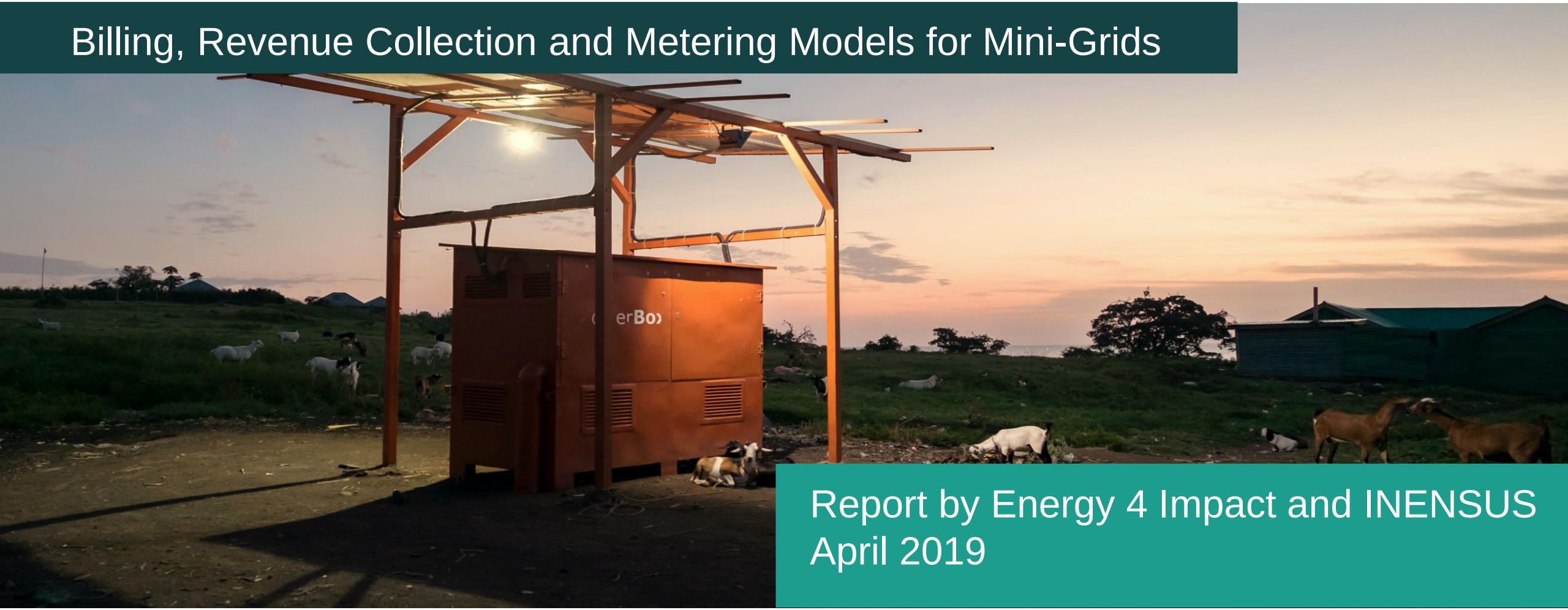
GREEN MINI-GRID HELP DESK

Billing, Revenue Collection and Metering Models for Mini-Grids



Report by Energy 4 Impact and INENSUS
April 2019

ENERGY4IMPACT
ACCELERATING ACCESS TO ENERGY

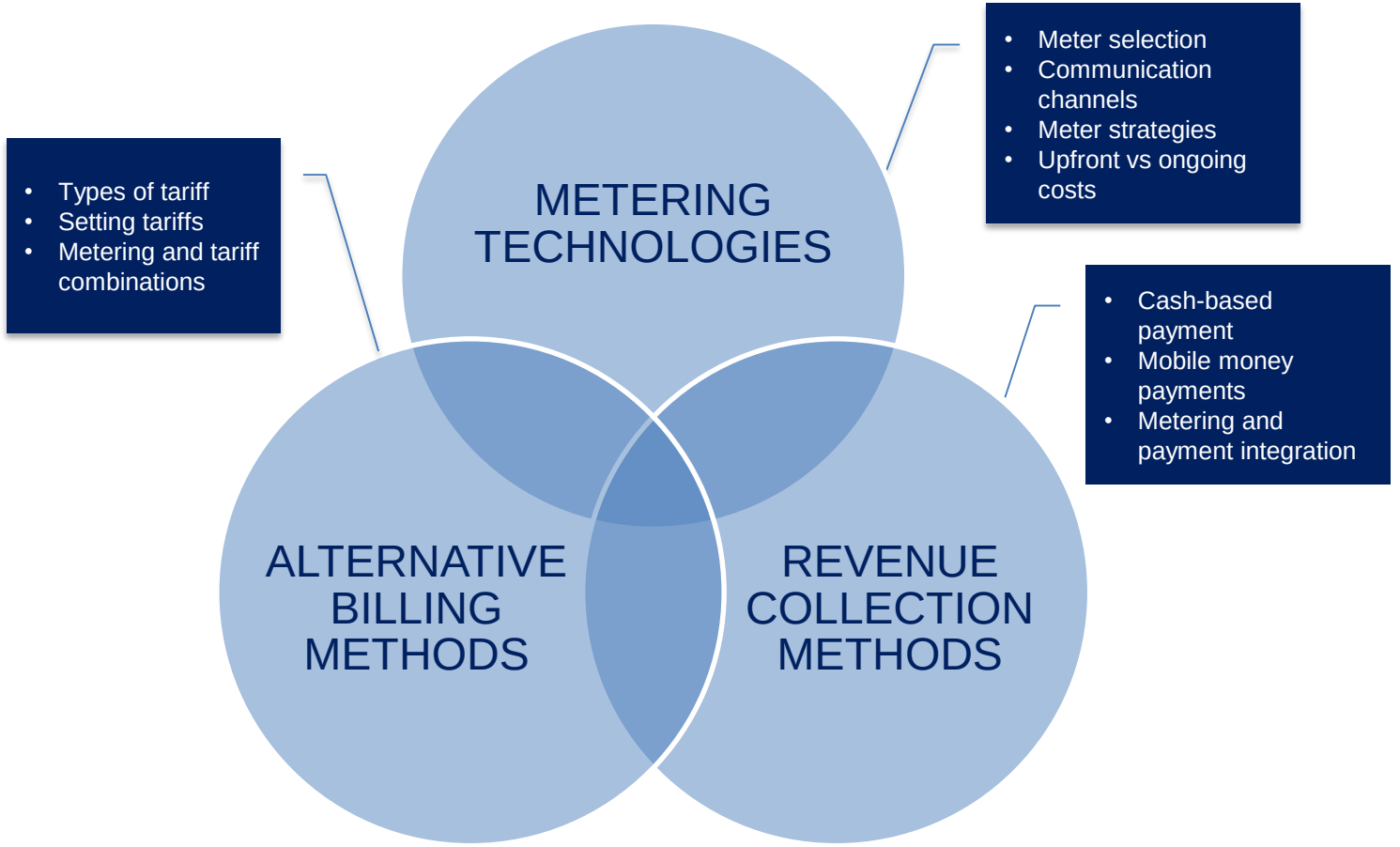
INENSUS

SUSTAINABLE ENERGY FUND FOR AFRICA

CONTENTS

EXECUTIVE SUMMARY

- One of the key success factors in any mini-grid is to have a proper customer billing system and revenue collection mechanism.
- It is important to choose the right pricing and tariff structure, to use an appropriate payment technology and, depending on the business model, to find a suitable metering solution.
- This report describes the pros and cons of different billing and revenue collection models, including the application of pay-as-you-go technology, and includes the results of a survey of 16 mini-grid operators in Sub Saharan Africa (SSA).
- The report is targeted at private mini-grid developers operating in SSA, but can be a useful document for all mini-grid stakeholders.



INTRODUCTION

- **Objective of report:** Provide overview of main mini-grid billing, payment collection and metering models, including the pros and cons of each.
- **Background:** Produced by Energy 4 Impact and Inensus (the “Help Desk) under the Green Mini-Grid Market Development Programme for the African Development Bank (AFDB) – Business Development Services and Policy Support Business Lines.
- **Target audience:** Mini-grid operators in SSA and other interested mini-grid stakeholders.

AUTHORS

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- Peter Weston of Energy 4 Impact edited and oversaw the report

Energy 4 Impact is a UK-registered non-profit organization which seeks to reduce poverty through accelerated access to energy, providing technical, commercial and financing advice to off-grid energy businesses in Sub Saharan Africa, including over 100 mini-grid developers.

Energy 4 Impact provides support on the ground to these businesses in the form of pilots for new technologies and business models and mentorship services for micro-enterprises. Supported by a small head office in London, most of Energy 4 Impact's staff are based out of its offices in Kenya, Tanzania, Rwanda and Senegal.

Energy 4 Impact has operated in Africa for the past 12 years and delivers results. The NGO's efforts have supported the growth of 4700 businesses, resulting in 17 million people gaining better access to energy, 10000 jobs, and 12.8 million tonnes of CO2 being abated. The capital raised by those businesses with our support has amounted to $135 million.

INENSUS is a mini-grid expert providing holistic technical, business and policy expertise based in West and East Africa. Its clients include private and public mini-grid project developers, international development organizations and financiers, and governments in the target countries.

INENSUS provides consulting and engineering services that cover all aspects related to solar-hybrid mini-grids for rural electrification. INENSUS has been in operation since 2005 and is headquartered in Goslar, Germany. The combination of consulting and engineering expertise makes INENSUS a unique "one-stop shop" for mini-grids and decentralized renewable energy systems.

Its expertise results from working as a mini-grid investor, developer and operator for more than 10 years in Senegal (through its joint venture ENERSA Energie Rurale Sahélienne S.A) and more than 5 years in Tanzania (through its joint venture JUMEME Rural Power Supply Limited).

METHODOLOGY

- Interviews with 16 mini-grid operators across 7 SSA countries with a total of 34 sites. See list of operators in Annex 2.
- Literature review - published articles, company and governmental websites, case studies and academic papers. See Bibliography.
- Authors' own observations and experience as a developer and provider of technical assistance to over 100 mini-grid developers and policy makers.
- This presentation is divided into 3 sections: metering technologies, revenue collection methods, and billing methods.

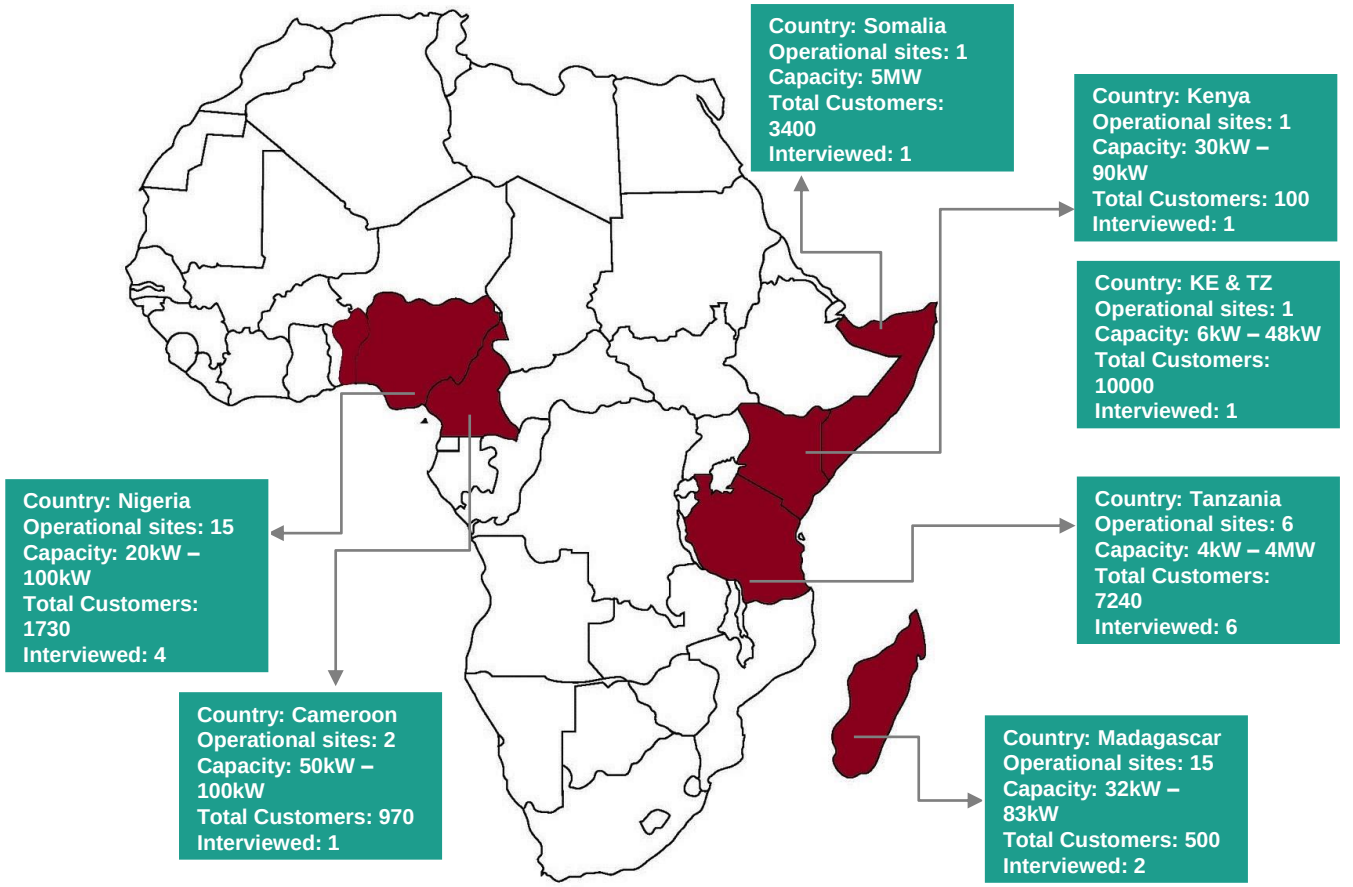

Figure 1: Summary of mini-grid operators interviewed

METERING TECHNOLOGIES

METERING TECHNOLOGIES

Meter Technologies

- **Meter purpose:**
  - Measures electric energy consumed.
  - Track electricity usage for billing.

- **Meter technology:**
  - Conventional (post-paid or pre-paid meters).
  - Smart meter.

- **Key determinants for meter purchases:**
  - Payment model – pre-paid or post-paid.
  - Visibility on energy consumption data.
  - Cost of meter.

- **Smart meters:** most popular meter type among developers interviewed.

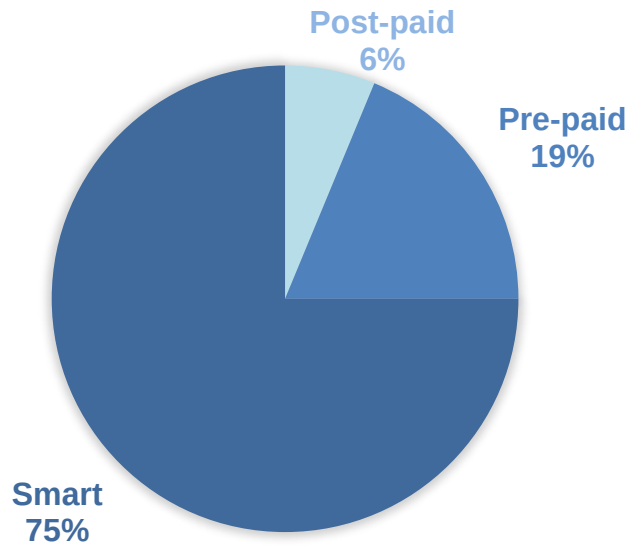

Figure 2: Type of meters used by mini-grid operators
Source: Authors' interviews

Smart meters are becoming increasingly popular *"because their prices have reduced considerably in the last few years, and the level of communication technology has improved significantly." Source: PowerGen*

METERING TECHNOLOGIES

Meter Types

- **Post-paid meter**
  - Measure current monetary or energy balance.
- **Pre-paid meter**
  - Measure amount of electricity consumed.
  - Use tokens/codes for energy recharging.
- **Smart meter**
  - Measure and communicate payment and consumption data without manual intervention.
  - Allow for remote monitoring, operation and maintenance of mini-grid sites.

Meter Type	Post-paid Meter	Pre-paid Meter	Smart Meter
Energy Consumption	Unrestricted	Based on kWh purchased	Based on kWh purchased
Meter Communication	None*	Transmits data to remote platform only	Transmits and receives data on remote platform
Billing Method	Payment for kWh consumed over previous period	Upfront payment for kWh	Upfront payment for kWh

Post-paid meters neither transmit nor receive data from remote platforms however, additional hardware can enable transmission*

Table 1: Summary of key meter features

METERING TECHNOLOGIES

Meter Types

Meter Type	Pros	Cons
Post-paid meter	+ Cheapest of the three metering options. + Robust and locally available. + No user-training required. + Not dependent on local mobile network.	- No real-time monitoring possible. - Meter readings recorded manually. - Vulnerable to electricity theft as remote detection is impossible. - Risk of low payment collection rate.
Pre-paid meter	+ Not dependent on local mobile network (for cash-based systems), but mobile money can be integrated. + Inexpensive compared to smart meters. + Offers customers flexible payment options.	- No real-time monitoring possible. - User training required. - Distribution of scratch cards is costly and time-intensive. - Installation complex to ensure ease of access for users.
Smart meter	+ Real time monitoring and analytics. + Ability to control remotely. + Predictive load analysis and demand growth forecasting. + Availability of ancillary services e.g. demand management.	- Dependent on mobile network. - Expensive compared to conventional meters. - Ongoing transaction fees to use proprietary software services. - External data storage leads to risks of privacy breaches or data mishandling.

Table 2: Pros and cons of meter types

METERING TECHNOLOGIES

Communication Channels

- **Radio Frequencies (RF) Mesh Network:** Highly reliable. Can stay operational even when a node* breaks down.
- **Long Range (LoRA) network:** Meters able to communicate without being in clear line of sight of each other.
- **Other communication channels:**
  - Power Line Communication (at higher frequency than power)
  - Data Cable along Power Line
  - GSM network.
- **Protocols:** System of rules that allow two or more entities of a communications system to transmit data. Used in small, low cost energy devices. ZigBee one of the most widely used protocols.
- No single standardised communication technology for mini-grids exists.
- 1 in 4 mini-grid operators interviewed had no communication channel setup.

*A network node is a connection point that can receive, create, store or send data along distributed network routes. Individual meters act as nodes in such setups.

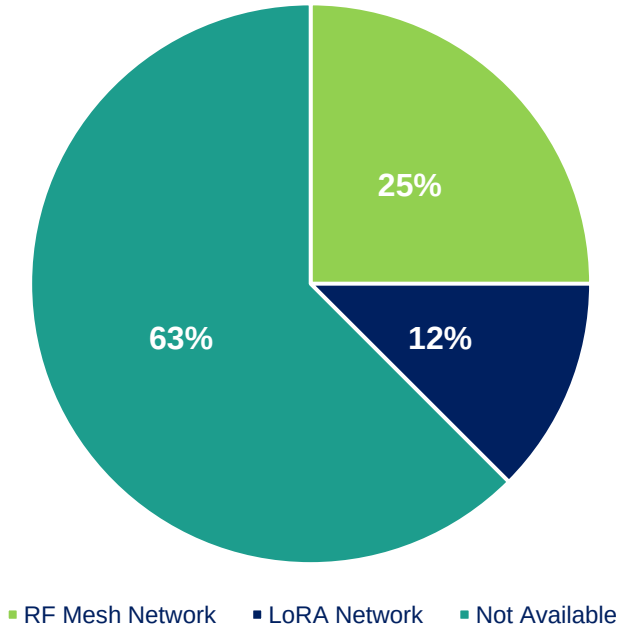

Figure 3: Metering communication channels used by mini-grid operators
Source: Authors' interviews

METERING TECHNOLOGIES

Communication Channels

Communication channel	Pros	Cons
LoRa network	+ No need for meters to be installed in a clear line of sight for communication. + Can handle long distances between server and furthest meter – up to 7km** + Low power requirements.	- Expensive. - Issues around reliability of communication.
Radio Frequencies Mesh Network (Zigbee, Z-wave)	+ Highly reliable. Can stay operational even when a node breaks down.	- Depends on strong and reliable communication infrastructure.
GSM network	+ Does not require multi-point infrastructure.	- Most expensive option because each meter has to contain a SIM card and use data/SMS.
Power line communication	+ Lower cost because data uses the existing power cable. Data uses higher frequency than power.	- Not suitable for transmission of large quantities of data. - Can only handle short distance between server and furthest meter – usually not beyond 700m* - Data signal can be affected by power signal due to electromagnetism.
Data cable along power line	+ No need for mobile network on site, so higher reliability.	- Higher capex costs - each line contains two cables (power and data).

Table 3: Pros and cons of communication channels

*Landis+Gyr, 2012 **Performance Evaluation of LoRa, 2018

METERING TECHNOLOGIES

Metering Strategies

- Mini-grid operators have adopted different business models around meters, but no standard model has emerged yet
- Most install meters from a single supplier.
- Some install meters from multiple suppliers e.g. PowerGen.
- Some manufacture or assemble their own meters to allow for customisation e.g. Devergy.
- Some invest in meter hardware and develop their own software and administration platform in-house e.g Jumeme.

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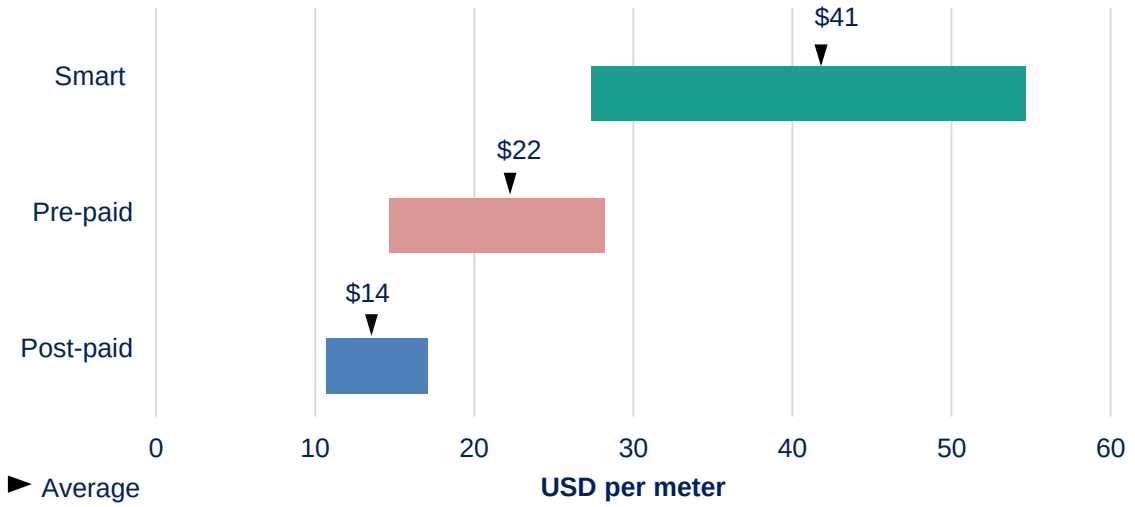
METERING TECHNOLOGIES

Pricing of Technology

- **Meter pricing:** of 12 meter providers analysed, the cost per installed meter ranged from $11 to $55.
- **Meter upfront costs:** comprises meter and ancillary equipment (hardware), installation cost.
- **Meter ongoing costs:** comprises software usage licence, administration usage licence, mini-grid performance fee and technical support.



Average is mid point of costs for different meter types*

Figure 4: Costs of installed meters by meter type
Source: Authors' interviews

METERING TECHNOLOGIES

Metering Costs – Upfront and Ongoing Costs

- **Hardware costs for meter and ancillary equipment:** vary based on meter type, supplier and country of operation (import duties, taxes). Expected lifespan of meter is 15 to 20 years, though meters may become redundant before this.
- **Installation costs:** vary based on meter type, communication channel and labour costs. Some meters can be installed by those with basic electrician training, while others are more complex.
- **Usage licence fee:** software fee depends on total number of meters purchased. Usually between 5% to 20% of initial hardware costs per year. Administration fee may be for entire system or specific features.
- **Technical support:** charge for technical support may be fixed for pre-defined services or paid on demand.
- **Performance fee:** fee depends on mini-grid size, number of meters and country of operation.

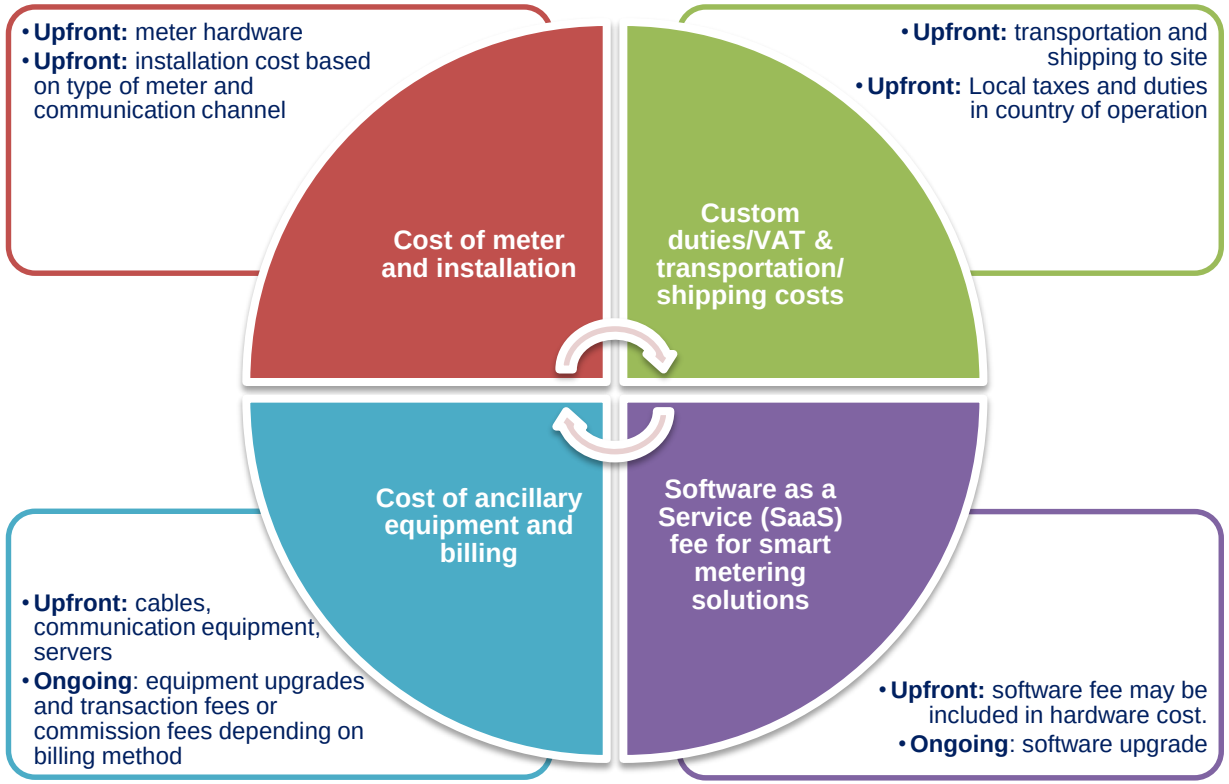


Figure 5: Upfront versus ongoing costs of meters

METERING TECHNOLOGIES

Metering Cost Components

Cost component	Description
Cost of meter ex works	Fixed cost.
Cost of shipping to site	Variable depending on site location.
Customs duty and VAT	Variable depending on country of operation.
SaaS fee for smart metering solutions	Variable depending on total number of meters, usually has a fixed cost component and the total cost is between 5 to 20% of the initial hardware costs per year.
Cost of ancillary equipment incl. servers, communication equipment, cables	Mostly fixed cost per site.
Cost for installation	Depends on meter type and communication channel but differences are generally small.
Ongoing maintenance	Variable per month/year depending on the meter type, can be significant for smart meters and their ancillary equipment which may require upgrades.
Ongoing operations	Conventional (post-paid) meters require physical meter readings to be carried out.
Transaction charges	Transaction charges for payments based on number of transactions. Mobile money fees for smart meters. Salary costs and/or commissions for local sales agents required for conventional meters.

Table 4: Metering cost components

CASE STUDY 1

Keeping Metering Options Open

PowerGen (PG) is an AC mini-grid developer and operator. PG operates its own mini-grids in Kenya and Tanzania and also installs mini-grids for other developers under an engineering, procurement and construction (EPC) model. PG owns a large workshop in Nairobi where the company builds generation units.

PG does not tie itself to a single meter provider or technology, but selects different providers eg SparkMeter and SteamaCo based on individual project requirements.

PG utilises a custom-built administration platform called *AMini* and other third-party tools as their backend software that gives them the flexibility to use different metering technologies.

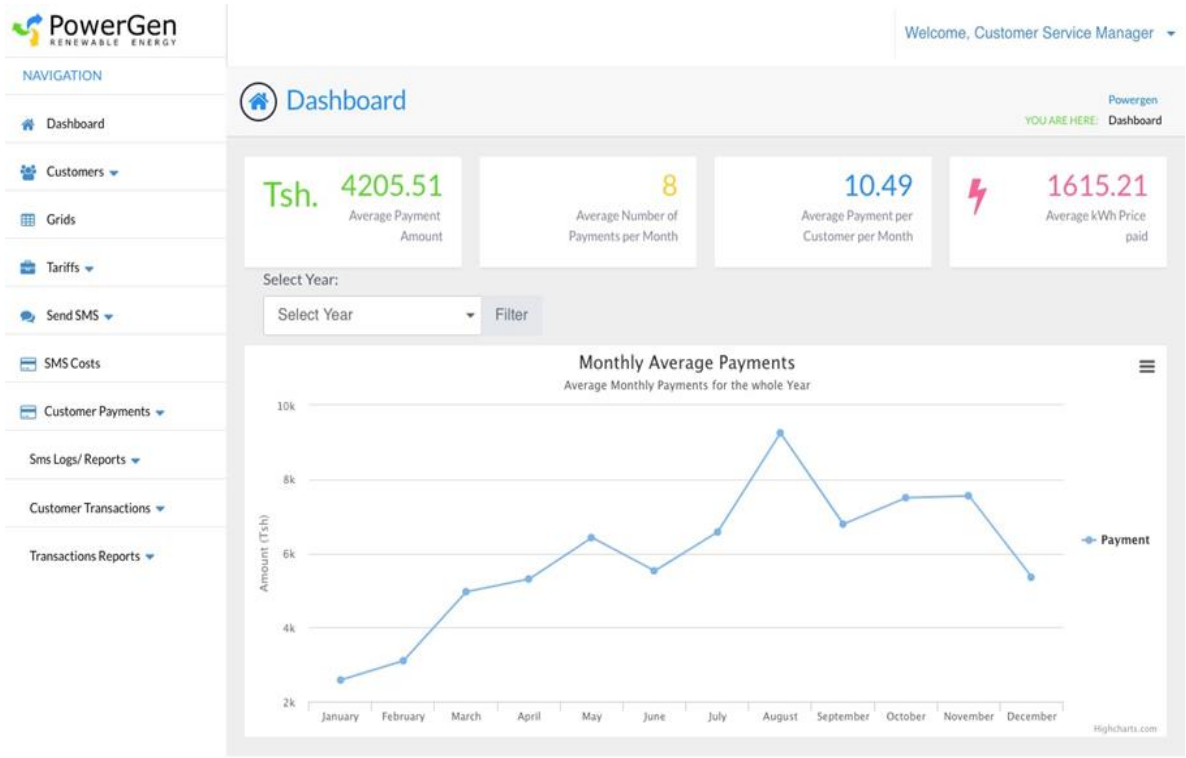


Figure 6: AMini administration platform user interface

REVENUE COLLECTION METHODS

REVENUE COLLECTION METHODS

Cash versus Mobile Money Payments

- **Payment collection:** Cash-based, mobile money or mix of both.
- **Pre- versus post- payment**: All but one of the operators interviewed require customers to pre-pay for electricity.
- **Cash-based:** 7 of the operators interviewed rely exclusively on cash payments from local agents and vendors. Tend to be in areas with little or no mobile money coverage.
- **Mobile money:** 4 of operators interviewed use only mobile money.
  - All in East Africa where mobile money infrastructure is well developed.
- **Combination:** 4 of operators interviewed use a mix of cash and mobile money. Allows customers to select their preferred payment model.

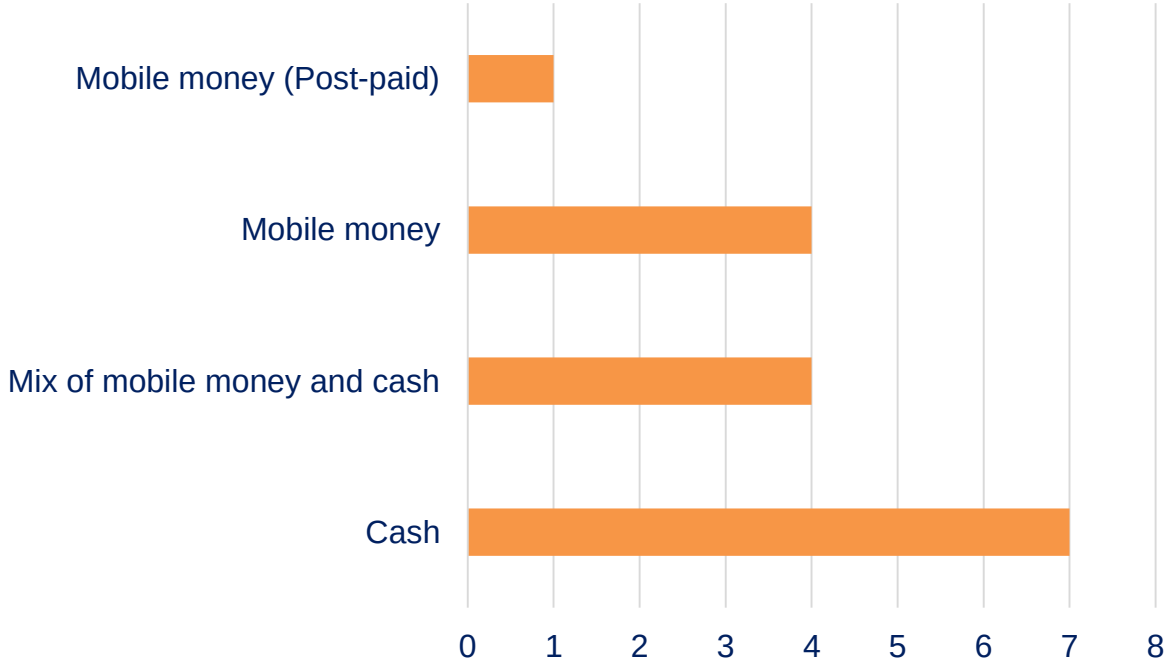


Figure 7: Revenue collection methods shown by number of mini-grid users
Source: Authors' interviews

REVENUE COLLECTION METHODS

Choice of Meter

- Different billing and revenue collection methods can be integrated with different types of meter.
- 44% of developers exclusively use local agents to collect payments from users (31% smart meters;13% pre-paid meters).
- Fixed and variable costs related to payment methods:
  - Commission fees for agents (typically 5% of electricity sales);
  - Mobile transaction fees;
  - Software fees;
  - Local office set-up costs for agents; and
  - Monthly meter cost and mobile money integrator cost (on a per transaction basis).

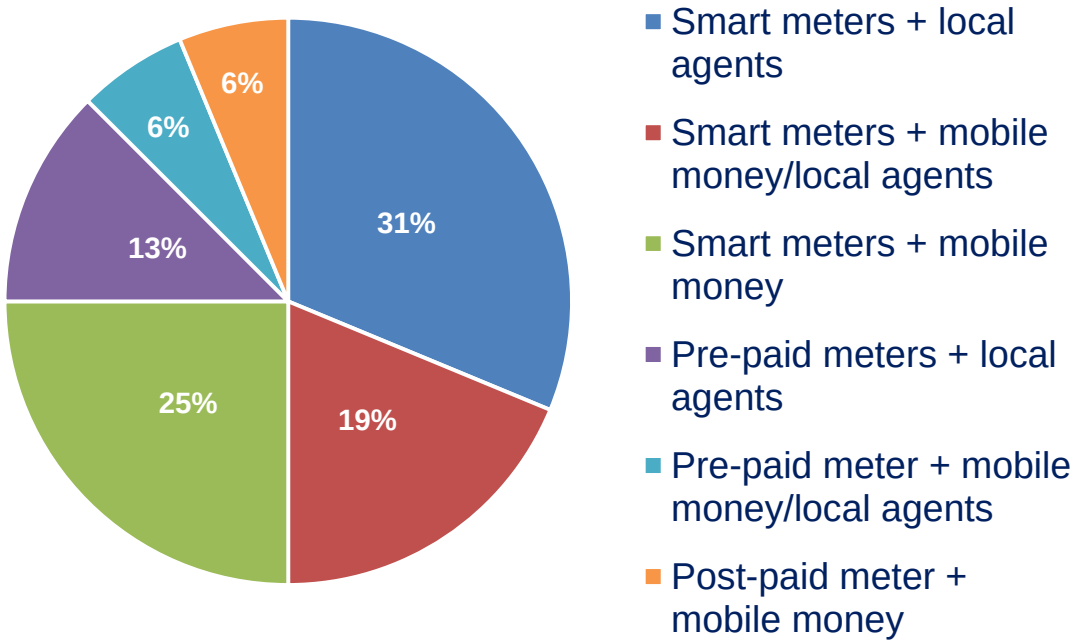


Figure 8: Meter type and revenue collection method used by mini-grid operators
Source: Authors' interviews

REVENUE COLLECTION – CASH-BASED

Requirements for Cash-based Systems

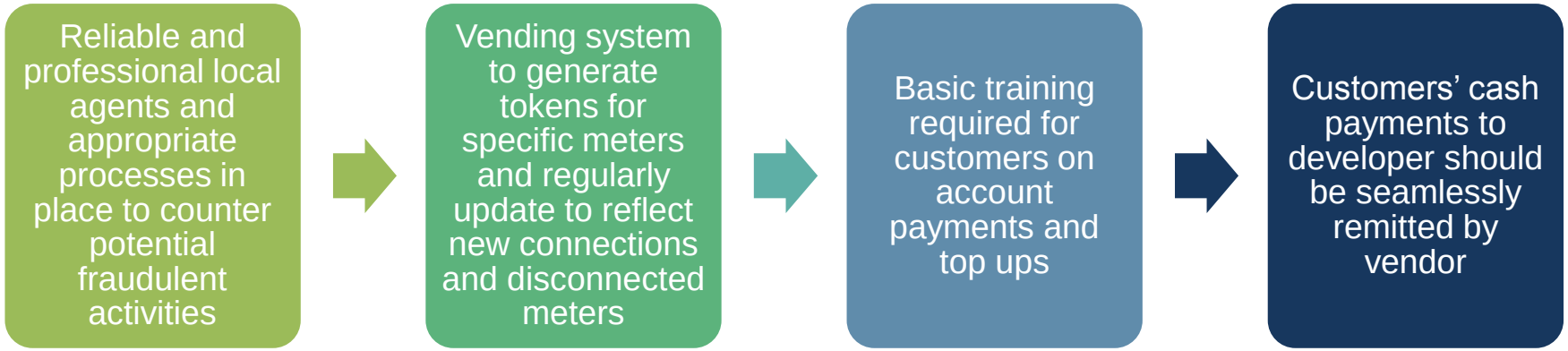


Figure 9: Requirements for effective cash-based revenue collection

Cash-based Payment Collection

- **Direct sales:** sales directly between developer or authorized resellers to the customer.
- **Indirect sales:** sales through authorized agents. Generally used in remote areas far from developer.
- **Cash receipts**: generated as token, scratch card or voucher.
- **kWh units:** acquired units are entered into meter through a keypad or smart card.
- **Transactions**: while customers can pay resellers in cash, agents can pass on revenue to operators in form of mobile payments.

REVENUE COLLECTION – MOBILE MONEY

Requirements for Mobile Money-based Systems

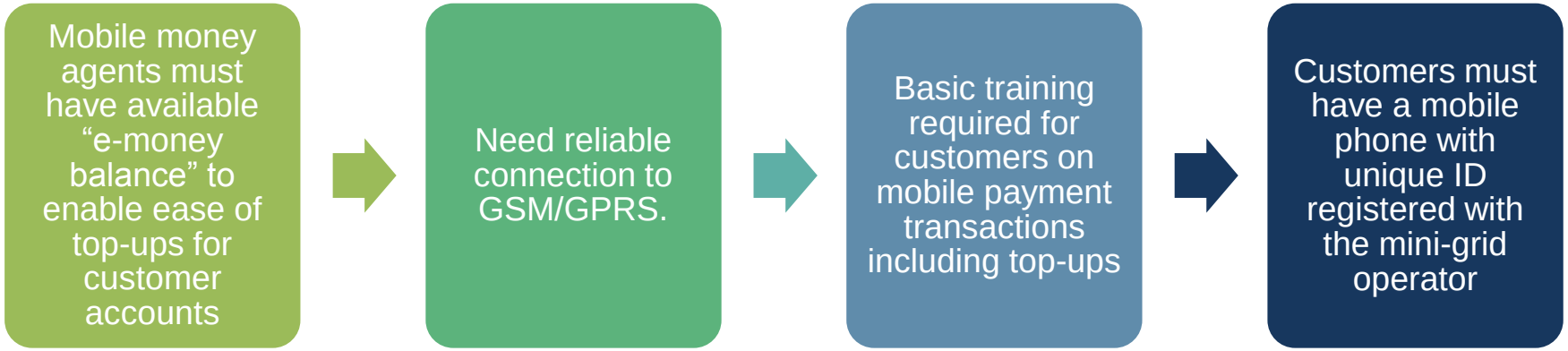


Figure 10: Requirements for effective mobile money-based revenue collection

Mobile Money Payment Collection

- **Sales:** carried out between customer and mobile money platform integrated into a mobile phone.
- **Mobile money operators:** operators charge a nominal fee passed onto customers as part of electricity costs.
- **Mobile money integrators:** mobile payments from different networks processed by integrators on behalf of the developer. Attract a fixed charge for each transaction.
- **Unique ID:** customers are provided unique IDs by mini-grid operator to enable direct third party account top-ups from mobile money agents.

REVENUE COLLECTION AND DATA PRIVACY

Customer Data Privacy and Ownership

- Smart meters generate a vast amount of data which can be accessed and analysed remotely.
- Data generated can provide insights on customer behaviour and increase developers' understanding of effective power utilization, including powering of specific appliances, and customer creditworthiness.
- Mini-grid operators are able to improve the efficiency of their operations, provide new services to their customers and optimise their overall service delivery.
- There is a need to raise awareness among developers and metering companies about their responsibilities around customer data to avoid potential data misuse.
- The problem is exacerbated because rules and regulations on customer data privacy and ownership do not exist in many African countries.

ALTERNATIVE BILLING METHODS

ALTERNATIVE BILLING METHODS

Tariff Setting

- When setting tariffs it is important to take account of the interests of different stakeholders e.g. customers, governments, regulators, and investors.
- Mini-grid operators can spend a significant amount of time, effort and cost in researching and designing appropriate tariff levels.
- Mini-grid operators can test different tariff models across different sites to try and find the “optimum” solution.

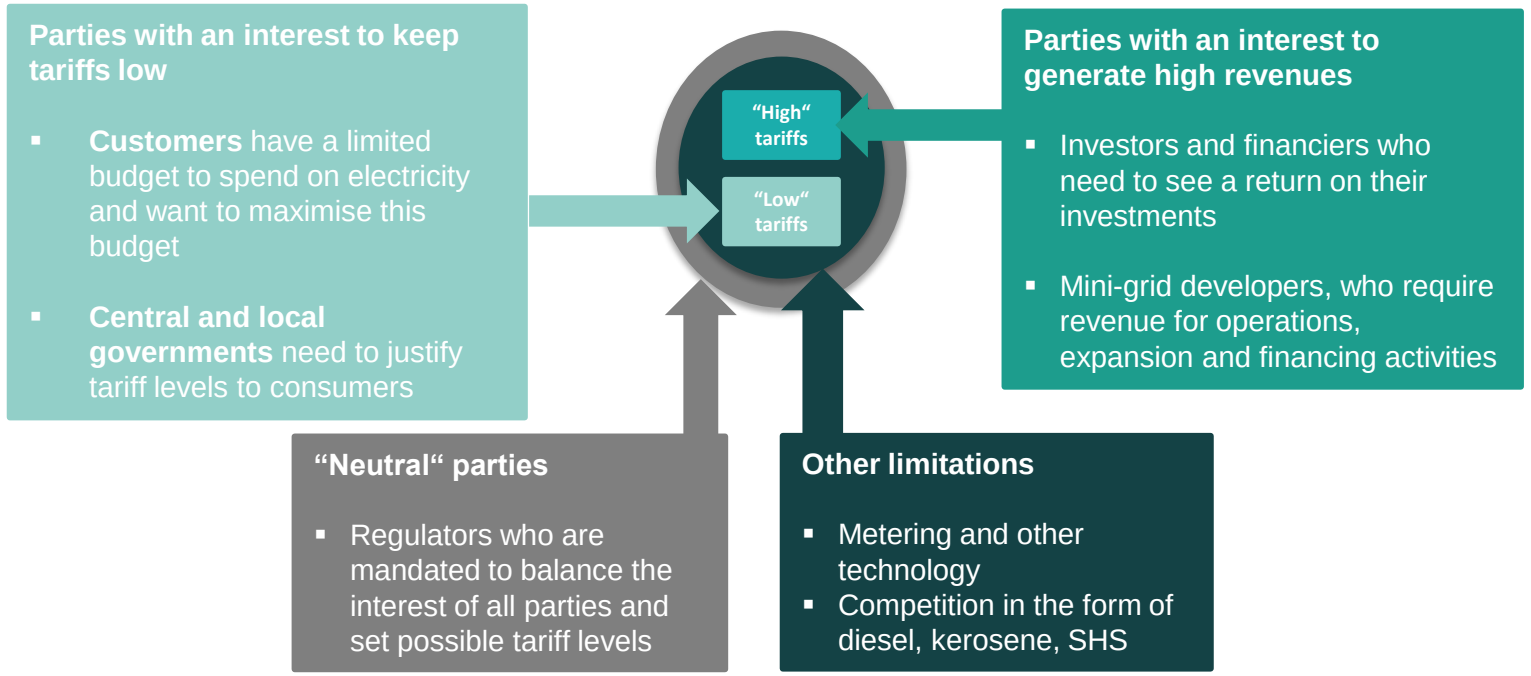
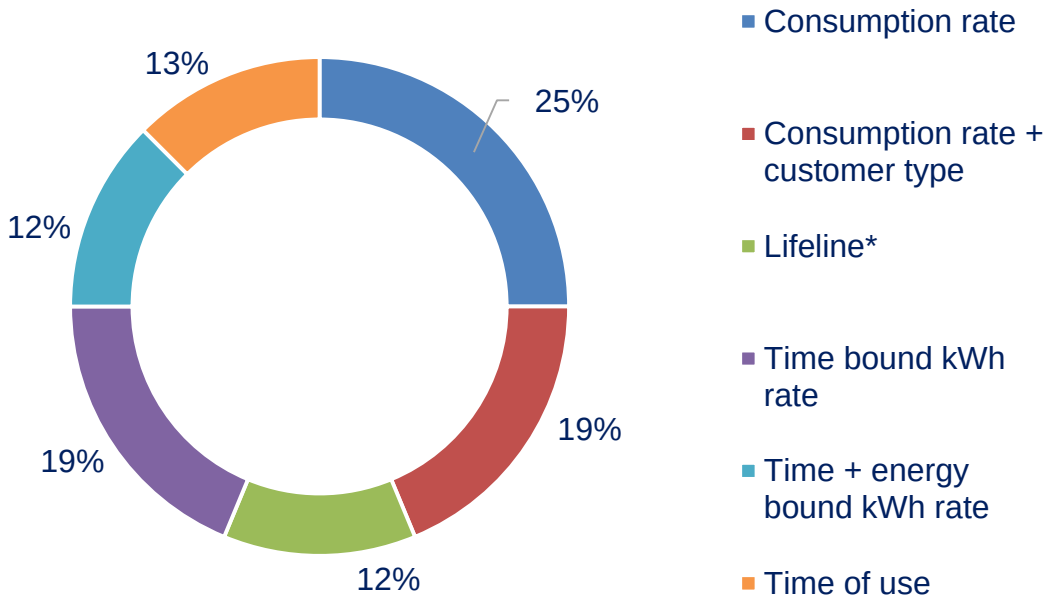


Figure 11: Stakeholder involvement in tariff setting

ALTERNATIVE BILLING METHODS

Tariffs

- **Types of tariffs:** Consumption-based, capacity-based, combination of above.
- **Consumption-based tariffs:** Most popular tariff among developers (used by nearly 45% developers interviewed). See Figure 14.
- **Capacity-based tariffs:** None of the operators interviewed use pure capacity-based tariffs. See Figure 15.
- **Combined tariffs**: Tariffs which have both consumption and capacity features (used by 55% of developers interviewed). See Figure 16.
- No single tariff-setting model dominates.



* Lifeline is a subsidised tariff designed to be affordable for low income households

Figure 12: Consumption versus capacity-based tariffs used by mini-grid operators
Source: Authors' interviews

ALTERNATIVE BILLING METHODS

Tariff Setting

- No “one size fits all” tariff approach.
- 75% of operators interviewed segregate customer groups and charge different tariff-rates.
- Some developers have reduced rates for households compared to commercial users to stimulate demand among households with low disposable incomes.
- Some have higher rates for household tariffs than commercial/productive users to incentivise more productive use activities.
- Complex tariffs can lead to customer confusion and reduced uptake of electricity.
- Developers still experimenting with different tariff structures.

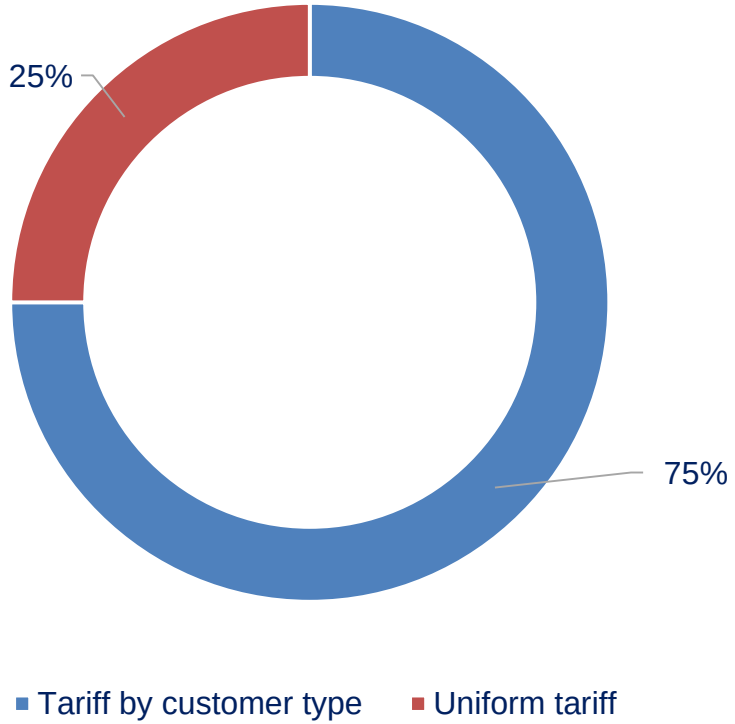


Figure 13: Uniform versus customer-based tariffs for mini-grid operators
Source: Authors’ interviews

CASE STUDY 2

Raising Customer Awareness through Local Power Committees

GoSolar Africa is a solar supplier and mini-grid developer operating in West Africa (Nigeria, Ghana, Togo and Mali).

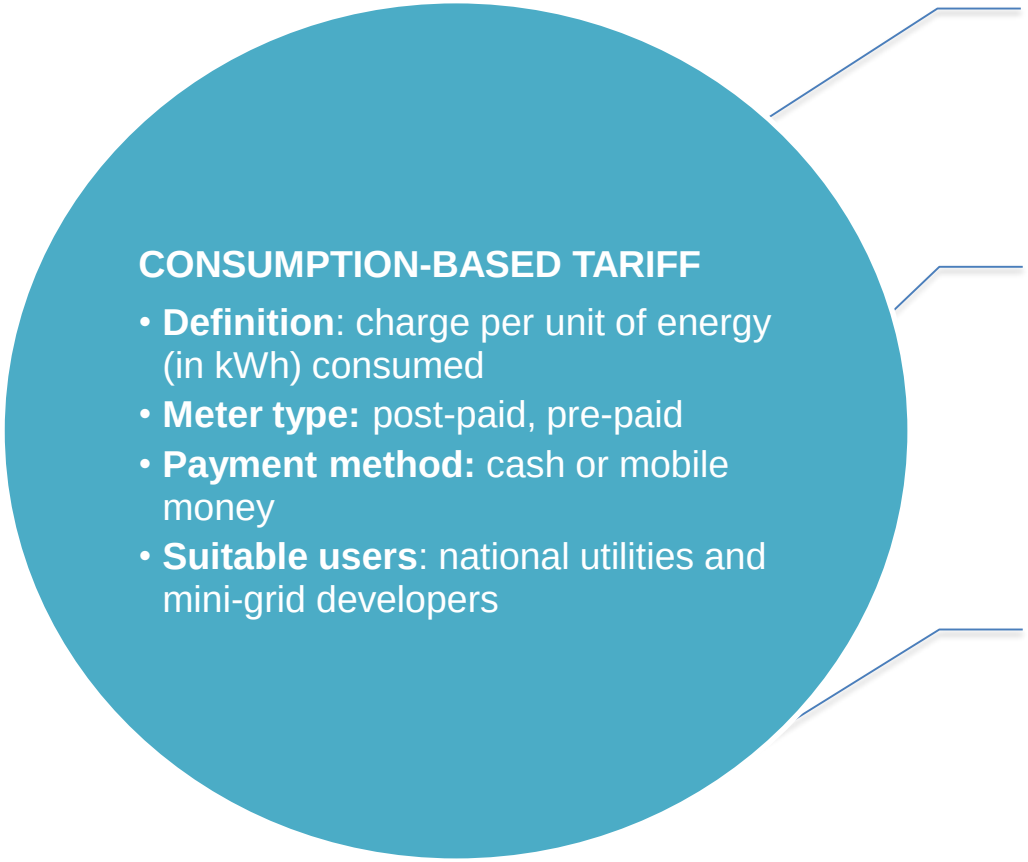
GoSolar's mini-grid customers in Nigeria have compared their tariffs with the lower tariffs of local larger electricity distributors and this has negatively affected customers' willingness to pay.

To address this problem, GoSolar has increased the involvement of the local communities in their mini-grids through the establishment of "local power committees" which meet regularly to discuss the project and provide formal feedback to the operator.

The committee is made up of well-trusted, highly respected community figures who are able to drive change. Creating the committee has helped raise community awareness and understanding of GoSolar's billing methods, and led to increased revenues and a reduction in customer complaints.

ALTERNATIVE BILLING METHODS

Consumption-based Tariffs



- **Energy use tariff**: Charge per unit of energy depends on overall consumption. Increased consumption often leads to lower average "per kWh" tariff for users.
- **Time of use tariff:** Charge per unit of energy depends on time of day (peak and off-peak). Lower tariff during off-peak. Often used for solar mini-grid hybrids (with diesel back up). For example, they may charge lower tariffs during day (when generation from solar is high) and higher tariffs at night (when they rely on more expensive diesel power or battery storage).
- **Seasonal tariff:** Charge per unit of energy depends on season. For example, solar mini-grids' charges per kWh may be higher in the rainy season.

Figure 14: Characteristics of consumption-based tariffs

ALTERNATIVE BILLING METHODS

Consumption-based Tariffs – Advantages and Disadvantages

Tariff Type	Advantages	Disadvantages
Consumption-based tariffs		
Simple consumption-based tariff	+ Incentivises energy efficiency. + No limiters required. + Allows customer flexibility to “pay as they go”.	- Difficult for customers to plan ahead, especially in the case of post-pay payments, because they may inadvertently use more electricity than desired. - Requires thorough customer education and training.
Energy use tariff (progressive or regressive)	+ Can promote lifeline or productive use customers.	- Complex structure may be difficult for customers to understand. - Requires smart meters.
Time of use tariff	+ Good for electric efficiency. + Convenient for PV-battery projects which can match generation with demand.	- Meters used are expensive which adds to the cost of electricity. - Customers require in-depth education to understand charges. - Discouraging usage during particular times of day may lead to customer dissatisfaction.
Seasonal tariff	+ Good for electricity efficiency. + Can match generation costs with revenue.	- Hard to determine operational cost per season. - Frequent tariff changes may not be perceived well by customers especially in low seasons when customers have limited cash at hand, and customers may have difficulty understanding the overall concept.

Table 5: Advantages and disadvantages of consumption-based tariffs

ALTERNATIVE BILLING METHODS

Capacity-based Tariffs

CAPACITY-BASED TARIFF

- **Definition**: Flat-rate subscription. Charge per unit of energy (in kW) based on maximum power demand
- **Meter type:** meters with load limits
- **Payment method:** cash, mobile money
- **Suitable users:** power-limited mini-grids developers e.g. micro hydro plants

- **Per device tariff**: Charge per unit of energy depends on number of devices with a limit on power rating. For example, two fluorescent lights of 10W each allowed per household.

Figure 15: Characteristics of capacity-based tariffs

ALTERNATIVE BILLING METHODS

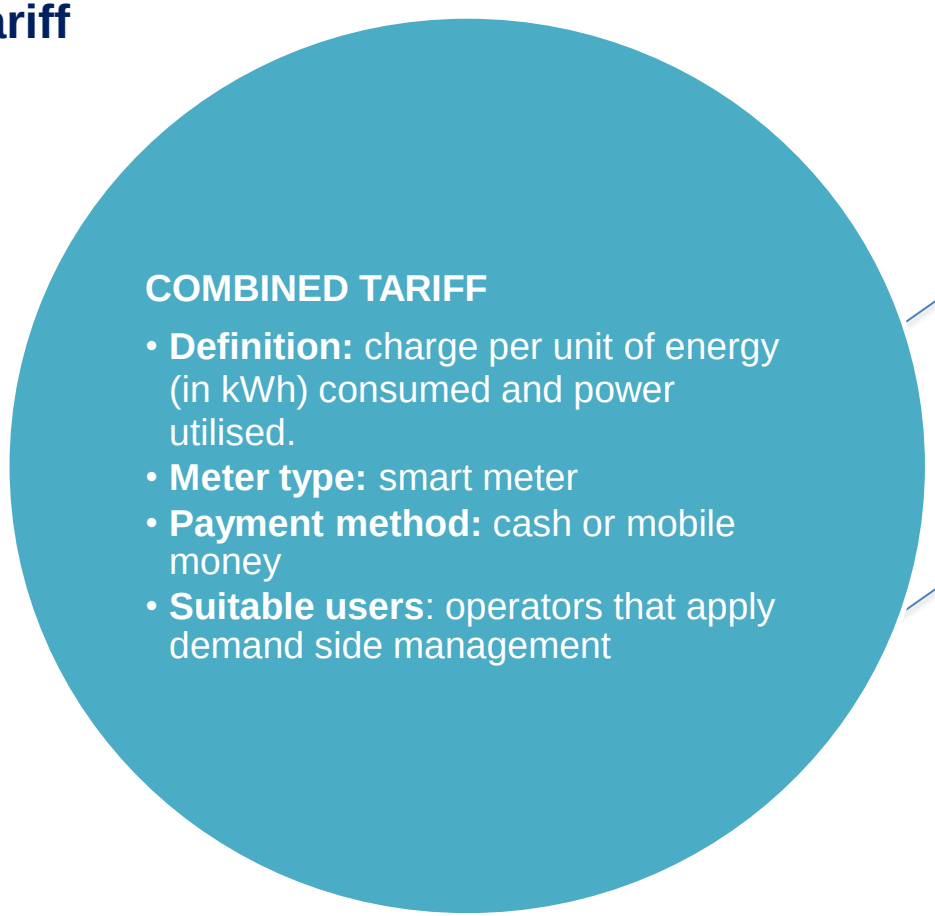
Capacity-based Tariffs – Advantages and Disadvantages

Tariff Type	Advantages	Disadvantages
Capacity-based tariffs		
Simple Capacity-based tariff	+ No meter required (only a load limiter). + Physical visit to read the meters not required. + No bill calculation. + Easy to understand for customers who can either use or not use specific appliances.	- Clients do not know the charge per kWh. - Difficult to forecast demand. - Does not encourage energy efficiency, may lead to very high consumption levels and difficulties in meeting demand throughout the day.
Per-device tariff	+ No meters are required. + Suitable for low income populations.	- Hard to predict demand. - Discourages productive use. - Difficult to enforce compliance. - Hard to calculate the cost of units of electricity consumed.

Table 6: Advantages and disadvantages of capacity-based tariffs

ALTERNATIVE BILLING METHODS

Combined Tariff



- **Energy as a Service Tariff**: Charge is dependent on hours of usage. Ideal for developers that want to ensure electricity is used for a specific purpose.

- **Time-bound Tariff:** Charged depends on amount of time electricity is used by customers. Combined with an energy limit applicable to the time frame.

Figure 16: Characteristics of combined tariffs

ALTERNATIVE BILLING METHODS

Combined Tariffs – Advantages and Disadvantages

Tariff Type	Advantages	Disadvantages
Combined tariffs		
Energy as a service tariff	+ Precise calculation of prices possible, so can match costs with revenues. + Customers do not need to understand the complexity of electricity tariffs.	- Customers are not fully aware of their electricity consumption. - Difficult to enforce compliance, need a limiter.
Time-bound tariff	+ Stimulates regular payments.	- Does not encourage electricity efficiency unless coupled with a consumption limit. - Can lead to customer complaints – need to ensure they are aware that they still pay for electricity even if they do not consume any during the allocated time.

Table 7: Advantages and disadvantages of combined tariffs

ALTERNATIVE BILLING METHODS

Metering and Tariff Combinations

Tariff types		Meter types				
		Load limiter only (no meter)	Load + time limiter only (no meter)	Post-paid meters	STS or Smart Card / RFID pre-paid meters	Smart meters
	Simple Consumption-based tariff					Visibility on real time data
	Energy Use tariff					Real time consumption monitoring
	Time of Use tariff					Real time consumption monitoring
	Seasonal tariff			Invoice calculation requires seasonal changing	Unit price requires seasonal changing	Ability to control remotely
	Simple Capacity-based tariff	Restricted power limit	Restricted power limit	Possible with current limiter, but not advisable due to additional cost	Possible with current limiter, but not advisable due to additional cost	Possible with current limiter, but not advisable due to additional cost
	Per-device tariff	Demand management	Demand management	Demand management	Demand management	Demand management
	Energy as a service tariff					Real time consumption monitoring Restricted power limit
	Time-bound tariff					Ability to control remotely

Recommended combination

Possible combination (not recommended)

Not applicable

Table 9: Metering and Tariff Combinations

ALTERNATIVE BILLING METHODS

Factors in Billing Design and Implementation

Target users: which do you want to grow and when? are you targeting private household users (volume sales) or commercial and productive users? Do you want bottom of the pyramid customers to always be able to afford power?

Load profiles: manage peaks and troughs in consumption during different times of day and for different types of user.

Ease of understanding and transparency: keep billing simple for customers to understand, in order to reduce the need for training and increase the willingness to pay.

Customer service and technical reliability: billing method should reflect the level of reliability and electricity access.

Impact on cost structure: billing method will affect the fixed and variable cost components of operation and maintenance.

Volume risks: manage significant increases in consumption to avoid load shedding.

Tariff regulations: comply with regulatory limits on tariffs for mini-grids.

Demand side management: consider DSM to alter demand profiles and overall load curves.

ALTERNATIVE BILLING METHODS

How to Choose the Right Billing Method – Part 1

Question	Answers	Implication
Is the focus of my mini-grid on residential or commercial customers?	Residential	Consider low residential tariff e.g. “freemium” model.
	Commercial/productive use.	Consider cheap/non-smart meters for residential customers and smart meters for commercial use. Reduce tariff for commercial users.
Is the analysis and utilisation of data important to my business or my investors?	Yes, data is important.	Consider smart meters in combination with a robust software backend and mobile money payments.
	No, data is not important.	Choose between smart and non-smart meters depending on cost factors.
What type of customers do I intend to serve with my mini-grid?	Mainly salaried customers, or situations in which many people contribute to the electricity budget.	Consider post-pay/bundled metering or the sale of “energy blocks” (similar to mobile network operators) which cover the fixed costs with the fixed income of customers.
	Mainly non-salaried customers.	Consider pre-pay meters.
Is mobile network available and reliable at the mini-grid site?	Yes, mobile network is there.	Consider smart meters.
	No, there is no mobile network.	Consider conventional meters or pre-pay meters.

Table 8: Billing Method Guide

ALTERNATIVE BILLING METHODS

How to Choose the Right Billing Method – Part 2

Question	Possible Answers	Implication
Would regular and frequent trips to site/the hiring of local workers significantly affect my bottom line?	Yes, I would rather visit the site as little as possible.	Consider smart meters in combination with mobile money payments and a backend software which helps operate and maintain sites remotely.
	No, I have a local team on ground/I am happy to visit often.	Any meter type can work.
Do you have alternative income streams (aside from mini-grids) in the specific community?	Yes.	Work closely with the local community to identify and tap into these business opportunities.
	No.	Consider running an appliance financing program to stimulate customers' demand for electricity, and the utilisation of smart meters to track customers' behaviour.
Am I constrained by technical/generation limits (incl. volume limits and technical reliability)	Yes.	Avoid billing method that incentivises increase in consumption or charges customers on a monthly/fixed fee basis.
	No.	Can choose from wide range of billing and metering methods.

Table 8: Billing Method Guide

CASE STUDY 3

Selling Bundles of Energy

Devergy is a DC mini-grid company which utilises a smart grid approach to connect customers to its solar generation units. It has a lot of flexibility over where it locates each generation unit, which helps avoid oversizing and reduce the need for cabling.

Devergy's tariff structure aligns the company's variable revenues with its fixed costs. It charges customers "bundles of energy" similar to how a mobile network operator offers internet packages. For each bundle, customers can consume a maximum amount of energy for a certain period of time (say one week or one month). There are also limits on how much power can be consumed instantaneously.

For example, customers who know they will only use light bulbs and phone charging can opt for a bundle with a small amount of energy. This model allows Devergy to better forecast future electricity consumption and likely payment dates.

CASE STUDY 4

Offering Ancillary Services

Renewable Energy Innovators Cameroon (REIc) has been operating micro-grids in Cameroon since 2014. REIc has designed a high-tech modular AC micro-grid system for remote areas. Together with smart meters from Sparkmeter, their modular system enables REIc to electrify villages with a starting demand as low as 12 kWh/day (2 kWp solar) rising to as high as 1500kWhr/day (250 kWp solar) by stacking several modules.

To boost its electricity sales, REIc offers access to market services for small-scale farmers in their communities using a mobile app and online platform called Achaba, which links farmers to buyers in the city. Each village has a REIc vendor trained to accept cash or organic food products as payment for electricity credits. The vendor uses Achaba to advertise the food products on the platform to registered members in cities who then buy the food products using mobile money.

The mobile app tracks the value and delivery status of the organic food products. Achaba allows the villagers to trade their produce for electronic and physical cash which they can then use to pay for healthcare, educational services as well as electricity.

ALTERNATIVE BILLING METHODS

Pay-As-You-Go

- PAYG covers a range of technologies, payment rules, and ownership and financing structures, which allow customers to pay in affordable instalments for an electricity product or service instead of a lump-sum payment and incorporate a technology that disables the system if a payment is overdue.
- In past 5 years, distributed energy services companies (DESCOs) have developed and marketed products via PAYG.
- Originally PAYG was just used to sell solar kits, but now it is also used to sell electricity in kWh and other related services.
- PAYG companies have experimented with different business models and now deliver a wide range of energy service packages ranging from simply solar lanterns and distributed solar home systems to mini-grids and some new areas e.g. irrigation pumps (pay-as-you-grow).
- Main building blocks of PAYG business model are the PAYG technology IP (proprietary or third party licence), the solar technology product offering, the sales and distribution model, working capital financing, customer vetting, payment options, payment flexibility, the leasing and ownership model, installation, activation technology, and data collection.

Common Features of PAYG

- Offer energy services, often with other appliances.
- Customer makes initial down-payment to cover cost of equipment, followed by regular payments.
- For mini-grids the down-payment could cover the cost of appliances or connection fees or household wiring costs.
- Payments are made by mobile money or by other means such as scratch cards, direct cash payments or mobile phone credit.
- Customers are charged per unit of time or per kWh consumed or according to a flat rate.
- Customer makes scheduled payments or can top up their account when they want. If their account is empty, the service stops functioning until a payment is made.
- Customers either make continuous service payments (perpetual lease or service model – essentially a distributed utility, which is the model more likely to be used by most mini-grids) or own the kit once a certain amount has been paid (the rent-to-own model now used by most distributed solar home system providers).

ALTERNATIVE BILLING METHODS

PAYG Development in the Mini-grid market

Opportunities for PAYG in Mini-grids

- Increase overall electricity demand, especially among low income and bottom of pyramid customers.
- Reach more customers, develop deeper customer relationships and offer more tailored products and services, such as highly efficient electric appliances.
- Diversify business model and create secondary revenue streams. Potentially mini-grid operators can become rural distribution companies.
- Due to the relatively close proximity between the mini-grid and their customers, mini-grid operators can potentially deliver products more easily and reclaim them in case of default.
- Continuously collect and analyse data on customer consumption and payments in order to identify and make improvements to operational performance.
- Take advantage of grant schemes to fund PAYG appliance financing schemes.

Challenges for PAYG model in Mini-grids

- Mini-grid business model is not proven yet and most operators lack working capital (especially debt finance) required for PAYG.
- Ability and willingness of mini-grid customers to pay deposit and make regular payments not known.
- Long lead time to build PAYG infrastructure.
- PAYG only possible in some countries if mobile payments are considered.
- Limited scope for economies of scale. Mini-grid developers have a more limited customer pool than solar home system companies.
- Need a well-structured revenue collection method.
- Limited organisational capacity of operators to set up PAYG and develop new revenue models e.g around appliance sales.

ALTERNATIVE BILLING METHODS

PAYG bundling strategies

Method	Payment mechanism	Pros	Cons
Sell appliance as a stand-alone next to electricity.	Requires a separate product account number from the electricity sale. Multiple payments (electricity and product) need to be made.	+ Electricity sales and product sales can be tracked individually. + Very flexible as customers can choose which appliances to purchase.	- Too many account numbers can lead to confusion for customers. - Legal concerns of disconnecting power if customers default on product payment.
Bundle appliance together with electricity.	One payment per month or week for every product purchased.	+ Very flexible as customers can choose which appliances to purchase.	- Can lead to confusion by customers. - Does not encourage efficient use of appliances. - Perceived by most customers as higher risk because fixed monthly payments are higher.
Bundle several appliances and electricity together as "packages".	One payment per month or week for the package.	+ Singular payment reduces complexity and makes tracking easier.	- Can lead to confusion by customers. - Does not encourage efficient use of appliances. - Perceived by customers as higher risk because fixed monthly payments are higher. - Limited number of possible packages leads to lower flexibility. - Customer is tied into single package for a long time. Default on package will lead to repossession of many products.

Table 10: Pros and cons of PAYG bundling strategies

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ABBREVIATIONS

BoP – Bottom-of-Pyramid
DESCO – Distributed Energy Services Companies
DSM – Demand Side Management
EA – East Africa
EPC – Engineering, Procurement and Construction
GMG – Green Mini-Grid
GPRS – General Packet Radio Services
GSM – Global System for Mobile Communications
kWh – Kilowatt hour
LoRA – Long Range
O&M – Operations and Maintenance
PAYG – Pay-As-You-Go
PUE – Productive Use of Energy
RF – Radio Frequencies
SME – Small Medium Enterprises
SSA – Sub Saharan Africa

ANNEX 1: INTERVIEW QUESTIONNAIRE

Questionnaire for mini-grid operator interviewees

1	**General Information**
1.1	Company Name
1.2	Name of person/position in company
1.3	Country of operation
1.4	Mini-grid projects developed
1.5	Mini-grid projection in operation
1.6	Generation capacity installed
1.7	No. customer connections
1.8	Years of experience in the mini-grid sector
2	**Business Model**
2.1	Please describe your business model
2.3	How are you generating revenue?
3	**Challenges**
3.1	What are the main challenges for a sustainable mini-grid business from your perspective?
4	**Success parameters**
4.1	What are the key parameters for a successful mini-grid business?
5	**Tariff structure**
5.1	Tariff structure/options offered to customers
5.2	Please describe the different tariff type for e.g. :
	1. Household 1
	2. Household 2
	3. Commercial user 1
	4. Commercial user 2
	5. Productive use 1
	6. Productive use 2

6	**Meter technology**
6.1	Which meter technology are you using and why?
6.2	Which meter brand/supplier? (if you can disclose the supplier)
6.3	Which communication protocol do you use?
6.4	Rating of different Key Performance Indicators of the metering technology used
6.5	Reliability of revenue collection
6.6	Reliability of data collection
6.7	Functionality
6.8	Customer communication and information
6.9	Costs
6.10	Do you have experience with other meters? If yes, which ones?
6.11	Please describe briefly your experience with those? Why are you now using other ones?
6.12	Other points
7	**Revenue collection**
7.1	How do you manage your revenue collection?
7.2	Can you breakdown the costs of your revenue collection model? Which ones are the most significant?
7.3	If you use mobile money, describe the advantage of using mobile money for your business
8	**Micro financing and bundled services**
8.1	Do you offer financing for appliances or similar?
8.2	If yes, are you using customer history to evaluate credit worthiness?
8.3	How do you collect payments?
8.4	Have you bundled your electricity sales with other services or do you plan to do so?
8.5	What service are you bundling with your electricity sales?
9	**Data privacy**
9.1	Have you faced any data privacy issues related to your business model? If yes, please specify
9.2	What are you doing to ensure data privacy?

ANNEX 2: MINI-GRID OPERATORS INTERVIEWED

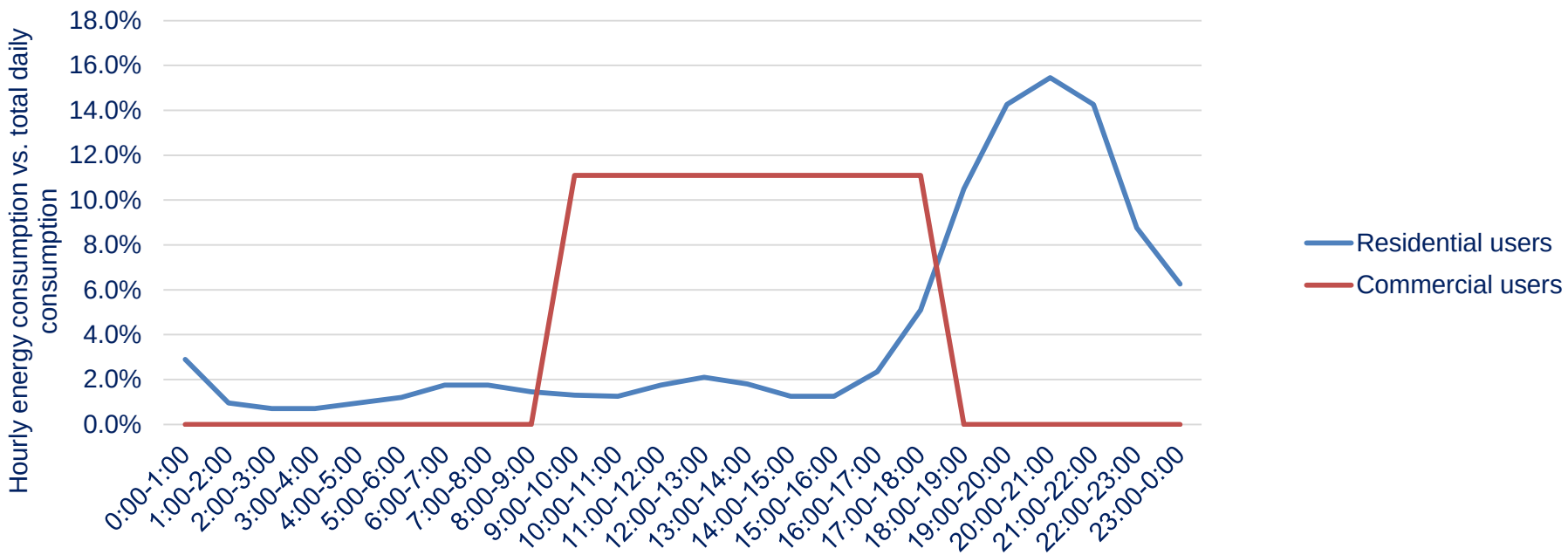
Mini-grid Operator	Countries of operation
Autarsys	Madagascar
Devergy	Tanzania
GoSolar	Nigeria
Havenhill	Nigeria
Husk Power	India, Tanzania
Majika	Madagascar
Nayo	Nigeria
PowerGen	Zambia, Kenya, Tanzania
Power On	Benin
Rafiki Power	Tanzania
Redavia	Tanzania, Ghana
REIC	Cameroon
Rift Valley Energy	Tanzania
Ruaha Power	Tanzania
Rubitec	Nigeria
Anonymous	East Africa

ANNEX 3: LIST OF METER PROVIDERS

Meter Provider	Website
Calinmeter	http://www.calinmeter.com/
Circutor	http://www.circutor.com/en/
Cken	https://zjcken.en.alibaba.com/
Conlog	https://www.conlog.com/
Elster	https://www.elster.com/en/index
Genus	https://genuspower.com/
Gram Power	https://grampower.com/
Hexing	http://www.hxgroup.cn/en/
Husk	http://www.huskpowersystems.com/
Ingelec	https://www.ingelec.ma/
Inhemeter	http://www.inhemeter.com/
Itron (bought Actaris)	https://www.itron.com/na
Landis Gyr	https://www.landisgyr.eu/
Logosmeter	http://www.logosmeter.com/
Lumeter	http://www.lumeter.net/
Merkur	http://www.merkur-hamburg.de/metering.htm
Powercom	http://www.powercom.co.il
Sagemcom	https://www.sagemcom.com/
Schneider Electric	https://www.schneider-electric.co.uk/en/
SHCET	http://cetelec.com.cn/
Siemens	https://w3.siemens.com/smartgrid/global/en/products-systems-solutions/smart-metering/components/Pages/smart-meters.aspx
Sparkmeter	www.sparkmeter.io
Steamaco	https://steama.co/
Superstar (Bangladesh)	https://ssgesh+A1:B25op.com/product/single-phase-postpaid-energy-meter/

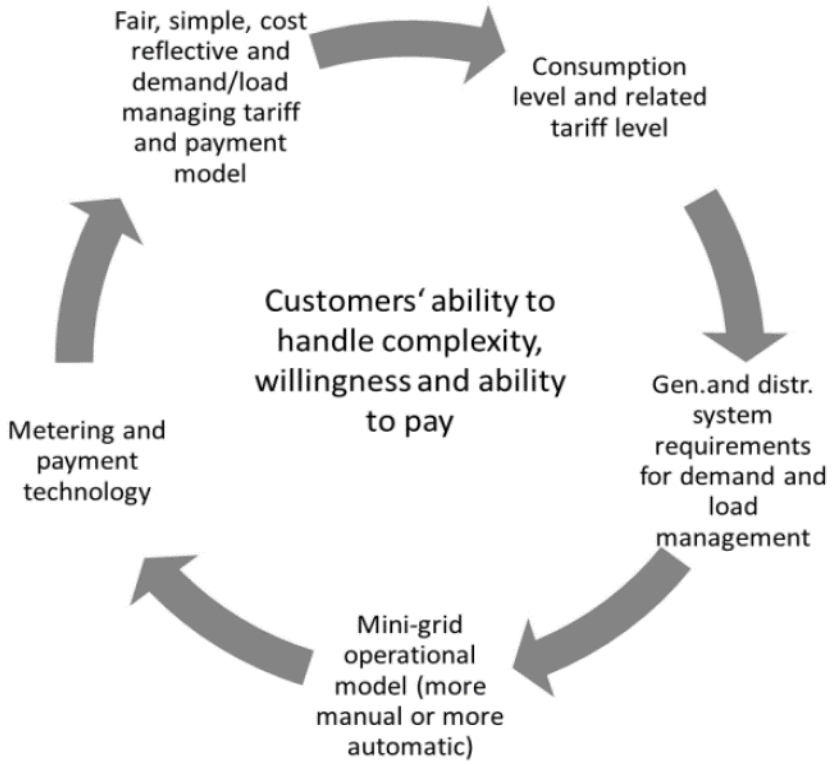
ANNEX 4: TYPICAL CUSTOMER LOAD PROFILES

Typical load profiles for residential and commercial users



ANNEX 5: DESIGNING A BILLING METHOD

Factors to consider when designing a billing method



ABOUT GMG HELP DESK

The Green Mini-Grid Help Desk has been created to support developers of green mini-grids in Africa through the provision of online information and more tailored advisory services in different areas including technical and engineering, business planning, capital raising, and legal and compliance.

The Green Mini-Grid Help Desk has been developed by Energy 4 Impact and INENSUS, is hosted by the African Development Bank and is funded through the Bank's Sustainable Energy Fund for Africa (SEFA). The Green Mini-Grid Help Desk is part of the Green Mini-Grid Market Development Program which aims to facilitate the creation of a green mini-grid movement and enabling environment across Africa.

Website: https://greenminigrid.se4all-africa.org/