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Enabling African Cities for Transformative Energy Access

Benchmarking energy access:

Case studies from five informal settlements in the global south

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Enabling African Cities for Transformative Energy Access

Case Studies: Benchmarking energy access

ICLEI Africa - Local Government for Sustainability

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Author: Mr Kweku Koranteng
Reviewer: Ms Nachi Majoe

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Executive Summary

For decades, governments in developing countries have pioneered energy access programmes established on centralised energy infrastructure. Despite extensive investment in improving grid infrastructure, the impact on electricity access is limited. Recent studies by the International Energy Agency (IEA) suggest that over 565 million people lack access to electricity and an estimated 894 million people in Africa do not have access to clean cooking solutions. The health impact of cooking with polluting fuels means increased risk of respiratory diseases to households.

To address the electricity access challenge by 2030 will require an estimated annual investment of about £20.69 billion in electricity infrastructure for on-grid and off-grid access and a yearly investment of about £1.45 billion for clean cooking solutions. These funds cannot come from the public sector alone. It is essential to establish new partnerships and collaborations that provide access to private, institutional and household finance. These new partnerships and collaboration require critical insights that combine the right technological innovation, community engagements, finance mechanisms, business models, research and development (R&D) and policy frameworks to unlock the multiple benefits that low-carbon, sustainable energy services offer.

This document provides a synopsis of five case studies from Kisumu - Kenya, Stellenbosch - South Africa, Dzivarasekwa Harare-Zimbabwe, New Delhi – India, and Dar es Salaam – Tanzania. These case studies highlight partnerships and collaboration in the delivery of sustainable energy services in the Global South. These case studies serve to share lessons and benchmarking for the Enabling African Cities for Transformative Energy Access (ENACT) project. ENACT's aim is to create a conducive environment that promotes energy security in Africa's ever-growing urban informal settlements, to support local governments in engaging with the private sector to deliver sustainable energy services to households and micro-enterprises – for both cooking and lighting.

Finding opportunities in problems: the unfolding tales of three renewable energy companies in Kisumu County, Kenya. A draft Sustainable Energy Policy of Kisumu County, has enabled an environment that supports partnerships and collaboration leading to a market-driven solution on clean cooking and solar systems. Notably, three market-led solar providers have been at the forefront of this innovation curve, demonstrating their capability through R&D in deploying solar systems in the county – Azuri, M-Kopa, and Mobisol. The Pay-As-You-Go (PAYG) service developed on MPESA's platform is synonymous with fintech innovation in Africa and standard payment for Solar Home Systems (SHSs) in the county.

People, Practice and Policy: The triple (P) powers for energising informal settlement in South Africa. A Public-Private Partnership (PPP) through the iShack project has unlocked government electricity subsidies, i.e., Free Basic Electricity (FBE), to support the adoption

of SHSs in Enkanini. The iShack case is an example of a government partnership with the private sector to unlock the full potential of renewable energy services for an informal community in the Stellenbosch Municipality.

Defying the odds in Dzivarasekwa: A community-based approach to energy access in Zimbabwe. A community-based renewable energy approach established through a coalition of consortium called "the Alliance", in partnership with the City of Harare, has addressed energy access challenges in Dzivarasekwa Extension of Harare. The women-led savings group established through continual engagement has gradually evolved into an avenue for promoting low-carbon, renewable and clean-energy products. This established social foundation now serves as a platform for community-led development initiatives. As famously expressed by the federation, "use what you have to access what you need."

The phases to phase mission, made possible through a transformative national solar policy programme of India. Insights from the Indian National Solar Mission (NSM) suggest that renewable energy industries require government interventions and private sector investment to bring down operational costs. Despite the challenge of developing a market-led approach, private-sector innovations in solar-powered systems in education, forestry management, and primary health care exceeded the expectations set out in the NSM. For example, Phase-II targeted 20 GW, surpassing this figure by 2018 ahead of the 2022 deadline. Due to this achievement, a more ambitious target of 100 GW has been rolled out for 2022. Under the NSM, the Ujala scheme has also led to energy savings of over 5,000 MW and emission reduction of greenhouse gases (GHG) by 79 million tonnes of CO_2.

Cooking in the cloud: An innovative technological approach to clean cooking adoption in Tanzania. KopaGas brought its proof-of-concept to market and has since its establishment in 2014 connected over 1,300 low-income households to LPG-fuelled clean cooking, impacting 6,500 lives. The KopaGas Pay-as-you-Cook service has removed affordability barriers to clean cooking fuel for low-income households. The benefit of this innovation is its impact on the cylinder turnover ratio, which is the number of times a cylinder is refilled and used in one year - 8.6 times compared to industry standards of 4 times a year in Tanzania. From this pilot project in Dar es Salaam, where only 5% of the population use LPG, households using KopaGas have reported households saving as much as 30% on fuel compared to charcoal and firewood.

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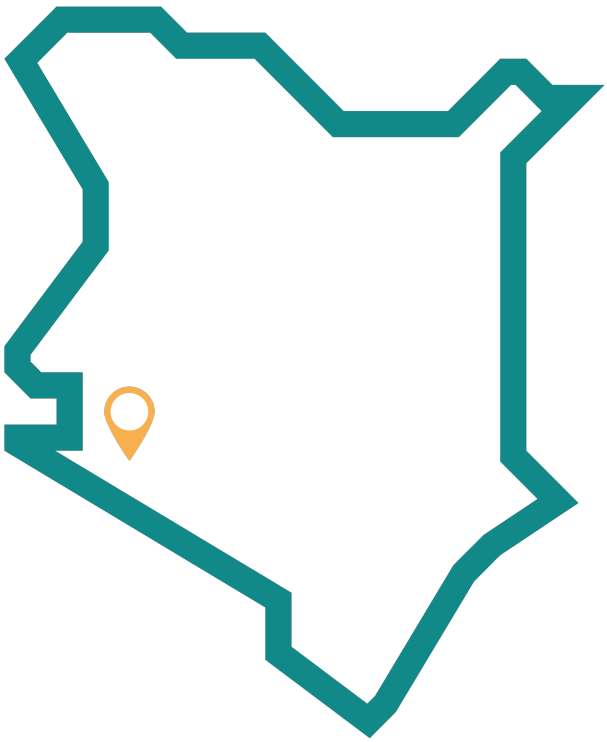
List of Acronyms

CBO	Community-Based Organisation
CERC	Central Electricity Regulatory Commission
DC	Direct Current
DOST	Dialogue on Shelter Trust
FBE	Free Basic Electricity
GHG	Greenhouse Gas
GSMA	Global System for Mobile Communications (Association)
GW	Gigawatts
GWh	Gigawatts per hour
ICT	Information Communication Technology
IoT	Internet of Things
IREDA	Indian Renewable Energy Development Agency
LPG	Liquefied Petroleum Gas
M2M	Machine to Machine
NBFC	Non-Banking Financial Company
PAYC	Pay-as-you-Cook™
PAYG	Pay-As-You-Go
SACCO	Savings and Credit Co-operative
SDI	Slum/Shack Dwellers International
SE4All	Sustainable Energy for All
SMS	Short Messaging Service
SSS	Specialised Solar System
SDGs	Sustainable Development Goals
W	Watts
Wp	Watt-peak
ZHPF	Zimbabwe Homeless People's Federation

1 Finding opportunities in problems: the unfolding tales of three renewable energy companies in Kisumu County, Kenya



Kisumu County, Kenya

Population	1,155,574
Providers	M-Kopa; Mobisol and Azuri
Technology	Off-grid systems (Solar Home Systems and lighting)
Emerging themes	Inclusive finance model, innovative technological model, beyond energy access models, market-led models

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1 Introduction

The draft 2019 Kisumu County Sustainable Energy Policy seeks to create an enabling environment to partner with the private sector to implement clean cooking, energy-efficient systems, and solar systems. The objective of the policy is to enhance access to affordable and reliable electricity to 70% of the population by the end of 2017 and universal access by 2020. The county is at the forefront of modern, clean cooking solutions for households, contributing to a marked increase in the uptake of briquettes, biogas and ethanol. Yet only half of the county's population is grid-connected, creating opportunities for renewable energy companies such as Azuri, M-Kopa, and Mobisol to offer energy solutions to bridge the county's electricity access gap.

Sections 1.1 to 1.4 below explain the five-core dimension attributed to the success of Azuri, M-Kopa, and Mobisol: these are the private sector innovation, finance and market-led model, technological model and access beyond energy provision as shown in image II below.

1.1 Overview of innovative private sector companies

Since 2012, renewable energy companies such as Azuri, M-Kopa, and Mobisol have collectively contributed to improving energy access through innovative technology and inclusive financing mechanisms in Kisumu County and beyond though offering their solar products and services across the county.

Azuri delivers affordable solar home systems on a commercial scale to customers in 12 countries in sub-Saharan Africa. The company has sold more than 150,000 systems to more than 750,000 beneficiaries and customers spanning three east African countries - Kenya, Uganda, and Tanzania. The company plans to bridge the digital and services gap between urban and rural communities through clean energy products and services.

Established in 2011, M-Kopa combines the power of digital micropayments with Internet-of-Things (IoT) connectivity to enable access to funds in the provision of solar systems. The aim of M-Kopa is to improve lives by providing affordable solutions through connected asset financing[1] to thousands of unbanked customers to gain access to life-enhancing products and services. With access to over $400 million (£299.53 million) funds, the services offered by M-Kopa include access to solar lighting, energy-efficient televisions and fridges, smartphones, and cash loans. In Image I below, an M-Kopa stand at a solar exhibition is shown.

[1] Pay-As-You-Go service connected to fintech services such as mobile money payment systems to service fees and charges.

Image I: Former USA President Obama visits an M-Kopa stand at a solar exhibition (Source: M-Kopa website)

Mobisol was established in 2010 to improve access to affordable energy systems and services to its customers in rural communities across six countries. Mobisol installed over 800,000 SHSs for households and small businesses to improve lives and stimulate economic activities in underserved, off-grid rural communities in sub-Saharan Africa, with an emission savings of over 80,000 tonnes of CO_2 emissions each year.

These three companies have operated in Kenya for almost a decade providing various renewable energy products and packages for low-income households, underserved and remote communities. Renewable energy solutions such as SHSs and clean cooking options provide immediate financial savings compared to expensive kerosene and batteries, not to mention the significant environmental impact and the potential effect on consumers' physical health. Azuri has around 150,000 customers, M-Kopa over 250,000, and Mobisol over 800,000.

1.2 Finance and market-led model

As illustrated in Image II below, a finance model points to the funding streams and regimes established to support an intervention. In this market-led model, market research identifies customer requirements before a product or service is released. These market-led solutions offer low-income households an opportunity to redefine and reimagine how they could access energy at the household level. For example, M-Kopa pioneered and kick-started the wider pay-as-you-go (PAYG) solar market; they use a combination of pay-as-you-go and flexible payment schemes, particularly for households who cannot afford an upfront, lump-sum payment.

Image II: Innovative dimensions of solar systems (Source: Adapted from Pay-As-You-Go Model (IRENA, 2020)

M-Kopa's core innovation lies with its business model that's been developed to make it affordable for its customers. "Kopa" means "to borrow" in Swahili, and each system the company sells is in effect a loan of about $165 (£123). Clients pay $35 (£26) upfront and agree to make a daily payment of $0.45 (£0.34) for a year, after which they own the system.

Azuri's Quad Solar Home System provides a complete household lighting package for as little as $0.50 (£0.37) per day. The Mobisol SHS is a large integrated home and business-level energy system with a solar panel, battery, power electronics, appliances, and pay-as-you-go functionality. The monthly instalment fee in Kenya is between $18 (£13) to approximately $54 (£40), depending on the system configuration purchased. Costs and pricing plans vary for other markets, including the option to pay in cash upfront for a cash discount.

Mobisol reduces the total package price in certain situations if the customer completes repayments within one to two years. The system supports payments through multiple mobile money platforms in the target countries, including M-Pesa, Tigo Pesa, Airtel Money, and MTN Mobile Money.

1.3 Technological model

The technological solution involves people, processes, information, and technologies in systems to support a set of business or technical functionalities that solve one or more business problems.

M-Kopa provides this solution by providing households with access to SHS, lighting system, and charging points for mobile devices. The SHS comes with a control box that contains the battery and a SIM card that can communicate with M-Kopa headquarters in Nairobi. As illustrated in Image III below, when a customer makes a payment via a mobile phone, the SIM card sends a signal to activate the batteries. The company also offers

customers energy-efficient appliances and an opportunity to build a credit record that improves long-term socio-economic status.

Azuri's product comes with four powerful LED lights, a rechargeable radio, torch, and mobile phone charging point. Once service providers fully recover the costs of the SHS, all the energy generated is free. Additionally, for customers who wish to upgrade their SHS, AzuriTV provides a 24-inch super slim LED TV, which comes with over 100 satellite TV and radio channels. Azuri (SHS) features HomeSmart, the company's unique machine-learning technology that ensures customers have 'light all night' by monitoring climatic conditions that adapt to customers' lighting and usage needs.

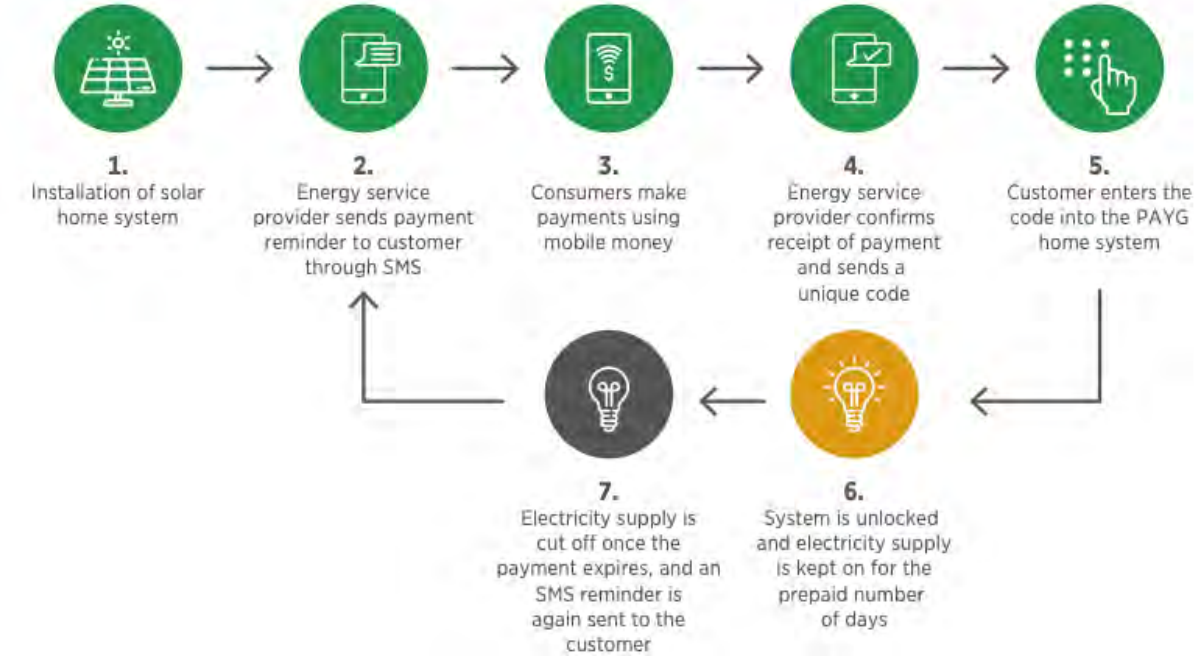

Image III: The Pay-As-You-Go operational model (Source: IRENA, (2020))

1.4 Beyond energy access

Azuri is in partnership with leading consumer brands that provide rural off-grid consumers with a choice of modern services and devices available through its pay-as-you-go solar solutions. For example, Azuri HospiCash, in partnership with APA Insurance, offers services that include income cover and life insurance, exclusively designed for off-grid customers at a small premium.

Azuri and Unilever partnered to offer free Sunlight washing powder with every Azuri Quad SHS. This promotion has further enhanced Azuri's vision of creating a level playing field, where all consumers can access and benefit from the digital economy. The secondary

benefits include household savings, economic inclusion enabled through flexible and affordable credit, credit history building, and consumer confidence.

1.5 Lessons learnt

In an industry study by Acumen in 2017, nearly 60% off-grid solar customers undertook more economic activity within just three months of purchasing a SHS by either gaining a new job, using their system directly within a business, or working for longer. The study reported that business customers kept their businesses open for an extended period, which meant they could earn more. Light at night also helped families to spend more time together and children could study for longer periods at home.

Service spiral is where a consumer moves up a product line, from an entry-level product to a more extensive product with more services. For example, customers who purchased entry-level products that offer lighting, a rechargeable torch and rechargeable radio could pay for that product over time, typically 18 months. Experience showed that awareness and ease of use of the system served were the motivational drivers for the continual upgrade of the service and products.

In the last quarter of 2019, Azuri went a step further by launching an off-grid solar centre, endorsed at the highest level by the County Government of Kisumu's Ministry of Energy and Industrialization. The Chief Officer for the Department of Energy and Industrialization, Eng. Daniel Okia noted:

"*The launch of the Azuri off-grid solar centre in Kisumu brought modern devices and services to our residents while addressing the challenge of energy access.*"

The centre unveiled the latest solar home solutions for customers to view and test technologies, extending further to offer customer support, servicing and repairs. Such innovations have shown tremendous potential to improve households and individual livelihoods.

1.6 Key insights

There are significant long-term benefits that come from being connected via solar-powered radios, TVs and mobile phones. These benefits include access to digital technologies, political engagement, and nurturing entrepreneurial ambitions. Household benefits also included savings on income, economic inclusion, and consumer confidence. These three companies have shown that combining technological and financial innovative models could provide instant access to products while building ownership over time through flexible micro-payments that could address energy access challenges in underserved settlements in Africa.

2 People, Practice and Policy: The triple (P) powers for energising informal settlement in South Africa

Enkanini, Stellenbosch, Western Cape – South Africa

Installations	1,700 units
Funding	ZAR 17 million (Approximately £9.8 million)
Emerging themes	Social enterprise model, blended finance model, social learning model, agile technological model

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2 Introduction

Informal settlements dominate cities across Africa; the World Bank's recent data shows that 70% of the urban population in Africa live in informal settlements. This further worsens the already precarious service delivery situation in urban areas. One such example is Enkanini, an informal settlement located at the periphery of Stellenbosch, with over 3,500 shacks and home to over 176,543 inhabitants. Image IV below shows solar-fitted rooftops in the Enkanini informal settlement.

Image IV: Rooftops of the informal (slum) settlement of Enkanini (iShack website)

Due to limited land access, many urban dwellers in South Africa live in informal settlements, with little to no essential utility services. The informal zoned (or un-zoned) land can take municipalities up to ten years to re-zone, and formalise such settlements. The organic expansion and rapid growth of such urban informal settlements make it difficult and expensive to install formal infrastructure. Settlements without legal services are driven to access 'free' electricity from the grid in illegal, informal and often dangerous ways.

Considering the constraining conditions in Enkanini, a group of transdisciplinary researchers from the Sustainability Institute in Stellenbosch launched a community engagement process in 2010. Their question was: "While residents of informal settlements wait for state-provision of conventional service delivery, what options are available in the interim?" After two years of applied research in Enkanini, iShack, a social enterprise, was established in 2012.

The iShack system is a concrete demonstration of an off-grid community-based renewable energy alternative. The first non-grid system enabled energy users to access the Free Basic Electricity (FBE) subsidy in an informal urban settlement. The first step in

the project was to gain access to government funds via the Green Fund, which provides energy services within an informal settlement with no legal occupancy. iShack's enterprise model has improved energy access to over 1,700 households. The model continues to evolve in the last decade through applied research alongside continual iterative learning, technological agility and blended financing.

Sections 2.1 to 2.4 below explain the four core models that made the iShack project successful: these are the social enterprise, blended finance, social innovation, and agile technology models.

2.1 Social enterprise model

The Social enterprise model of iShack projects is to improve electricity access to underserved communities. It is principled on non-extractive profit, and funded through a blend of financing options such as subsidies, grants and household contributions. The service delivery model had low barriers to entry, as systems installed required no upfront subscription fees. The monthly rental fee included free use of the system, a TV, LED lights, cell-phone charging capability, and access to a maintenance service. The system had an additional configuration of a sim-card payment system, which enabled the system's remote management.

2.2 Blended finance model

The blended finance model of the iShack project began with grant funding from the Bill and Melinda Gates Foundation that assisted with the installation of the first twenty "improved shacks" (iShacks)[2] in Enkanini in 2011 - well insulated, north-facing, and fitted with solar panels. After the successful pilot project in late 2013, the Green Fund, managed by the Development Bank of South Africa (DBSA), granted the project an additional ZAR 17 million (approximately £9.8 million) at a zero-interest loan to roll out another 1,500 systems in Enkanini.

"Help-To-Buy" is a social innovation model through iShack's new pilot project in 2017 in Siqalo, a new informal settlement. The absence of subsidy funding from the City of Cape Town prompted this different financial model ('Help-To-Buy'). iShack, in partnership with the community, developed the scheme to help residents buy the SHS over twenty-four months, paying off the cost in affordable monthly instalments.

"From our point of view, this is where a local government has an incredible opportunity to make a meaningful contribution to the 'Just Energy Transition' since it is precisely these

[2] The iShack's original business model was to experiment and improve conditions in shacks, hence the name iShack (improved shack). It took an incrementalist approach of continual improvement on every aspect and energy access was one key component of that process.

members of society (living in un-electrified informal settlements) who are most in need of the 'free-basic electricity' subsidy" Director of iShack, **Damian Conway (2020)**"

2.3 Social innovation model

The contractual relationship, established on a robust social agreement (the "Help-To-Buy" is offered on a 'no bad-debt' basis) thus includes elements of a social innovation model. Before the launch of the project, iShack researchers spent considerable time with residents and community leaders in Siqalo to engage and explore the idea of a community fund - the "Help-To-Buy" scheme (see Image V below). The scheme is a sustainable financial model for households to access off-grid energy services as the community wait for grid-electrification.

The early adopters agreed to volunteer as 'Solar Captains' and subsequently recruited new clients into their respective teams. These Solar Captains helped disseminate information (technical and financial) and they mediate if team members are late with their payments. This loose social process, which relies mainly on clear upfront communication and induction of new clients, has worked relatively well in the model's 100-household pilot stage. The unresolved cases of payment defaults have been less than 5%.

2.4 Agile technological model

The agile technological model was established on the notion of continual adjustment of systems to address anticipated and expected needs. Despite the challenges of the initial system, some benefits came with the search for alternative solutions. These included further technical innovation, assessment of the financial model, and an alternative system provider. The result was a smaller system in terms of capacity, that could provide similar energy utility levels but with more sophisticated control and remote-monitoring functionality—a DC SHS with 50-75Wp photovoltaic panels, and standard lead-acid battery.

The new system (see Image V below) is self-contained, with a tamper-proof functionality, and an enabled remote monitoring functionality. The data of each SHS can be analysed remotely, allowing for remote disconnection of non-compliant households. The battery storage supports three to four LED lights, low-energy media devices such as a small TV, radio, or music system, and cell phone charging.


Image V: Community engagement on the left and the second technology system installed (iShack website)

2.5 Lessons learnt

With the initial home system, residents signed up voluntarily, and joining rates reached 100 residents per month. However, when maintenance problems started escalating, especially with the introduction of TVs and when batteries approached their end of life, some clients began to tamper with the systems by bypassing the switch functionality. However, providing an affordable scheme to enable clients to buy new batteries is another strategy that has mitigated this service challenge.

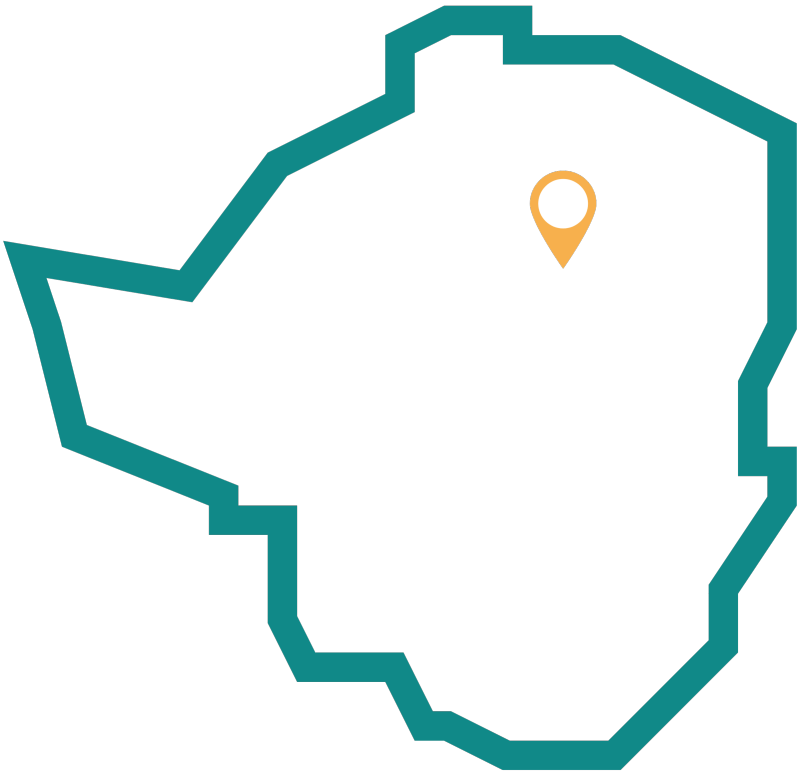
Monitoring battery life and performance is an integral part of off-grid utility management. Assessing a battery's life-cycle is a complex task under real-world conditions; this is worsened by client tampering which further threatens a battery's life.

2.6 Key insights

The Enkanini iShack project has inspired replication in two informal settlements: Siqalo-Philippi and Longlands-Lynedoch (Stellenbosch). iShack continues to develop mechanisms and processes, often made possible by managing systems through the adoption of Information Communication Technology (ICT) and client-management applications to improve payment compliance. With blended funding model from the Melinda and Bill Gates Foundation, the Green Fund, and affordable payment schemes from households, with local government subsidies. The case study also highlights an innovative social learning model that explores viable solutions through rigorous community-level learning and sustained engagement—powered by an agile technological model that allows for the continual reconfiguration of systems to improve customer experience.

3

Defying the odds in Dzivarasekwa: A community-based approach to energy access in Zimbabwe



Dzivarasekwa Extension, Harare – Zimbabwe

Population	69,824
Technology	Solar Home System (SHS)
Units installed	651
Emerging theme	Social learning, co-operative savings (revolving fund), CBO consortium management model

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3 Introduction

Community-based Organisations (CBOs) such as the Dialogue on Shelter Trust (DOST), the Zimbabwe Homeless People's Federation (ZHPF), and Shack/Slum Dwellers International (SDI) are some of the organisations at the forefront of transforming energy access. In Zimbabwe, CBOs formed a consortium called the Alliance and partnered with the City of Harare to provide SHSs to households. The objective of the Alliance is to improve households' energy access, and simultaneously leverage the SHS implementation capacity to lobby the government to improve other essential services such as water and sanitation. This was the first time the city authorities collaborated with informal communities in this way.

Image VI: Installed SHS in Dzivarasekwa Extension: ICCCAD3 (2020)

Dzivarasekwa Extension is a former transit camp of 480 unelectrified households established in 1991 on Harare's periphery. Following the devastating shack fires in 2014, the SHS project was launched in 2016 and is currently upgrading the settlement through the Alliance's support. The Alliance helped the community to acquire knowledge on low-carbon energy alternatives such as Improved Cookstoves (ICS) and SHSs. Through a series of demonstration workshops, the community had an opportunity to assess a wide array of clean energy products. This resulted in most products being rejected, and narrowed down the options to two SHSs. These options were financed through a specially established loan scheme which was a finance mechanism for households to purchase the system. Community members were involved in every stage of project development,

[3] International Centre for Climate Change and Development (ICCCAD) is one of the leading research and capacity-building organisations working on climate change and development in Bangladesh.

including co-designing, co-producing solutions, information dissemination, installations and maintenance.

The project was established as a separate business or legal entity, but personnel from the Alliance's respective organisations endorsed the project to provide financial, technical, and operational oversight, as well as capacity and support. Also, central to the implementation plan, community members received training in all technical aspects of the project. A team of 21 members was established; comprising 3 mobilisers, 15 technicians, 3 loan officers, and a Gungano Urban Poor Fund representative.

Two main models were used in this project, a financial model and a combination of a technological innovation model and capacity building model, as explained below.

3.1 Financial model

The 'Federation Model'[4], championed by SDI, was adopted to mobilise residents via savings groups. It provided a horizontal accountable support platform that allowed for repayment of group loans—no interest charged on the loans and no overall profit margin. Vetted individuals from the community could secure a loan and become members of the Community Savings Group (minimum 20 members). Households were incentivised with more favourable loan terms and could join a 'Solidarity Loan Group' (minimum five members). A 'revolving fund' principle guided the repayment model to the fund. Although each participant signed a contract, there was room for flexible repayment in unpredictable circumstances. For example, in response to hyperinflation in 2007-2008, the fund allowed repayments in building materials instead of cash. The project encouraged women-led savings and loan groups and has generally found this a practical approach, where delayed payments per month have been under 5%.

Another condition was that eligible savings groups had to demonstrate their managerial and organisational capacity. The group had to have a savings-scheme constitution and consistency in savings, and conduct regular minuted meetings with an attendance register. Also, group members paid a 50% lower joining deposit; if the group had enough savings to cover at least a month's instalment per group member—this instalment was held in trust in the event of a default. The system had a mark-up on the unit cost that covers installation and other costs. Loan officers received a 5% commission on all collections. As a last resort, the loan contract contained a clause that stipulates repossession of a system in the case of repeated payment failure.

3.2 Technological innovation and capacity building model

The project offered two different SHS solutions, a 6 Wp system that powers three lights and a cell phone charger, and a 200 Wp 'entertainment' system that can power a radio, TV or computer, cell phone charger, and up to 10 lights. The entertainment system's price

[4] Patel S, Burra S, & D'Cruz C. 2001.

included an extra margin to cross-subsidise the 6 Wp system. The ratio of 6 Wp systems to 200 Wp systems is approximately 15:1.

In terms of capacity building, trained community members are engaged as technicians to scope, install, repair, and maintain the solar systems. They also educate new users on how to use the system. Installers received a flat fee per installation, in addition to informal maintenance and repairs sought after by private households. Although the Alliance coordinated the technicians, and manages and monitors them through the Alliance's structures, the project did not employ them permanently.

3.3 Lessons learned

Limited capital investment constrains the scale and extent of replication of a model. Without a profit or loan-finance return, it is challenging to attract scaling capital beyond 'demonstration' grants. Consequently, it is also daunting to provide a steady stock-flow without a high growth rate, so households must often wait many weeks before installing systems. Also, project operations cost is financed from non-recoverable grants rather than a cost loan facility, making it unsustainable.

Despite the SHS effectively being priced very low, the government's lack of subsidy support means that most households' barrier to entry remains high. Thus, even at the current demonstration scale, the model is unlikely to provide universal access within a single community. Nevertheless, some financial and operational deficiencies may constitute more fundamental obstacles to the current model's scalability.

Notwithstanding the promising efforts to support informal 'green-economy' entrepreneurship, there is no security of income or employment for the technicians. The model's current form at best provides a modest side-income for a few people in the medium term. The project's durability as a longer-term energy service (instead of a more direct SHS sales and installation service) is limited. The project does not have an energy-service business plan, and the operational personnel have been seconded from and paid for by partner organisations. Operating systems, record-keeping and data management procedures, and policies for dealing with clients (as long-term energy clients) are limited. Thus, responses to complaints are often slow and day-to-day operations can be inefficient or inconsistent. Project supervisors have observed poor communication between the technicians. There is also no plan in place to assist clients with replacing faulty components or periodically exchanging batteries.

The Alliance is now replicating the Dzivarasekwa model in five other settlements in three Zimbabwean cities. The national target is 1,325 households, and 651 have accessed the SHS loan scheme so far. Like the iShack Project experience, there have been various policy and operational changes to the model in response to the initial inevitable set-backs. However, the deliberately flexible adaptive approach taken by the Alliance partners has enabled practical and incremental improvements to the model over time.

3.4 Key insights

Out of over 480 households in Dzivarasekwa, approximately a quarter signed up for the loan scheme and 85% via the Solidarity Loan Group. Early signs show that group loans have been very successful in terms of repayment compliance. Since 2016, the roll-out showed that 95% of all payments had been complied to monthly. Hence, there has not been the need to reschedule loans or repossess items.

The group's regular meetings have become a revolving avenue for promoting low-carbon, renewable and clean energy products and services. However, the meetings aim to mitigate loan defaults from its savings and loans programme. The social structures and rituals provide a basis for further community-led development initiatives.

4 The phases to phase mission, made possible through a transformative national solar policy programme of India

New Dehli, India

Population	1.353 billion
Technology	Solar PV (rooftop) grid-connected, solar stand-alone
Units installed	20GW of installed solar systems
Emerging themes	Financial and cost implications; energy security and operational implications

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4 Introduction

Globally, national governments are leading efforts to reduce carbon emissions through low-carbon initiatives. According to the International Energy Agency, in 2000, there were 152 renewable energy-related policies globally, and this number rose to 2,449 in 2020. India is one of the top-tier countries with policies focused on renewable energy, low-carbon, and clean energy strategies to decarbonise its energy sector. These policies are at national and sub-national levels (cities, provinces) and linked to specific initiatives and programmes such as the National Solar Mission (NSM), an example of which can be seen in Image VII below.

Image VII: Solar panel installations (NSM) (The Economic Times, 2020)

Alongside policies, market-driven initiatives, programmes such as Ujala, established in 2010, have strong policy support from the government. It is an example of a self-sustaining government initiative that has surpassed traditional benefits for energy savings and reduced carbon emissions. The policy has also attracted large-scale investments into the manufacturing of LED bulbs, employment creation, and other macro benefits—for example, the affordable "LEDs for All" initiative launched in 2015 under the Ujala scheme. The scheme is to replace over 200 million ordinary light bulbs with LED bulbs. The initiative resulted in over 5,000 MW energy savings and reduced greenhouse gas emissions (GHGs), namely 79 million tonnes of carbon dioxide.

As one of the eight missions under India's National Action Plan for Climate Change (NAPCC), the Government of India launched the Jawaharlal Nehru National Solar Mission (hereafter JNNSM or the National Solar Mission) in November 2009 (it officially took off in January 2010). It now boasts a target of 100 GW of solar PV by 2022. The mission has three phases, Phase I (2010–2013), Phase II (2013–17), and Phase III (2017–2022), each with different target achievements. The mission also has other goals such as promoting R&D, providing public information, developing trained human resources for the solar

industry, and expanding the scope and coverage of earlier incentives for industries to set up solar photovoltaic (PV) manufacturing in India. For various reasons, this mission has garnered much attention and inspired fully-fledged research while simultaneously impacting the country's innovation ecosystem. The sections below discuss the financial, energy security and operational implications, to Off-grid opportunity for the poor under the NSM.

4.1 Financial and cost implications

The cost savings on solar PV systems make it highly competitive compared to other power generation sources, such as coal, gas, crude oil, and even hydro-power. The NSM's objective is to create a rapid scale-up of capacity and technological innovation to drive down costs compared to grid-electricity. The NSM aims to achieve grid parity[5] by 2022 and parity with coal-based thermal power by 2030 but recognises that this cost trajectory depends on the scale of global deployment and technology development and transfer. The NSM recognises that there are several off-grid solar applications, mainly to meet rural energy needs which are already cost-effective and provide for their rapid expansion.

Today, domestic coal-based power generation is the cheapest electricity source in India. Future scenarios suggest that this could change. Already faced with crippling electricity shortages, the price of electricity traded internally touched $0.095 (£0.071) per unit for base loads and around $0.12 (£0.090) per unit during peak periods. The situation could also change as the country moves towards imported coal to meet its energy demand. The price of power also considers the availability of coal in international markets and the cost of developing imported infrastructure. It is also evident that as the cost of environmental degradation is factored into the mining of coal, as it must, the price of coal is likely to increase. In the event of energy shortages, the country is increasing the use of diesel-based electricity, which is both expensive – costs as high as $0.16 (£0.12) per unit - and environmentally unsustainable. In these likely events, using solar energy becomes urgent and feasible to enable the country to meet its long-term energy needs.

The critical consideration is to find an optimum financial strategy that pays for the high initial costs of these applications through appropriate government support. Currently, market-based and micro-credit-based schemes have achieved limited penetration in this segment. In this quest, the government has promoted decentralised applications through financial incentives and promotional schemes. The policy promotes solar systems for lighting in remote tribal settlements without access to grid electricity, supporting them with subsidies to the tune of 90%. The subsidy and the demand generated is leveraged to achieve indigenisation and lower prices through the scale effect. Connected villages via

[5] Grid parity (or socket parity) occurs when an alternative energy source can generate power at a levelized cost of electricity (LCOE) that is less than or equal to the price of power from the electricity grid. The term is most commonly used when discussing renewable energy sources, notably solar power and wind power (Deutsch and Berényi 2020).

solar systems have been made possible by promoting market-led approaches that have unlocked finances at the national level to enable banks to offer low-cost credit to households.

To create a sustained interest within the banking community, the NSM proposes to provide a soft refinance facility through Indian Renewable Energy Development Agency (IREDA), for which the government provided budgetary support. IREDA would, in turn, provide refinance to Non-Banking Financial Companies (NBFCs) and banks with the condition that it is on-lent to the consumer at rates of interest not more than 5%. The policy provides an annual tranche to refinance operations for 10 years. At the end of the period, the funds would be paid back to IREDA as capital and revenue grants for on-lending to future renewable energy projects.

The NSM considers up to a 30% capital subsidy (which progressively declines over time) to promote innovative solar energy applications and structures, a non-distorting framework to support entrepreneurship, up-scaling, and innovation.

4.2 Energy security and operational implications

The rapid scalability of solar PV makes it possible for easy deployment. Endowed with vast solar energy potential, about 5,000 trillion kWh per year, energy is incident over India's land area, with most parts receiving 4-7 kWh per sq. m per day. Hence both technology routes for the conversion of solar radiation into heat and electricity. These include solar thermal and solar photovoltaics that could provide effective solar energy use in India. Solar also provides the ability to generate power on a distributed basis and enables rapid capacity addition with short lead times. Off-grid decentralised and low-temperature applications could be advantageous from a rural electrification perspective and meet other energy needs for power, heating and cooling in rural and urban areas. The constraint on scalability could be the availability of space, since in all current applications solar power is space-intensive. Also, without adequate storage, solar power is characterised by a high degree of variability. In India, this would be particularly true in the monsoon season.

Solar is the most secure energy of all due to it being abundantly available. Theoretically, a small fraction of the total incident solar energy (if captured effectively) can meet the entire country's power requirements, including the large proportion of the underserved population in the country.

4.3 Off-grid opportunity for the poor and unserved

A key opportunity for solar power lies in decentralised and off-grid applications. In remote and far-flung areas where grid penetration is neither feasible nor cost-effective, solar energy applications are cost-effective. They ensure that people with no access to light and power move directly to solar, leap-frogging the fossil fuel growth trajectory. While the

solar policy has set a target of 1,000 MW by 2017, which may appear small, it intends to bring change to millions of households. The strategy from 2017 planned to;

- Provide lighting systems under the ongoing remote village electrification programme of the Ministry of New and Renewable Energy (MNRE) to cover about 10,000 villages and hamlets.
- Set up stand-alone rural solar power plants in unique category states and remote and challenging, hard-to-reach areas such as Lakshadweep, Andaman & Nicobar Islands, the Ladakh region of Jammu, Kashmir, and other border areas.

The policy has promoted other off-grid solar applications, including hybrid systems to meet power, heating, and cooling requirements. These solar industries still require government interventions and private sector investment to bring down operational costs, despite the challenge of enabling a framework to develop market-led approaches by the private sector. There is evidence of private-sector innovations in solar energy systems that could power computers to assist learning in schools and hostels, and evidence of Information Systems (IS) used to assist in the management of forests. In Madhya Pradesh, solar systems are used to power milk chilling plants in Gujarat, to empower women Self Help Groups (SHGs) involved in "tussar" (yarn) reeling in Jharkhand, and in cold chain management for Primary Health Centres (PHCs).

4.4 Key insights

Innovation in the renewable energy ecosystem has made it possible to regulate the industry. These policies apply to R&D technical support institutions, financial institutions, non-governmental organisations (NGOs), and business enterprises in manufacturing solar systems.

During the implementation of Phase I (2010-13) of NSM, there was enthusiastic participation from Indian and international investors. The grid-connected segment had substantial discounts to the benchmark tariffs determined by the Central Electricity Regulatory Commission (CERC) on the 500-megawatt (MW) solar thermal and solar photovoltaic (PV) projects. The bundling of solar power with cheaper conventional power reduced solar power's tariff impact on the distribution utilities.

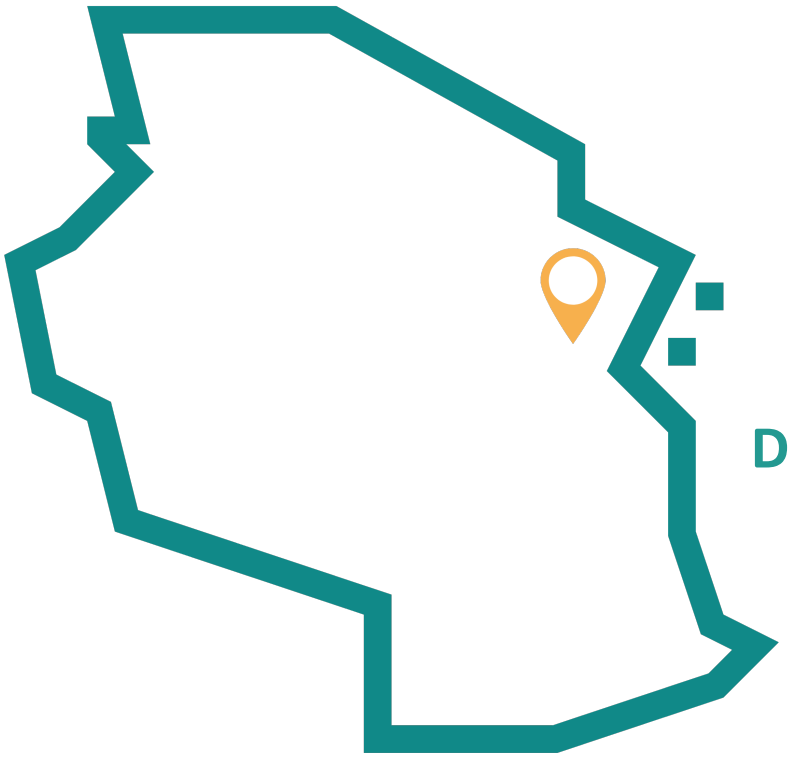
Another unique feature of NSM Phase I was adopting a reverse auction method for awarding projects to qualified bidders. The bidding process fully realised the benefits of declining module prices in the global market and declining demand in critical economies, which led to surplus supply in the international market. The levelled tariffs discovered through the competitive process have been far lower than the CERC benchmark tariffs. The average levelled tariffs have also declined between the two batches in Phase I, from $0.20 (£0.15) per (kWh) to US$0.15 (£0.11) per (kWh). These have made India amongst the lowest cost destinations for grid-connected solar PV in the world. In addition to the competitive solar energy pricing, the pace of added solar capacity has also been

remarkable. In three years, solar power's total installed capacity has increased from around 30 MW to more than 2,000 MW, with NSM contributing around 500 MW of that capacity.

In the NSM Phase II, the mission identifies the need for international support in technology transfer and financial assistance to meet its higher goals. Large-scale expansion of grid-connected solar power is its main target. However, further investment in research and strengthening the innovation ecosystem could drastically improve India's comparative advantage. The targeted 20 GW increased to 100 GW by 2022 in India's 2015 Union Budget, was surpassed in 2018.

5

Cooking in the cloud: An innovative technological approach to clean cooking adoption in Tanzania



Dar es Salaam - Tanzania

Population	6,702,000
Technology	Clean cooking – metered LPG system
Units installed	148 households and 2 small-scale businesses
Emerging themes	Innovative technical business and financial model

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5 Introduction

The Sustainable Development Goals (SDGs) calls for universal access to affordable, reliable, sustainable, and modern energy by 2030. Approximately 2.3 billion people globally do not have access to clean cooking fuels.[6] Interventions in clean energy, low-carbon energy solutions must be scaled up significantly to support these goals, with the proper cost-benefit analysis needed urgently. Traditional cost-benefit analyses often leave out the health benefits in the calculation. There are no reliable estimates of the health benefits of adopting clean energy, therefore total benefits are underestimated. Traditional cooking fuels such as firewood and kerosene (see Image IV below) are sources of indoor air pollution in developing countries, resulting in millions of premature deaths.[7]

Image VIII: Indoor cooking with firewood (KopaGas website)

To improve access and tackle this challenge, the Mobile for Development utility programme of the Global System for Mobile Communications Association (GSMA) received support from the government of the United Kingdom in 2015 to pilot the KopaGas project in Dar es Salaam, Tanzania. The project has deployed next-generation Liquid Petroleum Gas (LPG) canister meters. This system is equipped with machine-to-machine (M2M) technology, enabling medium and low-income households to switch away from dirty and expensive charcoal. The business model eliminates upfront costs and allows households to pre-pay for gas quantities that fit their budget, improving

[6]World Bank, 2018.
[7]Institute of Health Metrics and Evaluation, 2016.

households' financial planning. The Pay-as-you-Cook referred to in this pilot, has improved access to clean cooking fuel.

5.1 Overview of the financial and business model

The GSMA Mobile for Development Utilities Programme awarded an Innovation Fund grant to KopaGas to design a low-cost meter for LPG canisters and test a Pay-As-You-Go (PAYG) cooking gas service, which inspired the KopaGas Pay-as-you-Cook service. KopaGas subsequently partnered with Oryx Energies, a leading LPG distributor in sub-Saharan Africa, to source and distribute gas canisters in Dar es Salaam. The project began with 5 customers as a trial in December 2016 and rolled out the service to 148 households and 2 businesses by August 2017. Only 5% of Tanzanian households use LPG consistently. About $60 (£44.66) to $100 (£74.43) is required to invest in a gas cylinder, stove, and accessories, which is roughly equivalent to 20 to 30 days of income for a household living on less than $3.10 (£2.31) per person per day. The refilling costs for a full cylinder represent an additional seven to 15 days of income.

For the PAYC service, KopaGas designed a smart meter on household gas cylinders. KopaGas aimed to deploy a PAYC service model for customers who cannot meet the upfront expense and refilling costs so that they can afford clean cooking gas for as little as $0.45 (£0.33) per day. The PAYC service included cylinder delivery to the customer's home.

KopaGas recruited PAYC customers (households) for the pilot project from a women's savings and credit cooperative (SACCO). The SACCO served as an avenue to mobilise women and create awareness of the system through demonstrations and seminars. Households paid $4.50 (£3.35) to register and an optional $9.00 (£6.70) for a stove sold on commission by the SACCO. The smart meter, gas cylinder, and unsold portion of gas remained the property of KopaGas, while customers had access to the LPG content.

5.2 Technological model

The PAYC service uses mobile money and GSM machine-to-machine (M2M) connectivity. Households pay via mobile money, specifically Vodacom's M-Pesa, for gas purchases. Payment information from the mobile money platform to the KopaGas cloud servers then updates the smart meter in real time using GSM M2M connectivity.

The smart meter uses SMS to communicate over the mobile network with the KopaGas cloud servers, see Image IX below. KopaGas initially chose SMS for M2M connectivity to develop an easy communication protocol that allowed its field staff to help debug and improve workflows and the user interface.

Image IX: Metered KopaGas (GSMA 2018)

The meters periodically relay information on gas consumption, cylinder usage, and battery levels, and have an anti-tampering safety functionality. When a cylinder is nearly empty (as measured by the meter), the meter generates a message prompting KopaGas staff to deliver a full cylinder. An update of credit information is given via mobile money payment. The meter display shows the time, gas remaining (GR), credit available (CR), battery level (BL), and volume of gas used (VU). KopaGas technicians send a message to unlock the meter via the mobile app to open the meters. This message is relayed to the cloud and eventually to the meter, giving swap gas canisters access. The smart meters are battery-powered, and when the battery levels are low, SMS alerts customers for immediate recharge. A fully charged battery lasts for approximately two months in a typical duty cycle.

In addition to these mobile-specific functionalities, KopaGas developed a mobile app for drivers at its traditional gas distribution centre. The app allows KopaGas to map its distribution routes and use drivers to collect payments from non-PAYG customers. KopaGas thus makes extensive use of mobile technology throughout its business processes as illustrated in Image X below.

5.3 Lessons learnt

The mobile money-based PAYC service led to the diversion of cooking fuel expenditures from cash paid for charcoal to mobile money paid for LPG.

In the baseline survey[8], 27.5% of respondents did not use mobile money for service and utility payments. 71% of customers had previously used charcoal or firewood for cooking, which they paid for in cash. Throughout the pilot, all active customers only lacked access to gas one day out of the month and purchased gas through mobile money every five days on average.

The PAYC service leverages M2M data to create a better user experience and a sound business model. The information on gas consumption is collected by the meters and transmitted via GSM M2M. KopaGas set up processes to replace empty cylinders within a day, leading to an enhanced user experience. Users have also managed to cut costs of transporting cylinders which add to the cost of using gas for cooking. Thus, it increased profits and made it an attractive model for companies like Oryx Energies.

The PAYC service uses gender-specific marketing and distribution to target women. 98% of KopaGas customers are women. By working with women-led SACCOs, KopaGas can shift the marketing, training, and pre-sales responsibilities to the savings group's entrepreneurial women. Another benefit was that all customers belong to SACCO, which made distribution and post-sales support cost-effective. The female technician received more calls and a higher rating than the other two male technicians. KopaGas plans to develop the technical skills of their female staff to serve their predominantly female customer base.

The PAYC service removes affordability barriers to clean cooking fuel for low-income households. An Acumen survey in 2018 found 48% of households lived below the poverty line of $3.10 (£2.31) per person per day, and 96% of KopaGas customers saved an average of $2.92 (£2.17) per week on cooking fuel. For an equivalent amount of cooking, LPG can be up to 30% cheaper than charcoal, especially for low-income households that make small daily purchases of gas. In Dar es Salaam, the typical household spends more than $30 (£22.33) per month on charcoal. Ninety-eight per cent (89%) of respondents consider the KopaGas service very good or good value for money, and 63% reported their quality of life had "very much improved." The survey also revealed that customers valued the time savings of cooking with gas compared to charcoal or firewood.[9]

5.4 Key insights

The PAYC service leverages M2M data to create a better user experience and a sound business model. A significant benefit of the M2M data is its impact on the cylinder

[8] GSMA (2018)

[9] Acumen Invests in Innovative Clean Cooking Solution 2018 report - https://acumen.org/blog/acumen-invests-in-innovative-clean-cooking-kopagas/

turnover ratio or the number of times a cylinder is refilled and used in one year. The ratio measures the efficiency of distribution; thus, how distributors manage the cylinder inventory affects the profit linked to gas consumption.

The PAYC service uses gender-specific marketing and distributes to targeted women who constitute over 98% of the customer base. The study also showed that female technicians received more calls and a higher rating than the male technicians. The PAYC service removes affordability barriers to clean cooking fuel for low-income households, making LPG 30% cheaper than traditional cooking fuels.

KopaGas' innovation is revolutionary, not because it utilises clean cooking methods, but because it makes cooking gas affordable through the PAYC system. KopaGas is already gaining early financial support from the Acumen Fund, Saisan Co. Ltd., and DEG / KFW. In January 2020, the UK-based holding company, Circle Gas Limited, acquired KopaGas' PAYC technology. The company aims to replicate the pilot and expand on access to technology across sub-Saharan Africa, where 900 million people have yet to transition to modern and clean cooking fuels.

References

Acumen. 2017. An Evidence Review: How affordable is off-grid energy access in Africa? Available: https://acumen.org/wp-content/uploads/2017/07/Evidence-Review-On-Affordability.pdf

Acumen. 2018. Acumen Invests in Innovative Clean Cooking Solution. Available: https://acumen.org/blog/acumen-invests-in-innovative-clean-cooking-kopagas/

Azuri. 2020. Company Profile. Available: https://www.azuri-group.com/ Accessed 14th December 2020.

Conway D, Robinson B, Mudimu P, Chitekwe T, Koranteng K & Swilling M. 2019. Exploring hybrid models for universal access to basic solar energy services in informal settlements: Case studies from South Africa and Zimbabwe. *Energy Research & Social Science*, 56, 101202.

GSMA (2018) KopaGas Mobile-enabled Pay-as-you-Cook™ service in Tanzania: https://www.gsma.com/mobilefordevelopment/m4dutilities/

The Economic Times of India. 2020. Jawaharlal Nehru National Solar Mission https://economictimes.indiatimes.com/topic/jawaharlal-nehru-national-solar-mission/news/3?from=mdrICLEIAfrica. 2020. 100% Renewable Energy for Cities & Regions in Kenya. *Unpublished report* https://africa.iclei.org/project/towards-100-re/

IEA. 2020. Dataset on renewable energy policies in India. Accessed 13 December 2020.

IEA, IRENA, UNSD, World Bank, WHO. 2020. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution-NonCommercial 3.0 IGO (CC BY-NC 3.0 IGO).

Institute of Health Metrics and Evaluation. 2016. Global Burden of Disease (GBDx) Data Tool. Available: http://ghdx.healthdata.org/gbd-results-tool. Accessed 13 December 2018.

IRENA. 2015. Africa 2030: a roadmap for a renewable energy future. Available https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_Africa_2030_REmap_2015_low-res.pdf

Nikolett Deutsch, László Berényi. 2020. Economic potentials of community-shared solar plants from the utility-side of the meter – A Hungarian case, The Electricity Journal, Volume 33, Issue 8,2020,106826, ISSN 1040-6190,

M-KOPA Solar. 2020. Company Profile. Available: https://m-kopa.com/ Accessed 14 December 2020.

Mobisol Kenya. 2020. Company Profile. Available: https://www.mobisolkenya.co.ke/ Accessed 14 December 2020.

Patel S, Burra S & D'Cruz C. 2001. Slum/Shack Dwellers International (SDI) - foundations to treetops. *Environ. Urban*. Vol. 13 (2), p45–59. Available: https://doi.org/10.1177/

Singh A & Krishna V. 2017. Exploring the Jawaharlal Nehru National Solar Mission (JNNSM): Impact on innovation ecosystem in India. *African Journal of Science, Technology, Innovation, and Development*. No. 9, p1-13. 10.1080/20421338.2017.1359466.

United Nations. 2018. "World Urbanization Prospects: The 2018 Edition". Available: https://population.un.org/wup/

World Bank. 2018. SDG7 Tracking: The Energy Progress Report. Available: https://www.worldbank.org/en/news/press-release/2018/05/02/sustainable-development-goal-sdg-7-global-progress-report Accessed 13 December 2020.