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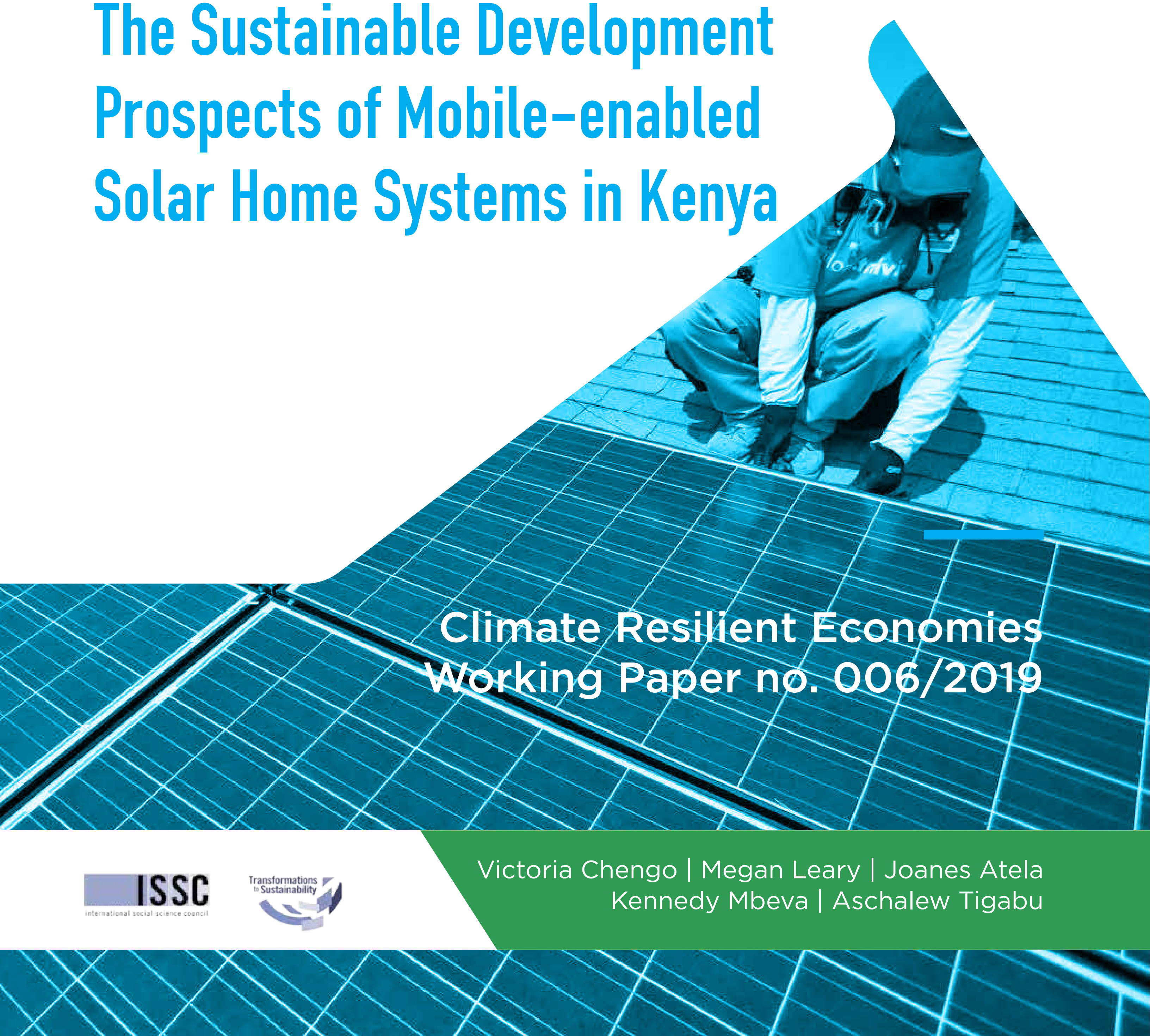
Understanding The Sustainable Development Prospects of Mobile-enabled Solar Home Systems in Kenya



Climate Resilient Economies
Working Paper no. 006/2019

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African Centre for Technology Studies (ACTS)
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About ACTS

The African Centre for Technology Studies (ACTS) is a pioneering development research think tank working to harness applications of science, technology and innovation policy for sustainable development in Africa. ACTS is an intergovernmental organization founded in 1988 to pursue policy oriented research towards strengthening the capacity of African countries and institutions to harness science and technology for sustainable development. ACTS envisions a sustainable economic, social and environmental future for Africa, through science, technology and innovation.

Through its research, policy analysis, capacity building, knowledge and technology brokerage, ACTS plays an instrumental role in enlarging the range of policy choices for sustainable development in Africa. ACTS was the first to organize an international conference in 1990 to explore policy options for climate adaptation and mitigation in Africa. In 2015, ACTS was awarded the Century International Quality Era Award (Gold Category) from the BID (Business Initiative Directions) Group for its commitment to 'Quality, Leadership, Technology and Innovation'.

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List of acronyms and abbreviations

ACTS	African Centre for Technological Studies
ASH	African Sustainability Hub
CIDP	County Integrated Development Plan
DRE	Decentralized Renewable Energy
ERC	Energy Regulatory Commission
FiT	Feed-In-Tariff
GDC	Geothermal Development Company
GESIP	Green Economy Strategy and Implementation Plan
GoK	Government of Kenya
IPP	Independent Power Producer
K-OSAP	Kenya Off-Grid Solar Access Project
KenGen	Kenya Electricity Generating Company Limited
KETRACO	Kenya Electricity Transmission Company Limited
KNEB	Kenya Nuclear Electricity Board
KPLC	Kenya Power and Lighting Company
MoE&P	Ministry of Energy & Petroleum
PAYG	Pay-as-you-go
PPP	Public-Private Partnership
PV	Photovoltaic
RE	Renewable Energy
REA	Rural Electrification Authority
SDGs	Sustainable Development Goals
SE4All AA	Sustainable Energy for All Action Agenda
SHS	Solar Home Systems
SREP	Scaling Up Renewable Energy Program
T-Lab	Transformation Lab

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Acknowledgements

This paper is a synthesis of the outcomes of the first and second Transformation Labs (T-Labs) executed by the Africa Sustainability Hubhosted at the African Centre for Technology Studies (ACTS) in Nairobi, Kenya. Our sincere appreciation goes to the International Social Science Council (ISSC), now International Science Council (ISC), who funded the*'Transformative Pathways to Sustainability: Learning across Disciplines, Contexts and Cultures'* project under which this research was carried out. Special acknowledgement as well to the entire Global STEPS consortium partners in the UK, Argentina, China, India, Sweden, and the USA with whom we collaborated in executing the project and supported our work tremendously.

Much appreciation to the Transformation Lab workshop series participants who presented a broad and deep understanding of the Pay-As-You-Go (PAYG) Solar Home System (SHS) space and contributed to a series of recommendations to improve the sustainability and transformative footprint of the problem space, which can be organised broadly into three categories: academic, technical and policy-related.

Furthermore, we acknowledge various ACTS staff who took time to review,comment and give suggestions to this paper, and those thatsupported the process in one way or another.

Abstract

Riding on the vast mobile connectivity in Kenya, a frequent claim is that mobile-enabled payment systems have transformed renewable energy access through the Solar Home Systems (SHS). But what is the evidence supporting this claim? Or in a broader sense, does exponential technological innovation always lead to socio-economic transformation in pro-poor energy access? Drawing from focus group discussions, fieldwork, analysis of relevant policy frameworks, this study explored this question and found that even though there was broad consensus on the innovativeness of these mobile-enabled payment systems, there were varying perspectives on whether it was indeed transformational. These innovations are central to this contestation of the meaning of 'transformation', which was defined differently by various actors in the solar home systems sector. Specifically, various actors emphasized certain aspects of technical and/or socio-technical transformations. The benefits, from the perspectives of end-users, were identified as improvements to health, creation of economic opportunity, improvement in communications leading to greater social inclusion and increased educational activity as a result of available lighting. The product developers emphasized the technical innovation and its associated business model, while the national and civil society actors stressed the importance of broader socio-economic transformations such as alleviation of poverty. However, the socio-economic benefits of mobile-enabled SHS systems remain contested, due to the non-conventional nature of the technological intervention that makes the measured impact of the SHS difficult to understand. Thus, the study revealed important insights on the need to embrace a broader definition of transformation, and the affiliated ways of measuring it. Exponential technological innovation, by itself, is not a guarantee of transformation.

Keywords: solar home systems; mobile-enabled payment systems; renewable energy; pro-poor energy access; innovation

1. Introduction

The challenge of pro-poor energy access is one that persists in developing economies, and Kenya in particular, as she embarks on a new development trajectory. Coupled with the need to develop sustainably, the transformative impact of renewable technologies faces new questions of viability. Kenya is faced with the twin challenges of immediate and future impacts of climate change, as well as the need to increase electricity access to enhancehuman development. Kenya's energy supply and economy are particularly vulnerable to the impactsof climate change. Temperature increases are likely to adversely impact the hydro-power-reliant energy supply and agricultural-based economy.[1]

The population of the East African nation is 48 million,[2] with an annual growth rate of 2.6%; as of 2016, 36% of the population lives below the national poverty line. Kenya's electrification rates indicate that the current energy policy regime does not address the needs of a nation aspiring to higher levels of socioeconomic development. 56% of Kenyans have access to electricity; in urban areas that rate stands at 77%, while only 40% of the rural population has access to electricity.[3,4]

Kenya, in many ways, is on a sustainable energy trajectory. Renewable energy plays a significant role in the energy sector: 69% of the country's electricity is derived from renewable sources (hydro, geothermal, biomass, and wind) and 31% from fossil-fuel sources.[5] Furthermore, the country's historic contribution to global greenhouse gas emissions (GHG) emissions is low at only 0.1% of total global emissions.[6] However, the low electricity access rate in rural areas means this use of renewable energyhas not translated to universal electricity access. The poverty rates, relatively low emissions and vulnerability to climate change across sectors indicate that expansion of energy services have two primary foci: pro-poor development and climate change mitigation and adaptation.

The Government of Kenya (GoK) has set ambitious economic goals, aiming to reach middle-income status as a newly industrialized country by 2030. Additionally, as a partyto the Paris Agreement on Climate Change, the Kenyan government has committed to decrease its GHG emissions by 30% by 2030.[7] In 2016, Kenya launched its SE4All Action Agenda aiming for a 100% access rate by 2030, with 80% of power and heat generated from renewable sources.[8] As it does at the international level, the co-existence of these agreements and initiatives creates a new policy space concerned with pro-poor development and climate change adaptation. Within Kenya, one particular sociotechnical innovation holds the potential to bridge these two pillars: the mobile-enabled PAYG SHS sector. This intersection demands particular interest in the Kenyan context and mirrors the entanglement that related initiatives may face at the global level.

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[1]Dalla Longa and van der Zwaan, "Do Kenya's Climate Change Mitigation Ambitions Necessitate Large-Scale Renewable Energy Deployment and Dedicated Low-Carbon Energy Policy?"
[2]approximately 75% of the population lives in rural areas and 25% in urban centres World Bank, "World Development Indicators | DataBank."
[3]The majority of the population, particularly in rural areas, relies on traditional biomass and waste (typically consisting of wood, charcoal, manure, and crop residues) for household heating and cooking EIA, "Kenya - International - U.S. Energy Information Administration (EIA)."
[4]World Bank, "World Development Indicators | DataBank."
[5]EIA, "Kenya - International - U.S. Energy Information Administration (EIA)."
[6]Ministry of Environment and Natural Resources, Republic of Kenya, "Kenya's INDC."
[7]Ministry of Environment and Natural Resources, Republic of Kenya.
[8]Ministry of Energy and Petroleum, Republic of Kenya and Sustainable Energy for All, "Sustainable Energy for All (SE4All) Kenya Action Agenda."

Within the context of diverse energy sources and limited access to energy, actors especially in the private sector have developed a variety of off-grid energy products. These products usually comprise of technical and business model innovations. They can thus be characterised as exponential innovations in the energy sector. Despite this proliferation of such off-grid solutions, a fundamental question remains unaddressed: is exponential innovation in energy solutions having a transformative impact on pro-poor energy access?

M-KOPA, an innovative mobile payment system comprising a solar home system (SHS) and a mobile-based payment system, was used a case study. It can thus be considered as mobile-payment-enabled SHS. M-KOPA thereforepresentsan important case study to investigate how exponentialinnovations in the renewable energy sector can lead to transformations in pro-poor energy access.[9]

This paper first outlines its research objectives and research questions. The methodology section provides an overview of the Transformation Lab (T-Lab) Workshop series that served as the source of primary data for this research, as well as the use of the Participatory Impact Pathways Assessment (PIPA), semi-structured interviews with key actors, and policy analysis. The subsequent results and discussion sectionsthen follow. The concluding section of this paper will provide recommendations that emerged over the course of the research for this project and the next steps to be taken to maximize the transformative impacts of the socio-technical innovation that is the mobile-enabled SHS.

2. Background

2.1 Mobile-enabled SHS as a socio-technical innovation

The emergence of Pay-As-You-Go (PAYG) microfinance enterprises is an extension of the pico-solar market, which has developed within the already prominent solar PV market in Kenya that has been present since the late 20th century. The pico-solar market in Kenya has grown to become the second largest in the world (behind only China).[10] Mobile cellular subscriptions totalled 38,982,188 in 2016, accounting for approximately 80% of the Kenyan population having a mobile cellular device.[11]These two factors, combined with the growth of the mobile money marketplace to nearly-ubiquitous status, have created an enabling environment for the mobile-enabled PAYG SHS sector.

Solar home systems are stand-alone photovoltaic units that offer a cost-effective way of supplying amenity power without access to a centralized electricity grid. SHS falls under the categoryof decentralized renewable energy solutions. A fundamental characteristic of these stand-alone systems is their provision of power to single consumers including singular households. This is distinct from a micro-grid system, which can supply power to several consumers such as a group of houses, commercial kiosks, and schools.[12] PAYG is a microfinance platform that refers specifically to household energy systems. PAYG platforms are intended to offset the high upfront capital costs for cash-poor off-grid consumers What distinguishes PAYG platforms

[9]For a detailed discussion on exponential innovation, see Juma, Calestous, Exponential Innovation and Human Rights: Implications for Science and Technology Diplomacy (February 27, 2018). HKS Working Paper No. RWP18-011. Available at SSRN: https://ssrn.com/abstract=3131243 or http://dx.doi.org/10.2139/ssrn.3131243
[10]Muok, Bernard O., Makokha, Willis, and Palit, Debajit, "Solar PV for Enhancing Electricity Access in Kenya: What Polocies Are Required?"
[11]World Bank, "World Development Indicators | DataBank."
[12]Mandelli et al., "Off-Grid Systems for Rural Electrification in Developing Countries."

within the off-grid PV energy sector is the coupling of IT-enabled payment systems and connectivity. [13] The platform allows for SHS to operate on a fee-for-service business model.

At its core, the PAYG SHS business model is a financing platform that leveragesthe distinctive circumstances of individual markets, such as in the case of M-KOPA inKenya. These include active use of mobile telecommunications systems, agent or representative networks that are extensive, partnerships with distributers that extend beyond the standard retail-consumer interactions.[14] M-KOPA was founded in 2011 and has been a leader in the mobile-enabled PAYG SHS sector. The company aims to "upgrade lives by making high quality solutions affordable to everyone".[15]

Use of these mobile-based systems has seen a boom in the last decade, building on the increased use of mobile-money transfers in Kenya. Initial studies focusing on the M-KOPA have suggested that, within a period of less than 5 years, about 450,000 homes (mainly the rural poor in East Africa) have been connected to solar power. About 500 new homes are being added every day.[16]

2.2 M-KOPA Business Model

M-KOPA is a solar energy company based in Kenya, operated by both Kenyan and foreign entrepreneurs.[17] The overall mission of the enterprise is to provide more flexible payment options for households, individuals or groups especially those living in rural areas in order to gain access to off-grid solar home systems. M-KOPA was founded in 2011 and aims to improve lives through the provision of high-quality products. Initial studies focusing on the M-KOPA case have suggested that, within a period of less than 5 years, about 450,000 homes (mainly low-income rural households in East Africa) have been connected to solar power. About 500 new homes are being added every day. The system targets off-grid households in particular those unable to afford grid-electricity connection. These households are locked into using unsustainable energy sources including kerosene and paraffin lamps, and wood among others. [18]

M-KOPA qualifies as a provider of Pico solar products, specifically basic solar home systems. The company is categorized underasset finance, operating as a micro-loan firm. The model employed by MKOPA follows the following process for providing service to end-customers: 1) down-payment and relatively informal credit check; 2) payment series via mobile money platform (M-PESA); and 3) device is unlocked and owned by customer. [19] The M-KOPA system relies on the M-PESA technological platform, offered exclusively to Safaricom mobile customers. Safaricom is a leading mobile network provider in Kenya. The mobile money system leverages the increasing number of households owning mobile phones and being able to access financial services, especially in rural areas with limited banking services.

The MKOPA system is designed to suit the needs of low-income households by providing flexible payment options and products that are tailored to meet socio-cultural needs. Specifically, the system targets off-grid households especially those unable to afford grid-electricity connection, thus being boxed into using

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[13]Alstone et al., "Pay-As-You-Go Financing and Digital Supply Chains for Pico-Solar."
[14]Alstone et al.
[15]M-KOPA, "Company Overview."
[16]Byrne, Mbeva, and Ockwell, "A Political Economy of Niche-Building"; Rolffs, Ockwell, and Byrne, "Beyond Technology and Finance."
[17]M' for Mobile and 'KOPA"- Kiswahili word meaning borrowing M-KOPA, "Company Overview."
[18]M-KOPA, "Company Overview."
[19]Alstone et al., "Pay-As-You-Go Financing and Digital Supply Chains for Pico-Solar."

unsustainable, energy sources including kerosene or paraffin lamps, wood among others. M-KOPA estimates that the majority of these consumers are living on less than $2 a day. Households are estimated to be spending an average of $150 per year on kerosene alone, which constitutes 20% of the household income on average. M-KOPA bundles provide a set of products which are designed for this customer base. [20]

Currently M-KOPA offers two bundles: the M-KOPA 5 Classic; and the M-KOPA 500. Products in these bundles include a solar panel and lighting system, a television set, a radio and a battery charger which allows users to charge their mobile phones and other appliances such as torches, eliminating the need to spend additional money to buy new batteries. Each bundle comes with a 2-year warrantee that allows for a full refund of deposits providing systems are returned in good working condition. The payment plan details for each bundle are outlined in Table 1. A customer can either get a full system or modularcomponents.

Customers are able to get MPESA loans to help them pay initial deposits then pay the rest in negotiable instalments. Customers pay a deposit to acquire the system and take it home while they repay the balance daily, weekly or monthly for a period of one year as per the agreement. The deposits can be made bycash, but the daily payments are made through the M-PESA platform to enable consumers to make payments regularly without travelling to the M-KOPA centres. The payment schedule is maintained through SMS alerts, reminding the customer to make payments as per their agreed schedule; see Annex I for the payment bands.

2.3 Gap assessing transformative nature of mobile enabled SHS

PAYG services began to emerge in association with SHS beginning in the 2000s. In early 2015 Kenya had approximately 10 PAYG solar enterprises operating in the country.[21]Limitedliteratureexists regarding the early forms the PAYG SHS sector. This is largely due to the lack of involvement from international development organizations[22]. While the benefits specifically linked to mobile-enabled payment systems to SHS are largely undetermined, some potential impacts can be extrapolated from the literature on off-grid solar PV, including those associated with stand-alone systems without PAYG features, micro-grid or community-based systems.

Evidence from studies on the impact of these technologies within Kenya indicatethat developmental benefits associated with solar electrification are linked to the use of "connective" devices.[23]The economically productive impact of off-grid solar PV in Kenya is generally marginal;however, the use of solar-generated electricity to power appliances such as televisions, radios or charging cellular phones increases the interconnections of people to markets and the cultural hubs of urban centres. Rolffs et al. claimthat despite the growth of the sector and dissemination of mobile-enabled SHS, there has been relatively little impact on the energy access figures in Kenya, despite the country being one of the largest per capita markets for SHS in the world.[24]

[20]M-KOPA "Company Overview".
[21]Alstone et al.
[22]Rolffs, Ockwell, and Byrne, "Beyond Technology and Finance."
[23]Byrne et al., "Sustainable Energy for Whom? Governing pro-Poor, Low Carbon Pathways to Development: Lessons from Solar PV in Kenya"; Kirubi et al., "Community-Based Electric Micro-Grids Can Contribute to Rural Development."
[24]"Beyond Technology and Finance."

Mobile payment systems are perceived to provide a viable alternative to high-cost electricity installation; local communities that cannot afford these services see an opportunity in these Decentralized Renewable Energy(DRE) solutions. Affordability is a major component of the transformative claims surrounding these systems. The view that SHS helps bring social inclusion and to some extent economic transformations to low-income households is shared amongst a myriad of actors including civil society, NGOs and grassroots organizations. This paper will examine the viability of those claims.

The percentage of the Kenyan population with access to electricity has significantly increased in the last five years. The World Bank reported that between 2013 and 2016 the percentage of the Kenyan population with access to electricity increased from 31.6% to 56%.[25] The percentage of this electricity that can be attributed to off-grid solar PV is more difficult to discern. By the end of 2014, more than 6MW of solar PV System capacity was installed in the residential and commercial sectors exclusively through the private sector initiative.[26] A 2014 study conducted by M-KOPA and Intermedia concludedthat approximately 14% of the Kenyan population relied on off-grid solar as their primary lighting or charging source, estimating that the off-grid and decentralized electricity market in Kenya is consisted of approximately 6.7 million households. [27] The SE4ALL initiative in Kenya maintained that this rate of off-grid solar PV combined with the World Bank reported electricity access rate of 38.9% rendered the net electricity access rate 47.1% in 2014.[28]

3. Research Design

3.1 Assess the transformative impact of PAYG SHS

While technological innovationshavewidely been accepted and often recognized as disruptive, both in Kenya and abroad, it is still unclear under what conditions they become transformative. There remain political, technical and social barriers for mobile-enabled SHS to be a strong, sustainable part of Kenya's energy supply. This paper is not intended to debate whether the dissemination of mobile-enabled SHS is having a net impact on electricity use in Kenya (i.e. offering some electricity access to those who otherwise would not be able to access the service). However, it will analyse the extent of the transformation associated with mobile-enabled SHS systems, how its impacts might be assessed, and types of benefits produced by this service. These socio-economic benefits can be defined as climate positive, poverty alleviation and relief of energy poverty. Specifically, we will address the policy scenarios that might enable the greatest impact both in terms of pro-poor development and climate change adaptation and mitigation.

This paper's main research questions are:

- What are the benefits arising from the rapidly evolving mobile-enabled SHS space?
- Has the mobile-enabled SHS space transformed in ways that lead to more sustainable and inclusive future benefits for all?
- What governance approaches are emerging to support mobile-enabled SHS innovations at the county and national levels?

[25]"World Development Indicators | DataBank."
[26]Ministry of Energy and Petroleum, Republic of Kenya, "Draft National Energy and Petroluem Policy."
[27]Rehema, "Kenya Emerges as Solar PV Hot Spot."
[28]Ministry of Energy and Petroleum, Republic of Kenya and Sustainable Energy for All, "Sustainable Energy for All (SE4All) Kenya Action Agenda."

4. Methodology

The objective of the research undertaken was to assess the transformative impact of the mobile-enabled SHS space in Kenya. The preliminary assumption isthat the technology is having an impact on Kenya in terms of providing electricity access where there was none before. Therefore, transformative impact refers to the socio-economic benefits associated with mobile-enabled SHS use, broadly defined. Net gains in electricity access, while indicative of important progress, were not the only concern here. Research was hence designed to suit this need. We did not restrict our analysis to this definition. Rather, we used it as a starting point for discussions with the various actors we engaged. The objective was to document and analyse their understanding of transformative impacts.

The research for this analysis was conducted under the portent of The Africa Sustainability Hub's (ASH) ISSC-funded project 'Transformative Pathways toSustainability: Learning across Disciplines, Contexts and Cultures', hosted at the African Centre for Technology Studies (ACTS) in Nairobi, Kenya. This project pursued action researchon what transformations are associated with mobile-enabled SHS and how challenges facing such transformations can be addressed based on co-learning.

4.1 T-Lab Workshops: Focused Group Discussions

Focused group discussions were undertaken through the Transformation Lab ('T' lab) Workshop series, which consisted of two workshops held in March 2017 and June 2018 in Nairobi, Kenya. The Transformation Labs were designed using the co-learning method in order to understand the transformations associated with mobile-enabled SHS system from a socio-technical perspective. The co-learning method is a social science-based approach that allows for substantive interactions between diverse stakeholders directly and indirectly involved in orchestrating sustainability and transformation[29].

These workshops were critical stakeholder's dialogues, organized by the African Sustainability Hub (ASH), the STEPS Centre and the African Centre for Technology Studies, on enabling sustainable and equitable access to solar PV solutions for all via mobile solar payment systems. The MKOPA solar initiative served as a test model for further interrogation and deliberations around issues of transformation, sustainability and equitable access to solar energy solutions. Both workshops enabled focused group discussions amongst a wide variety of players in Kenya's energy sector to explore pathways for the utilization of mobile-enabled SHS.

The research component was based on the deliberations of the Transformation Lab (T-Lab) Workshop Series hosted by ACTS in conjunction with ASH and the STEPS Centre. The T-LAB series consisted of two workshops held in January 2017 and June 2018 in Nairobi, Kenya. The observations and information garnered from these workshops provided the primary research for this project.

M-KOPA qualifies as a provider of Pico solar products, specifically basic solar home systems, and is deemed to be one of the most impactful enterprises of its kind in East Africa[30].The Company was chosen as a case study for these reasons. In the first T-Lab workshop, participants presented their understanding of the transformative impacts of M-KOPA, while the second T-lab workshop deliberated on the pathways to transformation.

The T-Lab workshops were designed to bring together different stakeholders from government, NGOs, civil society, private sector development partners, research and academia. Participants deliberated on what needs to be done to support equitable, sustainable access for all via mobile-based payment systems. Semi-structured interviews with key stakeholders complimented both the group discussions that occurred in the T-Lab workshops and the energy policy analysis. The interviewees were identified according to their involvement in the solar sector or their influence on the Kenyan energy policy. These interviewees were mainly drawn from both state and non-state-based organizations such as representatives of M-KOPA,

[29]Pereira, Dr. Laura, "Coming to Terms with Messiness."
[30]Alstone et al., "Pay-As-You-Go Financing and Digital Supply Chains for Pico-Solar"; MIT Technology Review, "The 50 Smartest Companies of 2017 Might Not Be What You Think."

Stockholm Environment Institute, Ministry of Environment and Natural Resources and Energy Regulatory Commission.

4.2 Fieldwork

The first workshop was followed by fieldwork involving visits to MKOPA users and product developers. These visits occurred in Nakuru County. Interviews were conducted with M-KOPA customers and testimonials obtained regarding the use of the M-KOPA products and noted benefits and challenges associated with the said product.

4.3 Analysis of Kenyan Energy Policy and Initiatives

Data collected for research in the second phase of the project (following the first workshop and subsequent fieldwork) involved an extensive literature review and document analysis. In-depth evaluation of Kenya's energy policies produced a significant portion of the data and arguments presented in this dissertation. Ten energy policy documents published by the Government of the Republic of Kenya were reviewed. Data was analysed through coding and thematic categorisation of qualitative data sets in line with key objectives of the study.

The themes and questions that emerged from the first T-lab workshop were applied to each document. Each policy's position on energy access, solar technology and poverty reduction was investigated, followed by their application of mobile-enabled SHS under these respective thematic umbrellas. The policies analysed were comprehensive and covered more than just solar technology/solo-generated electricity. The policies analysed were selected based on relevancy and availability. Due to time constraints, there were some policies that were not close-read but remain relevant to the subject. Additionally, energy policy in Kenya is continuing to evolve at a rapid pace, and some more recent policies that are in their draft stages or recently made public were not able to be included. See Annex II for the list of policy documents that were analysed.

5. Results and Discussion

5.1 Mapping the landscape of actors

Solar energy in Kenya is situated within a rapidly growing, multi-sectorial policy landscape. The expansion of solar technology use in Kenya can be described as a conflicting force in the country's energy sector between centralized (grid extension) and decentralized energy solutions. The landscape of actors within the field of SHS specifically represents diverging interests, views, knowledge and narratives. In order to best understand the socio-economic benefits arising from the rapidly evolving mobile-enabled SHS, it is important to map the actors involved. Discussion from the T-lab workshop series and policy analysis illuminated that this space is dominated by the relationship between the private sector and the Government of Kenya. Most notably, how the expansion of energy services on the part of the government and the expansion of mobile-enabled SHS providers.

Kenya's Ministry of Energy and Petroleum (MoE&P) is a primary state actor, responsible for creating and implementing energy and petroleum policies to develop an enabling environment for the efficient implementation and growth of the energy sector. MoE&P is responsible for drafting a number of the key policies analysed for this research[31]. Within the Ministry, regulation of the energy process rests under the purview of the Energy Regulatory Commission (ERC) (see Figures 1 and 2). The ERC is responsible for economic and technical regulation of generation, transmission and distribution of electric power, renewable energy, and downstream petroleum sub-sectors; oversight functions include tariff setting, review, licensing, enforcement of sector regulations, development of energy plans, approval of power purchase agreements and network service contracts[32].

[31]Ministry of Energy and Petroleum, Republic of Kenya, "Draft National Energy and Petroluem Policy"; Ministry of Energy and Petroleum, Republic of Kenya and Sustainable Energy for All, "Sustainable Energy for All (SE4All) Kenya Action Agenda."

[32]Ministry of Energy and Petroleum, Republic of Kenya, "Draft National Energy and Petroluem Policy."

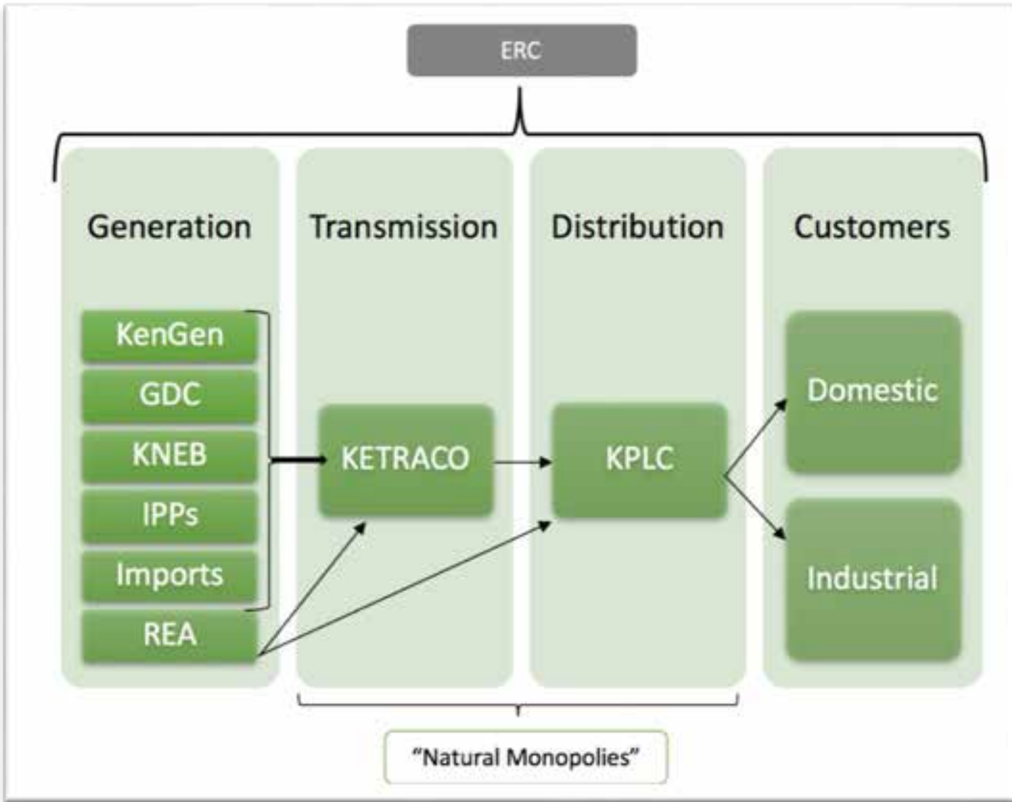

Figure 1. Overview Kenyan electricity grid network

The ERC and the vertically integrated electricity generation and distribution model are dominated by "natural monopolies", with singularly state-run entities responsible for majority of functions. The institutional structure is such that the GoK dictates the electricity market. The physical and organizational structure of Kenya's electricity sector is demonstrated in Figures 1 and 2. Figure 2 highlights the shareholding of the different participants across the electricity network. When looking at the ownership of the electricity utilities, the dominant involvement of the GoK is apparent (noted in blue). Geothermal Development Company (GDC), Kenya Nuclear Electricity Board (KNEB), Rural Electrification Authority (REA), Kenya Electricity Transmission Company Limited (KETRACO) are fully state-owned. These entities all operate on behalf of the GoK. Kenya Electricity Generating Company Limited (KenGen)[33] and Kenya Power & Lighting Company (KPLC)[34] are majority state-owned. The only bodies outside the governmental elite are the independent power producers (IPPs) and the imports, which represent only a slight fraction of the electricity. Currently seven IPPs operate in Kenya, selling in bulk to KPLC, contributing approximately 30% of effective generating capacity to the national grid[35].

[33] 70% state-owned, 30% private investors
[34] 50.1% state-owned, 49.9% private investors
[35]Ministry of Energy and Petroleum, Republic of Kenya and Sustainable Energy for All, "Sustainable Energy for All (SE4All) Kenya Action Agenda."

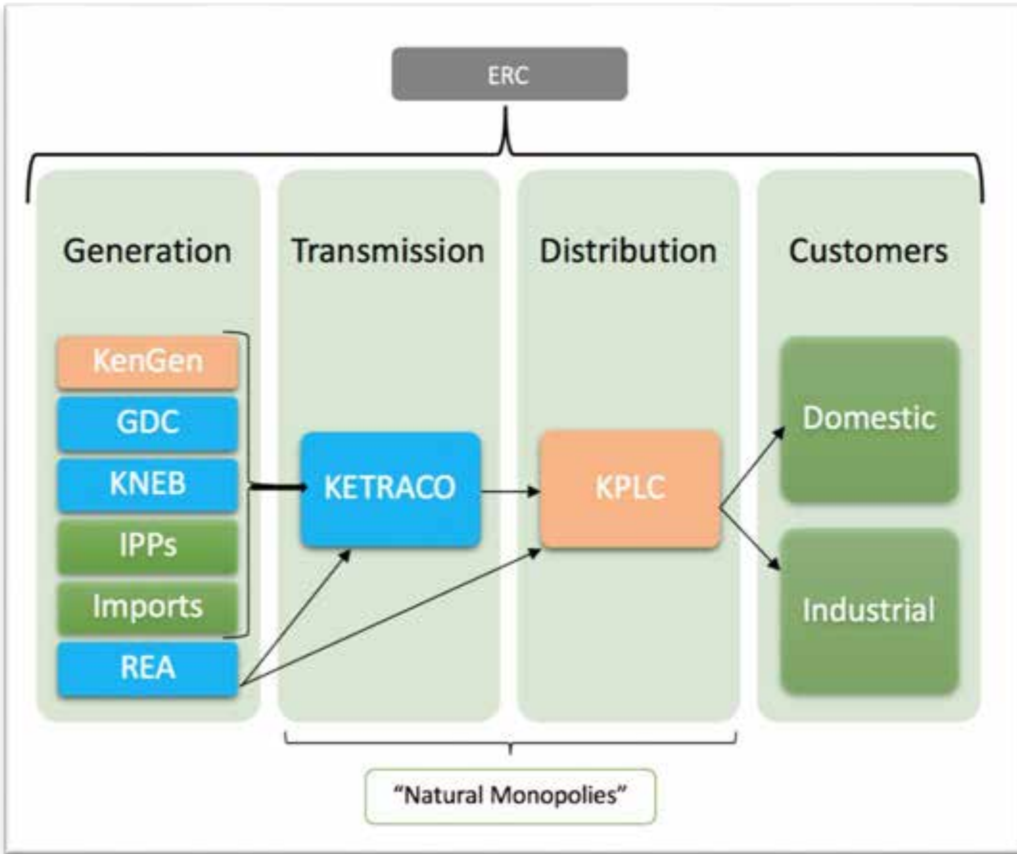

Figure 2. Overview electricity grid network - distinction between state-owned (blue) and partially state-owned (orange) entities

5.2 The socioeconomic impacts of the mobile enabled SHS innovation

The use of mobile-enabled SHS systems differs from the common methods in that the product is entirely developed and disseminated by the private sector and so does not rely on the state to be as active in order to expand electricity access. However, due to the non-conventional nature of the technological intervention the measured impact of these products is difficult to understand. The socio-economic benefits of mobile-enabled SHS systems are largely not undetermined. Providers make sweeping claims which include improvements to health, creation of economic opportunity, improvement in communications leading to greater social inclusion and increased educational activity as a result of available lighting. There is no data that supports the sustainability of these claims. Therefore, to understand the broader socio-economic benefits of mobile-enabled SHS, once can draw from customer experience with MKOPA's product(s).

In discussions with M-KOPA consumers in Nakuru County, they noted advantages of the mobile-enabled SHS system/M-KOPA payment model as[36]:

- The price of an MKOPA unit is all inclusive unlike accessing or connection to the grid. When connecting to the grid persons have to purchase different components separately hence increasing the cost of connection, accessing TV, radio or charging phones in addition to the cost of connection

[36]African Center for Technology Studies, "Field Visit Notes for MPESA Payments for Solar Home Systems in Kenya."

to the national grid. 'Its costs Ksh 15000/= for wiring and approximately Ksh 50,000/= to get connected to the national grid,' said Vincent from Kampi ya Samaki, Nakuru County.

- A customer can return the product and get repaid all deposit if it's within 48hrs since acquisition or get replaced if it's not working.
- In case the customer defaults paying as agreed in the initial agreement then they review the repayment to enable the customer pays all within a year.
- It provides a 2- year guarantee and in the event that the customer wishes to return part of or the whole of the product, they can provide it in good condition. The customer is refunded their entire deposit in these cases.
- M-KOPA provides support to its customers beyond solar systems. Its advances other products like water harvesting systems like water tanks, support entrepreneurship like poultry farming, access to soft loans
- Customers interact with the technical or management through a customer care telephone number, email, social media (Facebook) or outlets at the nearest towns or centres, according to M-KOPA.

Some of the challengesfaced by customers are:

- The network coverage for the TV is widely distributed in the country but some customers in particular terrain or regions like Bomet and households based in valleys are struggling to access several TV programmes
- Some customers, due to the inconsistencies in income generation, do default payments because they rely on unsustainable or unpredictable sources of income.
- Charging of high-power consuming systems like smart phones.

5.3 The national innovation systems for the transformation of the mobile-enabled SHS space, including policy makers, firms, innovators, universities, civil society

a. Broader Policy Landscape

The landscape for solar technology in Kenya, as previously mentioned, is defined by the relationship between the private and public sectors; in this case mobile-enabled SHS enterprises and the GoK, with civil society and other non-state actors acting intermediately. Amongst all these actors there is a general sense of the need to enhance the access to SHS, and an understanding of the innovative approach of mobile-enabled payment systems, however actors diverge in their views of how to go about achieving this. For example, the GoK has contradictory policy directions amongst its initiatives related to solar energy. The government is primarily in favour of main grid extension to promote electricity access. The private sector on the other hand is in favour of fiscal policy interventions to support their own enterprises.

The promotion of decentralized solar solutions is done almost exclusively through the GoK's Feed-in-Tariff scheme and VAT exemptions of solar products.

b. K-OSAP

The Kenyan Off-Grid Solar Access Project (K-OSAP)is one of the two Kenyan energy policy initiatives that acknowledge the potential of the mobile-enabled PAYG SHS. However, this project uses its success as a model, not a partner. This initiative currently serves as an off-grid electrification strategy in the eyes of GoK though it is not a comprehensive policy. It is primarily designed to complement the existing structure of the electricity sector. This initiative creates intricate barriers to partnerships with private-sector actors in the PAYG SHS sector, even putting the GoK into direct competition with these actors.

The K-OSAP initiative intends to benefit "household, public and community institutions, enterprises and community facilities that cannot access electricity through the national grid and whose use of electricity will replace kerosene and other fuels". The imperative to drastically increase access to electricity is the main driver of the project. The off-grid program aims to electrify 14 underserved counties (see Table 6). These counties are described as "remote, low density, and traditionally underserved" (pg. 27). The program will use primary hybrid mini-grid[37] and provides for the participation of some private sector actors. The mini-grids to be used will be developed under a public-private partnership (PPP); private funds will be used under this partnership to co-finance the development of the units and their distribution networks.

5.4 Linkages between international, national and sub-national innovation systems governing the mobile-enabled SHS systems

a. International linkages

The proliferation of mobile-based payment solutions to access solar home systems in Kenya, mainly offered by social-entrepreneurs and other non-state actors, indicates a shift in demand for energy services. Mobile-enabled payments for SHS are gaining widespread usage among microenterprises and households as an option to enhance pro-poor access to the SHS. Indeed, this has enabled off-grid access to energy by growing proportion of the population in rural areas Rehema, "Kenya Emerges as Solar PV Hot Spot"; Muok, Bernard O., Makokha, Willis, and Palit, Debajit, "Solar PV for Enhancing Electricity Access in Kenya: What Polocies Are Required?".

The mobile money payments in Kenya, widely known as M-PESA, builds on the increasing number of households (especially in rural areas) owning mobile phones; approximately of 80% of Kenyans own mobile phones (World Bank, 2016). These enterprises appear to be an acceptable decentralized energy application that can simultaneously address traditional barriers to overcoming energy access (i.e. affordability) and disseminates a climate adaptable RE technology. However, policies supporting its use are severely lacking.

It remains unexplored as to why the GoK has not utilised the continuously growing mobile-enabled PAYG SHS sector in reaching its development goals. The problem that needs to be addressed is how mobile-enabled PAYG SHS can be integrated in to Kenya's wider energy policy as a strategy for simultaneously expanding energy access (and hence spurring pro-poor development) and climate adaptation. This is the question that is explored in this paper. The research presented is concerned with the current obstacles within

[37] Hybrid-mini grids powered through a combination of solar PV, battery storage and thermal units running on diesel Kenya Power, Rural Electrfication Authority, "Kenya Off-Grid Solar Access Project (K-OSAP)."

the Kenyan energy regime to the integration of mobile-enabled SHS sector, as well as the opportunities for partnerships in the future.

b. Energy regulation under a newly devolved government

The role of energy governance is critical across Kenya's energy policies. There is a devolved energy governance established as a result of the two-tier government structure under the 2010 Constitution (see Figure 1). Across Kenya's energy policies, the distribution of functions and powers between the two levels of governments creates two distinct, albeit connected spaces in which PAYG solar services can now operate. This structure informs the governance approaches that could potentially elevate the mobile-enabled PAYG SHS space.

Under this devolved energy governance, the county governments are responsible for developing individual county plans, as well as reticulation of energy services and regulation of said services. Given the barriers to the integration of the mobile-enabled PAYG SHS sector into the national policy regime outlined in the preceding chapter, the autonomy afforded to county government in terms of energy services is a great opportunity for the PAYG enterprises.

5.5 Challenges and emerging opportunities: technical, policy and socio-economic

Despite PAYG business models being innovative technological solutions to pro-poor energy access challenges, their socio-economic transformative impacts remain contested. The greatest barrier that appears within the state-dominated sector is the transmission portion. The integration of mobile-enabled SHS would not only be the merging of private sector into a vertically integrated, state-run sector, but also the integration of decentralized off-grid technology into a largely grid-based centralized system. Converging the two approaches to electricity generation would be challenging and requires extensive consideration. The institutional structure is such that the GoK dominates the electricity market. The implication of such an institutional structure makes the adoption of grid-connected solar energy difficult, let alone the integration of a privately owned and operated decentralized solar energy provider.

As noted in Figure 2 (see Annex IV), there is a minimal amount of diversity in electricity generation including non-state actors. However, the transmission of electricity falls under the responsibility of one state-owned entity (KETRACO). This structure means that PAYG enterprises who provide domestic consumers with the ability to generate and consume electricity within their own households, eliminate the transmission and distribution portions of the electricity networks. The state and the private sector are hence in competition with each other within the sector. This is a major barrier for the integration of off-grid generated electricity in general. The GoK is less incentivized to utilize the private sector to expand modern energy services if it perceives it to undermine their control over the sector.

6. Conclusion and Recommendations

6.1 Conclusion

This study analysed whether PAYG model, a technical innovation for solar home systems, had transformative socio-economic impacts on pro-poor energy access. Through the Transformation Lab process, which included guided group discussions and participatory impact pathways assessment (PIPA), several of key perspectives emerged that dictate how we understand the socioeconomic benefits and transformative impacts of mobile-enabled payments for SHS. These benefits (dictated by each perspective) are economic benefits, poverty reduction, access to renewable energy, Kenya's national development trajectory, climate change adaptation, and the attitudinal transformations towards solar (or similar initiatives).

The first perspective on understanding the impact of mobile-enabled payments for SHS is defined in terms of the practicality of the systems, the empowerments associated with ownerships and acceptability by local communities that results in greater economic inclusion. This perspective can be summed up as the economic benefit of use of mobile-enabled payments for SHS to end users and the greater local communities. Largely this benefit is realized by an increase in the disposable income of end users that is cycled back in to local economies. The second poverty reduction amongst end users. This is a conceptualized transformation that differs from the first in that it is a long-term, sustained reduction in poverty levels of end users. The transformative impact of mobile-enabled payments for SHS in terms of poverty reduction is harder to quantify. We understand this perspective through the narratives provided by end user testimonials.

The third perspective through which the transformative impacts of mobile-enabled payments for SHS are understood is that of sustainability, specifically the increase in access to clean renewable energy. The impact in this particular regard is the result of incentivizing fuel switching, abandoning the use of kerosene and paraffin lamps. The low cost of this switch frames the transformative impact and helps to define mobile-enabled SHS as an economically viable, sustainable and non-harmful form of energy. This perspective was extended in group discussions to some end users for whom use of mobile-enables SHS represented a net gain in electricity that resulted in gaining energy access point blank.

The transformative impacts of mobile-enabled SHS were also assessed through the lens of climate change. This perspective promotes the use of mobile-enabled SHS in low carbon development in the context of local communities, in addition to lowering the carbon footprint at the household level. Viewing the benefits of mobile-enabled SHS through the lens of energy access and climate change mitigation and adaptation feeds into the country's low carbon development trajectory, by tapping into the low-income segment of the Kenyan population whose main activities revolve around household and agro-pastoral activities yet face challenges with access to low emissions energy technologies.

Finally, the attitudinal changes that are promulgated by mobile-enabled SHS define another aspect of its transformative impact. These include the empowerment associated with ownership of the SHS and greater understanding of and engagement with solar technology (and related initiatives) at the community level. Additionally, the impact of mobile-enabled SHS can be understood in terms of end users' critical engagement with the proliferation of energy services and their own experience of gaining energy access.

6.2 Recommendations

The Transformation Lab series provides some recommendations to improve the sustainability and transformative footprint of the mobile-enabled PAYG SHS space. These recommendations can be broadly grouped into three categories: academic, technical and policy-related, and extended into actions that could be taken by national government, county governments, enterprises including but not limited to PAYG models and civil society at large. However, many of the below recommendations centre heavily on multi-sectoral cooperation.

- Academic

There is an opportunity to enhance role of academic institutions in up-scaling the mobile-enabled SHS space. Critical stakeholders and participants in the T-LAB Workshop series called for a greater quantity of data related to mobile-enabled SHS. Academic institutions can help drive the research that needs to be undertaken to quantify and multiply the transformative impacts of PAYG initiatives. One such role could be undertaking research at the household level, specifically investigating the operation of mobile-enabled SHS in correlation with long-term poverty reduction, economic benefits, and social development indicators.

Academic institutions could also play a pivotal role in the sharing of best experiences or practices, and intellectual property amongst critical stakeholders in the space. Knowledge sharing and practical research in coordination with government and private sector actor could aid in understanding the extended benefits of mobile-enabled SHS beyond the basic household needs such as lighting and phone charging

- Technical (focused on the product)

Technical changes to mobile-enabled SHS bundles are recommended in order to adapt to the transformative needs of end users. Expanding the types of SHS bundles available to end users would augment the economic function of these energy services. Tailoring SHSs to context, or linking what is included in an SHS bundle to specific economic need or functions, such as farming or fishing, would scale-up the transformative impact of these systems. Furthermore, these changes would extend economic benefits to the market economies (and beyond the household services that they address currently).

- Policy

Recommendations that concern policy relating to mobile-enabled PAYG SHS were concerned primarily with adjusting and enforcing existing policies, rather than creating new ones. Improvements to the current policy space were generally regarded as a preferable step forward in the T-Lab workshops. Initiative such as K-OSAP can be used to foster partnerships between the private sector and government entities, but adjustments need to make to reduce the tensions and direct competition that are threatened in the policy's current state.

Regular and equitable enforcement of VAT exemptions and FiT schemes for off-grid[38] is also highly recommended. The policy frameworks for successful monitoring, evaluation and growth of the mobile-enabled SHS sector are in place, but need to be ameliorated and adapted to better fit the growing industry.

[38]Ministry of Energy and Petroleum, Republic of Kenya, "Draft National Energy and Petroleum Policy."

Additionally, policy needs to be more inclusive of mobile-enabled SHS specifically in order to best replicate its socioeconomic benefits on a wider scale.

Another facet of policy recommendation involves generally shifting the focus from national policies to county-level government policies in order to better facilitate the incorporation of mobile-enabled SHS initiatives into the energy mix. The potential for partnerships between enterprises like PAYG businesses and county governments in expanding energy access is great, particularly with the drafting of the CIDPs by each of Kenya's 47 counties. The use of mobile-enabled SHS at the county level could replace costlier grid expansion that is not feasible in some locations.

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About ACTS

The African Centre for Technology Studies (ACTS) (www.acts-net.org) is an independent, non-partisan, inter- governmental Pan-African development policy research organization, working to harness applications of science, technology and innovation for accelerated sustainable development in Africa. Founded in ACTS 1988, ACTS remains one of the leading think tanks in Africa globally with a specific mandate to conduct research and policy analysis; to provide technical advisory services; and to undertake capacity building and dissemination of knowledge on applications of science, technology and innovation for sustainable development.

About ASH

The Africa Sustainability Hub (https://steps-centre.org/global/africa/) was launched on 10 June 2015 with a main focus to support social research and capabilities of African researchers, policy makers and change makers to understand and solve some of the underlying social issues affecting the achievement the post-2015 SDGs. The hub is established on a mutual partnership between Africa and UK leading research and policy think tanks on sustainability: the African Centre for Technology Studies (ACTS), the STEPS Centre at the University of Sussex, the Africa Centre of the Stockholm Environment Institute (SEI), and the African Technology Policy Studies Network (ATPS). ASH focuses on enabling sustainable and equitable access to solar PV solutions for all via mobile solar payment systems in Kenya.

About T-Labs

T-Lab is a part of a wider project in six countries around the world, for which ASH focuses on enabling sustainable and equitable access to solar PV solutions for all via mobile solar payment systems in Kenya. Under the ISSC-funded 'Transformative Pathways to Sustainability: Learning across Disciplines, Contexts and Cultures' project, ASH pursued action research on what transformations are associated with mobile enabled payments and how can challenges facing such transformations can be addressed based on co-learning by applying the T-Lab methodology.

Annex I: M-KOPA Payment Scheme

Product Bundle	Devices included in Bundle	Payment plan	Deposit amount	Daily payment	Number of days	Total Price	Cash price
M-KOPA 5 Classic	• 1 8W solar Panel • 1 rechargeable FM/USB radio • 1 control unit with lithium battery • 4x1.2W LED bulbs • 1 5-in-1 phone charge cable • 1 custom charge cable • 1 rechargeable LED torch	Installment	2,999 KES (22.56 GBP)	50 KES (0.38 GBP)	420	23,000 KES (173 GBP)	18,999 KES (142.94 GBP)
M-KOPA 500	• 1 control unit • 1 flat screen digital TV • 1 TV remote control • 1 TV antenna • 1 portable radio • 1 20W solar panel • 3x1.2W LED bulbs • 1 user manual • 1 rechargeable LED torch • 1 custom charge cable • 1 phone charging cable	Low deposit	5,999 KES (45.13 GBP)	100 KES (0.75 GBP)	570	62,999 KES (473.97 GBP)	49,999 KES (376.16 GBP)
		High deposit	7,499 KES (56.42 GBP)	125 KES (0.94 GBP)	380	54,999 KES (413.78 GBP)	49,999 KES (376.16 GBP)
		M-KOPA TV + Zuku	7,499 KES (56.42 GBP)	135 KES (1.02 GBP)	550	81,749 KES (615.03 GBP)	60,999 KES (458.92 GBP)

Table 1. Payment scheme M-KOPA product bundles ("Products," 2014)[39]

[39] All values in Kenyan Shillings (KES) converted to British Pounds (GBP) using Oanda Currency Converter "Currency Converter | Foreign Exchange Rates | OANDA."

Annex II: Policy documents analyzed

Policy/Initiative	Date Published	Access Source
Kenya's INDC to the Paris Agreement	2015	Accessed online
National Climate Change Action Plan	2013	Accessed online
Medium Term Plan 2018-2022 (Vision 2030 Programme)	March 2017	Accessed online
Green Economy Strategy and Implementation Plan (GESIP) 2016-2030	August 2016	Accessed online
Kenya Sustainable Energy for All Initiative (SE4All) Action Agenda (AA)	January 2016	Accessed online
The Energy Act 2015	2015	Accessed online
Draft National Energy Policy	June 2015	Accessed online
Scaling-Up Renewable Energy Program (SREP) Investment Plan for Kenya (2011)	September 2011	Accessed online
Kenya Off-Grid Solar Access Project (K-OSAP)	March 2017	Accessed online

Table 2. List of Policy Documents Analysed

Annex III

	Underserved County	Surface area (km2)	Population	Population density (Pax/km2)	Access rate (%)	
					2009	2014
1	Garissa	45,720	623,060	14	11.6	23
2	Isiolo	23,336	143,294	6	18.5	23.9
3	Kilifi	12,246	1,109,735	91	16.7	20.5
4	Kwale	8,270	649,931	79	10.6	16.2
5	Lamu	6,498	101,539	16	17	19.1
6	Mandera	25,797	1,025,756	40	2.5	17.8
7	Marsabit	66,923	291,166	4	7.5	21.7
8	Narok	17,921	850,920	47	5.9	12.2
9	Samburu	20,182	223,947	11	6.2	15.2
10	Taita Taveta	17,084	284,657	17	15	32.8
11	Tana River	35,376	240,075	7	2.5	3.3
12	Turkana	71,598	855,399	12	2.4	2.7
13	Wajir	55,841	661,941	12	3.4	7.5
14	West Pokot	8,418	512,690	61	2.6	3.3
	Total & Averages	**417,210**	**7,574,110**	**18.2**	**8.7**	
	National	**581,296**	**38,610,097**	**66.4**	**23**	**36**
	% of National	**72%**	**20%**			

Table 3. Overview of Underserved Counties in Kenya Kenya Power, Rural Electrfication Authority, "Kenya Off-Grid Solar Access Project (K-OSAP)."

Annex IV: Kenya's devolved energy governance

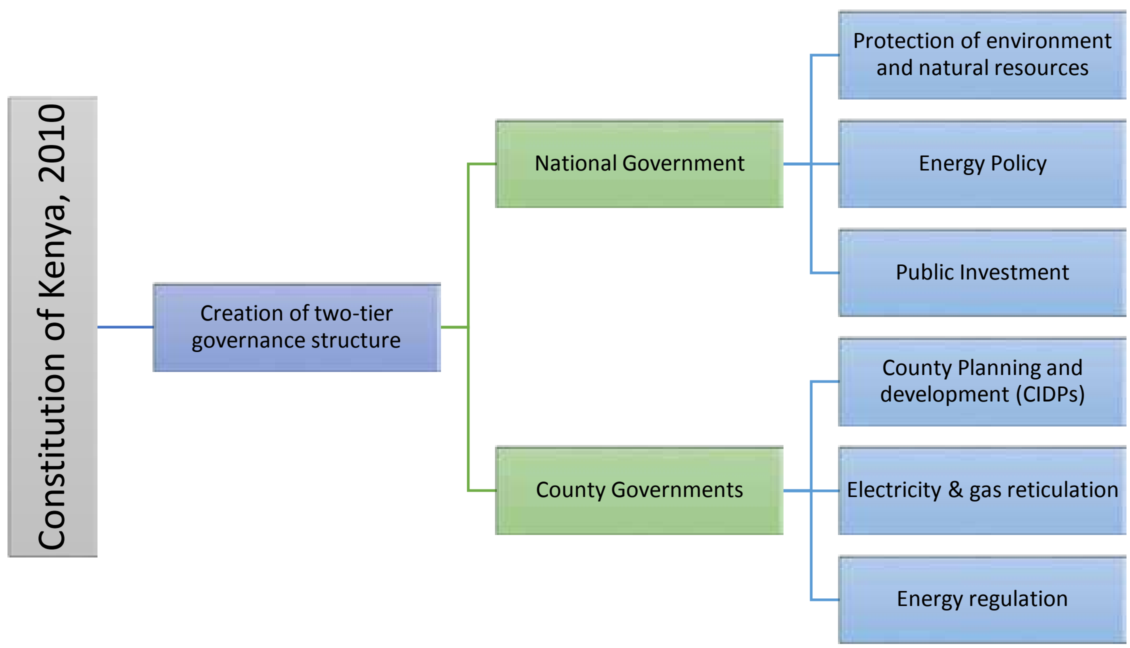

Figure 3. Overview Kenya devolved energy governance, Draft National Energy and Petroleum Policy, Fourth Schedule (2015)

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