, the lowest level of satisfaction, but still held mostly positive (64 percent) impressions of PayGo financing. Owners of large solar home systems financed through microcredit had an overwhelmingly positive (83 percent) opinion of flexible finance schemes.

Among the customers who were dissatisfied with flexible financing it was highlighted that it was sometimes difficult to make their payments, that flexible financing was more expensive in the long run, and that the service was cut off due to missed payments. Others mentioned that the payment terms were inconvenient (e.g., either too short, too long, or the scheme did not offer incentives for the early completion of payments) and that solar companies were unwilling to work with personal hardships (such as sickness or job loss) that affected a customer's ability to pay on time. IESPs revealed that they help customers understand how much flexible financing adds to the total system cost, which helps explain why so many users are aware of the added cost.

The demand-side survey tracked the same customers from June 2016 to December 2018 and finds that 49 percent of them purchase at least one additional energy product after their initial purchase in 2016. All customers had made their first purchase in 2016 and there was no significant difference in income poverty distributions across the groups. Table 4 shows the detailed customer journey by type of customers (product group) and additional products purchased. Out of all customers who purchased a small solar lamp in 2016, 63 percent decided to buy an additional solar product, this compared to 39 percent who initially started with a medium SHS (39 percent) and large SHS (39 percent). On average, customers purchased an additional 1.5 products.

Of the 171 customers who started with a small solar lamp, only 5 percent followed up with the purchase of a large SHS, 28 percent purchased a medium SHS, and 26 percent purchased an extra solar lamp between June 2016 and Nov 2018. Among customers who initially purchased



86%

of customers who used flexible financing generally viewed these schemes positively, regardless of their past experiences with it.

a PayGo financed medium SHS, 15 percent invested in another SHS, 9 percent purchased an SPL, and the remaining customers invested in maintenance components (replacement batteries or solar panels) or else purchased appliances like televisions and refrigerators that could be powered by their current systems.

For those customers who started with a large SHS system, we find that several of them added new solar panels (11%), appliances (9%) and batteries (9%) between June 2016 and Nov 2018. This group has seen the largest increase in electricity output (Wh/day) as they have invested in generating extra wattage capacity for their systems. There is a substantial up-side potential for selling larger systems as they lock customers into longer term energy usage. This market potential for larger systems is also important as currently in Uganda 71 percent of solar products sold are still below 20 Wp, 19 percent are between 20-100Wp and only 10 percent are 100 Wp and larger (USEA and GOGLA 2019, forthcoming).



49%
of the customers
purchased
at least one
additional
product within
3 years of their
initial purchase.

Table 4: Additional Products purchased by Solar Customers Between June 2016 and November 2018.

PRODUCT OWNED IN 2016		LARGE SHS*	MEDIUM SHS *	SPL*	SOLAR PANEL*	APPLIANCE (TV, RADIO ETC.)	BATTERY*	AT LEAST ONE ENERGY PRODUCT SINCE 2016
SPL (<3WP) (n= 171)		5%	28%	26%	1%	2%	2%	63%
medium-SHS (10w-34w) (n=129)		3%	12%	9%	7%	9%	3%	39%
Large-SHS (>50wp) (N=124)		8%	6%	7%	11%	9%	11%	39%

* Purchases that add to total electricity output

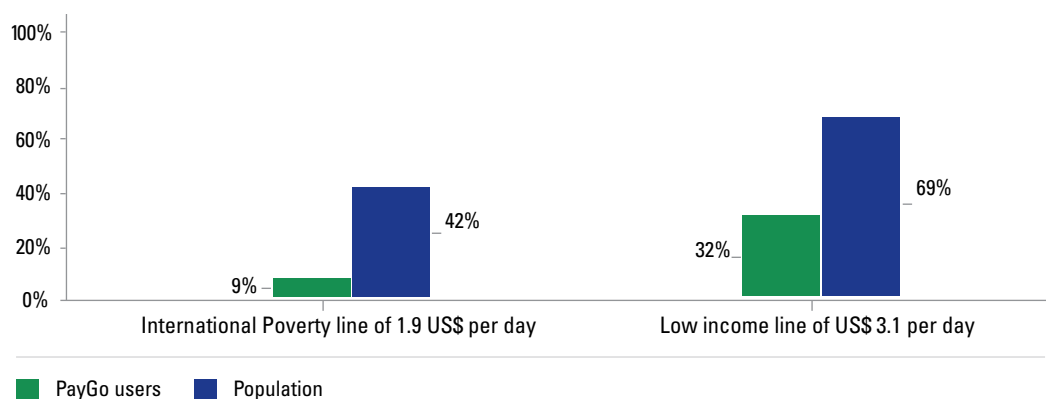
Note: Customers who first purchased a solar home system in 2016 were divided into three groups according to the size of the system: small, medium or large. The values in the table correspond to the percent of all customers in each group (small, medium or large) who purchased additional products after first round of survey in 2016. Row percentages do not sum to 100 percent.

EFFECTS OF CLEAN ENERGY USE ON HOUSEHOLD WELL-BEING

In the context of Uganda, extreme poverty is defined as the lack of money to meet basic needs such as food, clothing and shelter.³⁰ For this population segment a solar home system is a 'luxury good,' and the energy ladder survey findings support this (Figure 10). We find that PayGo solar financing is serving low-income people rather than the poorest of poor, with only 9 percent of PayGo solar customers living below the poverty line of US\$1.9, compared to 42 percent of the overall Ugandan population. Similarly, 32 percent of PayGo users live below US\$3.1 a day as compared to 69 percent of the general population. People living in extreme poverty remain a small customer segment for solar home system providers.

There is little variation in poverty distributions between customer who purchased a small, medium or large system, indicating that PayGo solar financing is affordable for both poor and rich customers. Flexible solar PayGo financing mechanisms, in particular with smaller and more frequent transactions (see section 2), may be easier to pay for by low income customers

Figure 10: Poverty Rate of Solar Paygo Customers, 2018



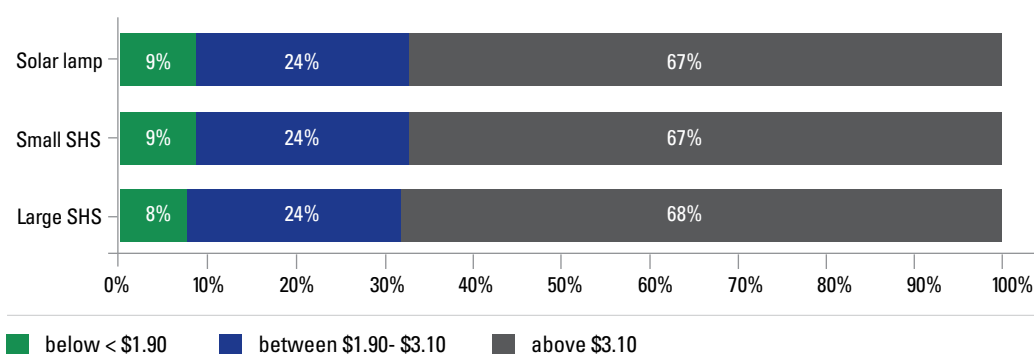
Note: Poverty lines are based on 2011 purchase power parity.

than cash-based purchases. A more detailed analysis from Goyal and Jacobson (2018) on household expenditures and mobile money transaction data also demonstrates that frequent, smaller transactions allows lower income people to purchase larger systems. This reinforces the need for affordable financing solutions to be tailor-made to low-income customers, who see the benefits in investing in a solar product.

The surveyed customers felt solar products mainly impacted their household's quality of life by reducing the use of traditional fuels (57 percent); other impacts included saving money³¹ (25 percent) and improving health (24 percent) and safety of the respondents (20 percent) (see Figure 12). Responders said their solar home systems saved money by reducing what they spent on charging their phones, buying candles and kerosene, and other energy sources (dry battery cells, electricity from the grid). Some customers highlighted that these economic savings can now be diverted to other basic household needs (for example, "taking the children to good schools"). Regarding health benefits,³² several solar home system users no longer fear the possibility of fire outbreaks or accidents caused by traditional fuels, and they no longer experience breathing problems caused by fumes. A related benefit is an overall improved feeling of safety; one client reported "reduced cases of theft because of the security lights." Some users reported an increase in study hours for their children at night, as well as the ability to watch television.³³

Interestingly, the bright lights also acted as a form of social status upgrade, with some respondents stating that both guests and neighbors were positively impressed by their solar

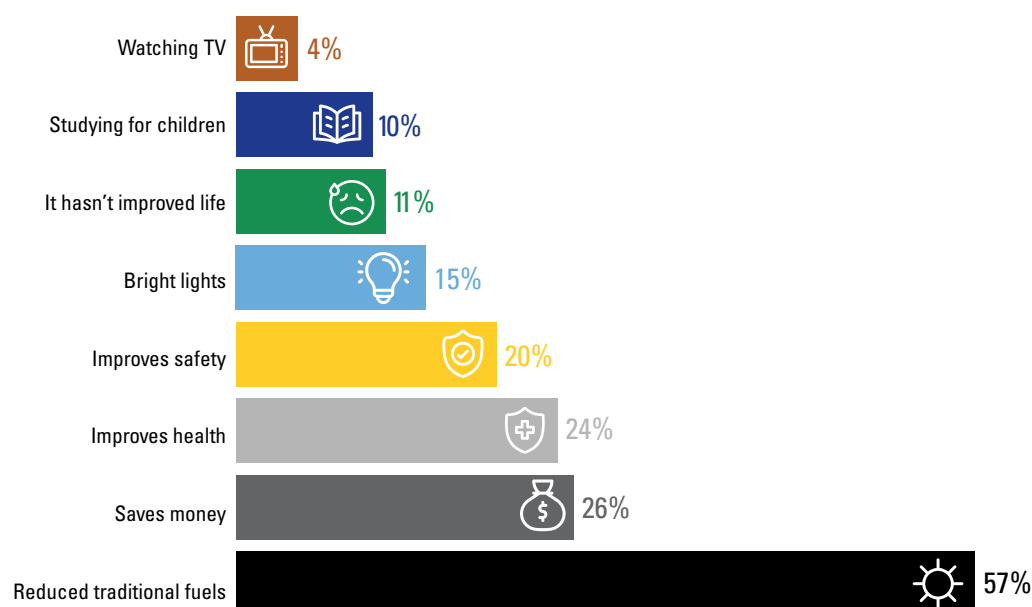
Figure 11: Distribution of PayGo Solar Customers, by Income Poverty Distribution (US\$) and Product Size



home systems and asked for more information on it. Such positive ‘word of mouth’ or market externalities could lead to more widespread adoption of solar products (for more on this see Goyal and Jacobson, 2018). Of course, negative experiences with new solar products also affected customer perception: 11 percent of surveyed customers reported no enhancements in quality of life, including those who had reported product malfunctions.

Knowing how smaller and larger products impact quality of life is important, as currently in the Uganda energy sector 71 percent of the products sold are still below 20 Wp (USEA and GOGILA 2019, forthcoming). The reduction in the use of traditional fuel is the most significant benefit to the households quality of life and was especially cited by small lamp owners. Respondents who purchased larger solar home systems were more likely to experience brighter illumination and an impact on children’s education. The perception of money savings varied strongly across products which could be explained by the higher price point and longer repayment periods experienced by buyers of larger solar home systems³⁴ (see Figure 15 in ANNEX I).

Figure 12: Quality of Life Improvements Among Surveyed PayGo Solar Customers



Note: Customers were asked to self-report quality of life benefits three years after the purchase of their solar products.

30 <http://www.worldbank.org/en/country/uganda/brief/uganda-poverty-assessment-2016-fact-sheet>

31 “They no longer spend on kerosene ... and they can now charge the phone at no cost”; “There are no more emissions, they no longer spend on kerosene”

32 “They are no longer worried about accidents from kerosene lamps. They feel more secure since the lights are brighter”; “Smoke from using kerosene is no longer in the house, Smoke is also no longer affecting the household’s health, there is bright light in the house”; “Yes, no longer has fear that family members can get burnt at the home, also smoke related problems no longer affected his children”; “reduced cases of theft because of the security lights”

33 For example, it was highlighted, “Reading of books became easier, entertainment from tv and all these components make the life good”; “Children are happy because of entertainment from the TV”; “The children had more time to revise books in the night.... They watch TV and are updated with the news.”

34 Detailed net present value cash flow analysis by Jacobson and Richa (2019, Jan) demonstrated that larger PayGo systems can be expensive and do not payback the system within the 2-year warranty period. Customers do not always account for opportunity costs of systems.

USING MOBILE MONEY DATA TO INFORM ENERGY POLICY AND MARKET EXPANSION

ESTIMATING ENERGY ADDRESSABLE MARKET IN UGANDA

There is limited information on the number of households using solar home systems and yearly SHS sales in Uganda (e.g see IFC 2018; NRECA 2018).³⁵ We use the mobile money transaction data of PayGo users to estimate the solar penetration and addressable market in Uganda.



We find that there were nearly 1.2 million solar home system users in Uganda.

The digital energy finance dashboard demonstrates that there were at least 257,895 PayGo users in Uganda in 2017 which grew to 672,236 in 2018. Since 76 percent of the mobile money customers use MTN's services (UBOS, 2017) and nearly 25 percent of SHSs are sold in cash, a simple extrapolation demonstrates that in 2018 there were nearly 1.2 million SHS users in Uganda. Furthermore, the demand-side survey demonstrated that nearly 12.4 percent of existing PayGo solar users purchased an additional SHS. We therefore reduce the estimated number of households using an SHS by 12.4 percent to nearly 1 million³⁶ (see Annex I for calculations). This translates into a household solar product penetration rate of 13 percent, nearly four times the estimation of NRECA (2018). We estimate that the penetration rate of solar home systems in Uganda may even be higher as we have not accounted for households who have completely repaid loans in 2017 and as a result stopped making PayGo solar mobile money transactions.

Considering that the number of households in Uganda grew by 3.6 percent per annum (UBOS, 2003-17) and 125,000 new grid connections are added every year, we estimate that number of solar home system users must grow yearly by 12.5 percent to meet the 2040 universal




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access goal. However, even if the rate of grid electrification is doubled to 250,000 connections annually, SHS uptake must grow by 11 percent annually to meet the 2040 targets. These estimations are valid assuming that the predicted household and grid-electrification growth rates hold true until 2040. In the short-term, grid and household growth looks more certain and at 12-15 percent growth in OGS, and the electricity access in Uganda is likely to reach 38-40 percent by 2022. Therefore, the OGS sector in Uganda must witness significant growth to reduce energy poverty in Uganda.

We also used mobile money data to highlight business opportunities for solar companies in Uganda; we did this by estimating the number of unelectrified³⁷ households that can afford a solar home system (see Table 5 in ANNEX I). We find that among 5.6 million unelectrified households in Uganda, nearly 3.5 million can afford small solar home systems of 10W. This customer group is a sizeable market for solar companies seeking to expand their businesses in Uganda.

To serve this substantial market, there needs to be improved consumer awareness of solar technology, its use, and its health and monetary benefits. Innovative financing mechanisms have to be designed aimed at making debt affordable for poor households living below US\$1.9 a day. To address some of these barriers, UNCDF and USEA have jointly organized several consumer awareness³⁸ and media campaigns³⁹ aimed at improving relationships between customers and PayGo companies.

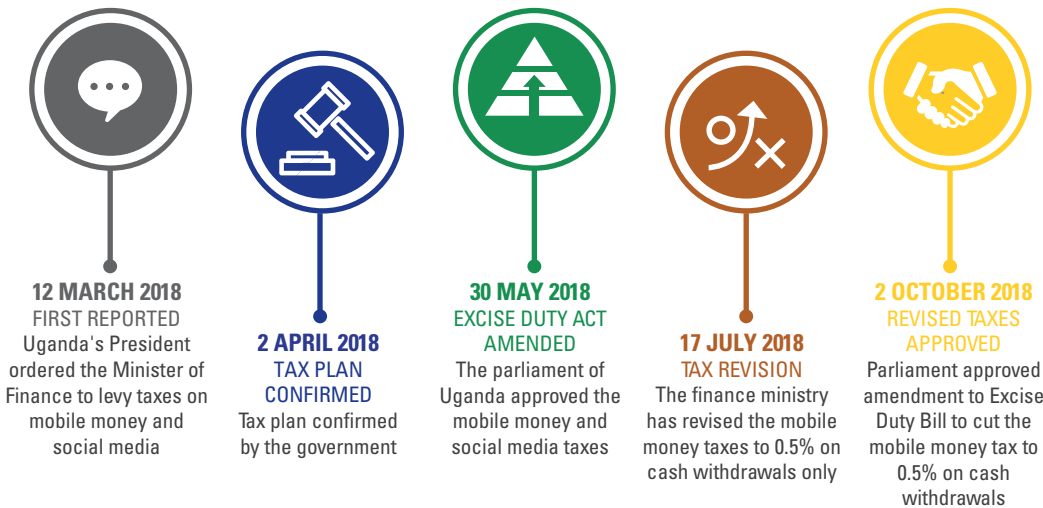


Nearly
3.5 million
unelectrified
households in
Uganda can afford
small solar home
systems of 10W.

IMPACT OF MOBILE MONEY TAXES ON DIGITAL ENERGY FINANCING AND FINANCIAL INCLUSION

To meet the UGX 16.2 trillion (US\$4.3 billion) revenue target for the fiscal year 2018-19, the Government of Uganda discussed amending the Excise Duty Act in March 2018 to allow the introduction of taxes on the use of social media and mobile money. The amendments to the Act were approved by the Parliament on May 30, 2018 and, consequently, starting on July 1, 2018, a 1 percent tax was levied on mobile money deposits, withdrawals, transfers and

Figure 13: Timeline of Uganda Mobile Money Tax



payments (see Figure 13). The immediate consequences of the tax were massive and impacted almost all transactions, including agriculture-related payments, school fees, PayGo and utility payments (UNCDF, 2018).⁴⁰ Following public protests, on October 02, 2018 the Parliament approved reducing the mobile money tax to 0.5 percent, and made it only applicable on cash withdrawals. With this judgement, mobile money users in Uganda still have to pay four different taxes: general tax such as Value Added Tax (VAT), mobile sector-specific tax such as excise duties on airtime usage, direct mobile money tax on transfer fees charged by MNOs and taxation on withdrawals.



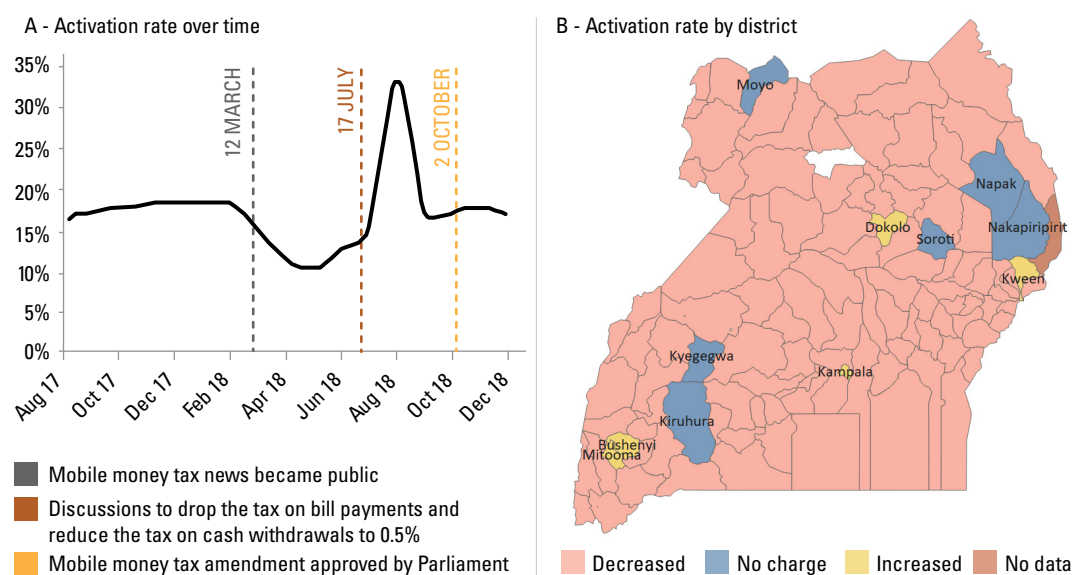
The number of new mobile money activations due to solar PayGo dropped significantly from March 2018 when people started hearing about the mobile money taxes.

To evaluate the impacts of mobile money tax on the digital energy finance and financial inclusion, we calculated the 'activation rate' as the percentage of new PayGo customers who activated mobile money for the first time 45 days prior to their first solar PayGo payment. Figure 14a shows the activation rate trend from early March, when the social media tax plan was first reported and the public became increasingly critical of the proposed tax, until final tax approval in October 2019.

We see that the number of new mobile money activations due to solar PayGo dropped significantly from March 2018 when people started hearing about the mobile money taxes. The activation rate fell to 10 percent in May 2018 when the Excise Duty Act was amended for



Figure 14: First Time Mobile Money Activation of New PayGo Solar Customers



However, when the tax on PayGo bill payments was cancelled the uptake of new PayGo solar products quickly recovered.

mobile money taxes and put forward for Parliament's approval. As soon as the discussions occurred in the news that the tax on bill payments may be canceled, the uptake of new PayGo solar products and mobile money activation quickly recovered and were back to previous levels even before the new tax relief measures began.

Furthermore, Figure 14b shows that the mobile money taxes had a nationwide impact on the uptake of solar PayGo, with the mobile money activation rate of new PayGo customers decreasing in 100 districts (of 112) and remaining neutral in 6 other districts in Uganda. This demonstrates the demotivating influence that a mobile money tax implementation can have, not just on Uganda's financial inclusion rates, but also on Uganda's energy goals. The Uganda case illustrates that if countries aim to expand clean energy access through digital means, mobile money taxation on bill payments should be avoided as it can have rapid and negative effects on the market, including customers switching back to cash purchases.

35 IFC (2018) reports that during 2015 to 2016, the average annual solar home system sales for five ESPs in Uganda stands at 20,000 units, with an annual reduction of 8 percent, while others such as NRECA (2018) estimate that around 300,000 households are using solar home systems.

36 Due to an unreliable grid in Uganda, nearly 16 percent of grid-connected households use complementary solar home systems to meet energy needs (Enclude, 2014). We have categorized these households as unelectrified in the analysis.

37 Households using solar pico devices that do not meet Tier 1 lighting requirement are also considered unelectrified.

38 As part of its efforts, USEA together with Energy without Borders has been conducting a month-long awareness campaign dubbed Let's Go Solar promoting the use of solar products in Soroti and Mbale Municipalities, to sensitize up to 149,675 and 108,558 households, respectively.

39 <https://bit.ly/2JRvtCc>

40 <https://www.uncdf.org/article/3892/understanding-the-consequences-of-mobile-money-taxes-in-uganda>

RECOMMENDATIONS

RECOMMENDATIONS FOR THE GOVERNMENT AND OTHER INSTITUTIONS SUPPORTING FINANCIAL AND ENERGY ACCESS POLICIES:



Our study has shown that PayGo solar service providers are creating a substantial new customer base for mobile money companies.

- **Facilitate partnerships among MNOs, aggregators and ESPs and remove regulatory cost constraints to accelerate digital energy finance in Uganda.** For example, the partnership between Fenix International and MTN Uganda allows customers to pay for off-grid electricity using mobile money services and it has resulted in 110,000 new mobile money and energy customers since the partnership began in 2013. Small solar companies, however, find it difficult to afford such partnerships since integration with mobile money platforms require a significant investment in time and resources. Recently, several payment aggregator companies have emerged in Uganda offering integration services that are fast and come with technology and customer support. These payment aggregators can play an important role in connecting off-grid households, energy service providers and MNOs, leading to the much-needed expansion of digital energy finance for small ESPs in Uganda. But the high regulatory costs that come with activating a Unstructured Supplementary Service Data (USSD) based payment platform are hindering the ability of aggregators to facilitate PayGo solar transactions.
- **Decrease mobile money fees on small PayGo solar transactions.** Our study has shown that PayGo solar service providers are creating a substantial new customer base for mobile money companies, with 16 percent of new customers (around 110,000) setting up mobile money accounts for the first time to make their PayGo payments. Yet these payments are subject to high transaction costs by MNOs. Most of the PayGo solar transactions ranges from UGX 5,000 to UGX 15,000, with an average amount of UGX 8,000. Such low-value transactions are levied a mobile money fee of nearly UGX500, which is relatively expensive for low-income households and discourages them from purchasing PayGo solar products and making digital payments. Reducing transaction fee will likely lead to more people opening mobile money accounts to access clean energy and other digital financial services. The lower fees will also result in a higher number of mobile money transactions that can easily recover the forgone revenues for MNOs.
- **Investigate the effects of mobile money taxes on digital payments and wider economic sectors.** Our research shows that taxing mobile money withdrawals may be a hindrance to Uganda's goals around financial inclusion and universal energy access. The use of mobile money for payments and remittances drives the financial sector's growth in Uganda, and its taxation may compel low-income people to resort to informal finance. For example, fewer people purchased PayGo systems when the 2018 temporary mobile money tax that also affected the PayGo solar market was first announced. Likewise, we find PayGo purchases quickly recovered when the tax for digital payments was canceled. The Uganda case also illustrates that if countries aim to expand PayGo renewable energy, it is better to avoid mobile money taxation on bill payments as it can have rapid effects on the market, with

consumers switching back to cash options. Taxing withdrawals may also increase the cost of other financial products such as education loans.⁴¹

- **Implement favorable tax policies for achieving energy access targets.** Taxation on solar products, including value-added tax, import, and excise duties, influences the affordability of solar products for so-called ‘last mile’ customers, a term that refers to low-income rural customers. Sudden changes in tax rates also affect the sector’s ability to estimate costs and pricing of solar products, creating an uncertain business environment. Following the introduction of new taxes and tariffs on the standalone solar sector in Uganda, energy providers are faced with uncertainty as to how much solar home systems will be taxed. There is also inconsistency in how taxes are being applied, with different companies facing different tax rates and some companies are even experiencing different tax rates on individual consignments of the same product. We encourage the Government of Uganda to constructively engage with USEA and GOGLA on the taxation of solar home systems, components, and appliances.

RECOMMENDATIONS FOR ENERGY AND FINANCIAL SERVICES PROVIDERS:

- **Expand PayGo solar in geographical locations with high rates of mobile money penetration.** Our analysis showed that districts with high mobile money penetrations have better access to off-grid electricity. Districts such as Masindi, Kriyandongo, Gulu, Lira, Busia, Mbarara, and Hoima have more than 60 percent mobile money adaption but less than 20 percent of households have electricity access. These districts could be primary target areas for energy companies seeking PayGo solar markets with a high potential for growth. On the other hand, districts such as Yumbe, Bukomansimbi Bududa and Kotida have extremely low levels of mobile money penetration (10 to 20 percent) and may require agent-led digital energy financing for improving energy access. Districts in the Karamoja region, including Napak, Moroto, Nakapiripirit, and Amudat, show low rates of mobile money penetration but have relatively high ability to pay for electricity. Such locations firstly require improved access to digital finance to expand clean energy usage.
- **Use customers’ transactional data to develop user-centric financing for PayGo solar home systems.** Our analysis showed that Ugandans make frequent energy transactions and in small amounts; it also revealed that half of the surveyed customers purchased additional energy-related products and appliances after buying their first solar products. Analyzing information on people’s financial behavior and product adoption over time can enable financial institutions to design user-centric and low-cost product financing methods that enable energy access, particularly for Uganda’s last mile customers living in rural areas. Existing PayGo payment plans can be better tailored to the customer’s needs; for example, solar product financing for farmers can be based on crop production. Several Fintech firms, including Ant Financial and Kreditech, are using mobile money transactional data to build credit histories for unbanked customers as a way to provide them with customized financial services.
- **Continue the use of the digital energy financing dashboard to identify target customers and expansion areas.** The dashboard can monitor Uganda’s Energy Access goals and market growth in real time, broken down geographically by province, district and even areas covered by cell towers. Finally, the dashboard can support in tailoring financial services



Our analysis showed that districts with high mobile money penetrations have better access to off-grid electricity.

and solar products to the needs of local markets and help plan electrification projects. For the purpose of this study, we used anonymized mobile money transactions data to identify districts and regions with high levels of mobile money and solar PayGo penetration and then superimposed the results with maps showing energy access and electrical grids. Similar analytics can also be done at a more micro-level (for example, using a map that shows mobile towers) to identify potential PayGo solar customers based on factors like income levels, distribution channels and mobile money adaption rates.

RECOMMENDATIONS FOR THE UGANDA SOLAR ENERGY ASSOCIATION:

- **Use mobile money data to monitor Uganda's OGS energy market.** The digital energy finance dashboard can monitor the progress of PayGo solar sales and penetration in Uganda at the cell tower, district and national levels on a weekly basis. The dashboard provides granular data that can supplement USEA's semi-annual sales data collection for tracking the overall solar market growth in Uganda. In addition, USEA and the Government of Uganda can use the dashboard to better plan energy access improvements in both the rural and urban areas.
- **Train ESPs on how to use customer data for better understanding of client needs, improving products and services, and expanding market outreach.** UNCDF, in partnership with USEA, organized a three-day data analytics workshop of more than 20 solar companies in Uganda. The training guided ESPs in using supply and demand data for market scoping, product development and improving customer experiences. Furthermore, the training discussed the implementation of PayGo technology for digitizing operations and open-source platforms for managing and reporting data. Furthering this work, USEA can collaborate with its members, particularly small solar companies, to collect and use data and build tools for effective monitoring and growth of the off-grid solar market in Uganda.
- **Collaborate with MNOs to create digital campaigns for improving public awareness of PayGo solar.** As the Uganda PayGo solar market expands awareness raising is crucial. Although nearly 86 percent of Ugandans are aware of solar products, there is limited awareness on purchase channels, financing and benefits for household (Enclude, 2014). In all, 73 percent of Ugandan households own a mobile phone (UBOS, 2017), providing an opportunity for USEA to improve public awareness about solar technology, its use, and its health and monetary benefits via digital campaigns. This, for example, could include launching a targeted SMS and automated calling campaign to inform people about PayGo solar.



As the Uganda PayGo solar market expands awareness raising is crucial.

41 <https://www.uncdf.org/article/3892/understanding-the-consequences-of-mobile-money-taxes-in-uganda>

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ANNEX I

Figure 15: Quality of Life Improvements by Product Type

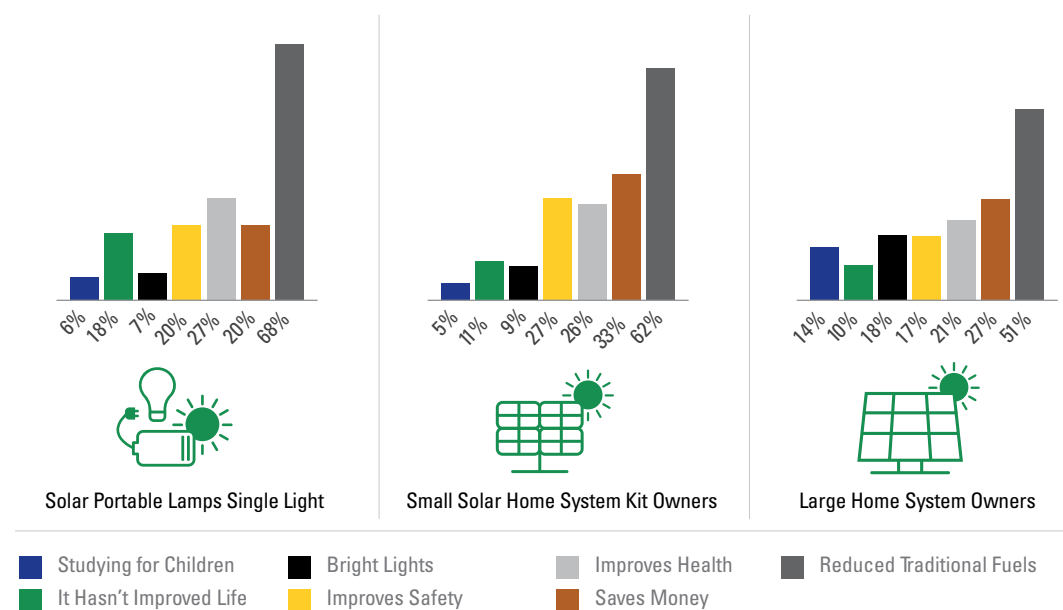


Table 5: Estimating PayGo SHS market in Uganda

UGANDA	
Number of households in Uganda (A)	8,000,000
Households with no access to grid electricity (B)	84%
Number of households with no access to grid (C)=(A*B)	6,720,000
Number of estimated solar home customers in 2018 (among largest MNO mobile money users) (D)	672,236
Mobile money customers using largest MNO mobile money (E)	76%
% Solar home systems purchased using PayGo (F)	75%
% Households buying a second solar home system (G)	12.4%
Number of households having solar home systems (H) = D*(1 - G)*E*F	1,033,121
Number of unelectrified households in Uganda (C-H)	5,686,879
Number of unelectrified households that can afford a small 10W PayGo solar system*	3,525,865

*This is estimated as follows: Nearly 10 percent of total monthly consumption expenditure of an average Ugandan household is spent on electricity. Purchasing a small PayGo SHS of 10W requires a monthly payment of at least UGX 21,000 (or US\$5.7). An average household spending UGX 21,000 monthly on electricity will have UGX210,000 (US\$57) worth of total monthly expenses. Nearly 38 percent of the Ugandan households earn less than US\$1.9 PPP a day (World Bank, 2014)⁴² (equivalent to around 222,000 UGX or US\$60 of monthly disposable income)⁴³ and may not have sufficient income to pay-off monthly installments towards a 10W PayGo SHS. This implies that among 5.6 million unelectrified households in Uganda only 62 percent or nearly 3.5 million household can afford a small SHS of 10W.



Unlocking Public and Private
Finance for the Poor