EEP
ENERGY AND ENVIRONMENT
PARTNERSHIP / SOUTHERN AND EAST AFRICA

DECEMBER 2016

SOLAR PV BUSINESS MODELS IN EAST AFRICA: LESSONS LEARNT FROM EEP SUPPORTED PROJECTS

EEP S&EA In-Depth Study II

This report highlights findings from EEP supported solar PV projects in east Africa. The information in this report can be used, but reference needs to be made to the source. Suggested citation: EEP S&EA (2016). Solar PV business models in East Africa: lessons learnt from EEP supported projects, Pretoria.

CONTENT

EXECUTIVE SUMMARY

A wealth of knowledge has been created through the implementation of the different solar PV business models by projects supported by EEP. This study was undertaken to analyze and synthesize the experiences and lessons learnt from some EEP supported pilot, demonstration and scale up solar PV projects in the east African region; especially those that have demonstrated success.

Most of the 50 EEP funded solar PV projects in East Africa (out of a total of 68 supported projects) applied one of five key business/delivery models: (1) Retail/over the counter, (2) Pay-As-You-Go (PAYG), (3) Consumer financing (via a partner financial institution), (4) Mini/micro-grid and (5) Fee-for-service. Next to in-depth analysis of the projects supported, a total of 13 EEP supported businesses in East Africa implementing one or more of these models were interviewed as part of the study.

The objectives of the study are to:

- Identify the key success factors for each of the business models,
- Identify barriers to implementing each of the business models,
- Make recommendations on how each of these barriers has been mitigated or overcome by the EEP supported projects
- Compare the different business models based on indicators such as:
  - Level of energy service provided (i.e. energy access tier),
  - Cost of electricity (e.g. system cost, monthly/ daily electricity expenditure),
  - Employment creation potential (i.e. how many full time employees are required to sustain a certain level of annual sales),
  - Scalability (i.e. effectiveness (current and potential) in increasing energy access)

To understand the business models in the context of the target market, market segmentation was done on the basis of the product or service delivered. The multi-tier framework was adopted and adapted for this.

MODEL COMPARISON AND SUITABILITY

The study determined that different models are suited to different market segments as demonstrated by the comparison of delivery models and product/ service pricing in the table and figure below:

- The retail model is best suited for task lighting products (tier 0.5);
- The PAYG and consumer financing models are suited for general lighting and phone charging systems (with or without TV) (tier 1.5 & 2) and;
- The fee for service model is suited for tier 0.5 and tier 1 (especially where income levels are very low and customers cannot afford outright purchase of a task light). It is also well suited for tier 2.5 and 3 (when PAYG becomes too expensive for large solar PV systems).

The micro-grids surveyed provide 5 - 100Wp per customer on average. Household customers who typically consume <50Wp, spend 3-8$ per month on electricity, while small businesses spend 10-15$ per month. These monthly costs are lower than PAYG system costs for a similar level of service. Mini/ micro-grids can therefore provide the spectrum of electricity services at a lower cost than other business models. They can only be implemented in locations with high population density.

TABLE 1:
COMPARISON OF SOLAR PV DELIVERY MODELS BY MARKET SEGMENT AND CONSUMER PRICES

Multi-tier Framework [modified‡]	Power capacity Wp	Delivery Model	Retail Price $	Deposit $	Daily fee $	Monthly cost $
Tier 0.5‡	~ 0.5	Retail	5.5 - 10			-
		Fee for Service		0 – 1.2		0.3
Tier 1	3	Retail	30 - 60			-
Tier 1.5‡	~ 8 - 15	PAYG		19 – 35	0.2 – 1.25	6 – 38
		Fee for Service		6 – 9	0.15 – 0.2	4.5 – 6
Tier 2	~ 30 – 50	PAYG		62	0.6	18
		Consumer Financing (via FI)	400		0.8 – 1	25 – 30
Tier 2.5‡	~ 80 – 200	PAYG		18 – 25	0.8 – 1.2	25 – 35
		Fee for Service		55 – 80	0.2 – 0.5	7 – 14
Tier 3	up to 400	Fee for Service		90	0.6 – 0.7	

Despite the potential of the fee-for-service model, it is very difficult to run sustainably on a fully commercial basis. Some level of financial support will be required to reach the necessary volume of operations, at which point sufficient revenues can be collected from existing customers to sustainable finance operations and expansion. It is also important to note that where there is competition between PAYG and fee-for-service solutions, customers prefer to pay to own the system.

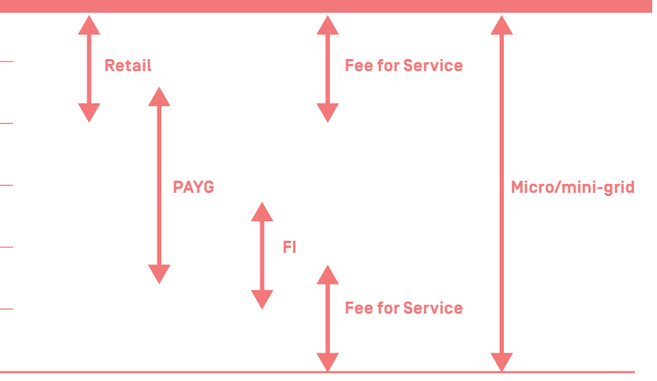
CROSS CUTTING ISSUES

All solar PV delivery models require rural personnel to undertake marketing and provide technical services (installation, maintenance and troubleshooting of systems). Most models also require the establishment of customer service systems. Solar PV businesses therefore provide a unique employment creation opportunity for rural youth. As an example a PAYG company selling 100,000 systems/year would require about 800 rural sales personnel (considering an average of 10 system sales per month per sales agent) and an additional 200 - 400 rural technicians. Solar PV companies therefore have to invest in training and recruitment which represent a significant cost and effort especially due to high turnover of staff (particularly rural based sales staff).

The key role that private sector can play in rural electrification through stand alone or mini/micro-grid solar PV solutions is often overlooked or misunderstood by government. Estimates for the cost of extending the grid to connect rural customers range from 1,000 – 3,000$ per connection. Considering that these customers will spend 2.5 – 30$/month on electricity, other electrification alternatives need to be considered. Increased complementarity between government electrification initiatives and plans and private sector solutions could enable the most cost effective approach to achieving electricity access.

FIGURE 1: MODEL COMPARISON – SUITABILITY OF MODELS

Multi-tier Framework [modified‡]	Power capacity Wp
Tier 0.5‡	~ 0.5
Tier 1	3
Tier 1.5‡	~ 8 - 15
Tier 2	~ 30 – 50
Tier 2.5‡	~ 80 – 200
Tier 3 &4	up to 600



HOW FINANCIAL SUPPORT COULD BE TARGETED

Insight gathered during the course of the current study has led to the identification of the following areas at which financial support could be targeted in support of the sector:

- Identification, training, recruitment and support of rural based staff/agents providing sales or after sales services for retail and PAYG models.
- PAYG businesses assess risk by analyzing the payment patterns and customer characteristics of their existing portfolio and use this to quantify the default risk for the future portfolio. In new countries/markets soft funding to establish this initial portfolio of customers would help in minimizing the commercial risk to the PAYG business and would thus possibly enable accelerated private investments in the sector.
- Soft funding for innovations in PAYG delivery models and/or products that significantly reduces the repayment fees would contribute to making off-grid solar PV solutions affordable for low income segments of the population.
- Large regions in some countries (especially where markets are considered difficult) still remain unserved or underserved and incentives are sometimes required to support businesses implementing retail and PAYG models to develop, support and grow distribution networks in these areas.
- The fee-for-service model can be very effective in providing electricity access in areas that are not viable for grid extension or mini-grids (due to low population density). It has demonstrated the ability to provide higher levels of service at costs lower than PAYG model (thereby providing an alternative for consumers who cannot afford PAYG) as well as providing continuous maintenance services. However, the model has high capital/investment requirements and a long payback period and therefore requires some form of subsidy to attract commercial investors.
- To be commercially interesting, a mini/micro-grid business needs tens to hundreds of thousands of customers. Considering access to finance and commercial viability challenges, it will be challenging for private mini/micro-grid developers to scale to these levels without a sustained stream of soft-financing. Some dedicated long-term source for soft funding (not unlike rural electrification funds) will be required to support private mini-grid developers if they can demonstrate that they are more effective than public utilities or rural electrification authorities.

1. INTRODUCTION

Solar PV projects have the largest share of the Energy and Environment Partnership programme's (EEP) project portfolio for East and Southern Africa. They represent 33% of all projects financed (68 projects) and 40% of EEP's total donor investment (20m€). The 68 solar PV projects are spread across 12 countries with the bulk of the projects (73%) implemented in East Africa. The 50 solar PV projects implemented in East Africa are disaggregated as follows: 15-pilot, 16-demonstration, 16-scale up and 3-feasibility study.

The EEP funded solar PV projects included in this study apply five key business models as elaborated below:

1) RETAIL/OVER THE COUNTER – Over the counter sales is the oldest approach to selling solar PV in East Africa. However, in the past, few business were dedicated to marketing only solar PV products. Solar PV was typically sold as an additional product with revenues from sale of solar products and services only representing <10% of the total business turnover. In recent times a large number of dedicated solar retailers have emerged. Their survival and success is dependent on the development and implementation of effective marketing, supply and distribution models.

2) PAY-AS-YOU-GO (PAYG) CONSUMER FINANCING – This is effectively a consumer financing model for solar PV systems that takes advantage of mobile money transfer systems and remote monitoring and control of solar systems (that enable the solar business to remotely disconnect a system in the event of default). Ownership of the system is transferred once the customer finalizes their repayments. The model offers customers flexibility of making repayments (i.e. can opt for daily, weekly or monthly) and enables the business to easily and effectively manage a large portfolio of dispersed borrowers. As the repayment duration typically ranges from 6 months - 3 years, this typically creates a significant cash flow burden for businesses which have the role of product and service supplier as well as financier.

3) CONSUMER FINANCING (VIA PARTNER FINANCIAL INSTITUTION) – A consumer financing model based on a partnership between solar PV supplier and Financial Institution (e.g. MFI, Savings & Credit Cooperative, Companies/Agricultural Estates/ Rural Based Industries with large rural staff); the PV supplier provides products and associated services while the Financial Institution provides the consumer financing and collects repayments.

4) MINI/MICRO-GRID – Mini-grids are expected to have a key role in expanding energy access to rural and peri-urban areas and in recent years there has been a lot of investment from development partners and the private sector in East Africa to develop business models and an enabling environment to make mini/micro grids a commercially viable venture. Their main advantage over stand-alone solar systems is they enable connected customers to increase their power and energy consumption without having to invest in additional capacity. They are technically most effective when a large number of customers can be connected within a short radius of typically 1 km.

5) FEE-FOR-SERVICE – An approach based on customers paying a monthly fee for electricity services, similar to a utility model, but using stand-alone systems (as opposed to mini/micro-grid systems) Ownership of the system is not transferred to the customer and the business/project is entirely responsible for maintenance/replacement of the system. The model is well suited to providing reliable and affordable electricity to dispersed communities, where large distances between customers make mini/micro-grids unviable. However, a significant upfront cost has to be borne by the business and the payback period is relatively long.

A wealth of knowledge has been created through the implementation of the different solar PV business models by projects supported by EEP. This study was undertaken to analyze and synthesize the experiences and lessons learnt from some EEP supported pilot, demonstration and scale up projects; especially those that have demonstrated success.

The objectives of the study are to:

- Identify the key success factors for each of the business models,
- Identify barriers to implementing each of the business models,
- Make recommendations on how each of these barriers has been mitigated or overcome by the EEP supported projects,
- Compare the different business models based on indicators such as:
  - Level of energy service provided (e.g. energy access tier),
  - Cost of electricity (e.g. system cost, monthly/ daily electricity expenditure),
  - Employment creation potential (i.e. how many full time employees are required to sustain a certain level of annual sales),
  - Scalability (i.e. effectiveness (current and potential) in increasing energy access).

A total of 13 EEP supported businesses were interviewed during the survey. The split by country and business model of surveyed businesses was as follows:

- By country: Tanzanian 4, Rwandan 4, Kenyan 3, Ugandan 1, and 1 regional (Kenya & Tanzania)
- By business model: Mini-grid 6, PAYG 3, Fee for Service 3, Retail/Over the Counter 2, Consumer Finance (via FI) 1 (NB: 2 businesses implemented more than one model)

2. ENERGY ACCESS

Although it is inevitable that the different business models will be compared against each other (i.e. to determine which is the most effective in achieving access), it is important to also consider that the different models each have a unique role to play in the market. The off-grid market cannot be served by a single model. Each model is particularly effective for a certain market segment and a combination of models is therefore required. However, as the size of the different market segments will vary within and between countries, it is inevitable that some models will be have a larger market share than others. It is important therefore to understand the business models in the context of the target market. To enable this assessment, markets are segmented on the basis of the product or service delivered and the multi-tier framework is adopted and adapted for this.

To achieve the Sustainable Energy for All (SE4All) target of "Universal access to modern energy by 2030" requires a wide range of interventions. The success of these interventions depends on the ability to assess the level of access to energy for planning and investment, and, later, for tracking progress. The multi-tier framework was therefore introduced as an approach for measuring energy access.

The multi-tier framework measures access to electricity through technology-neutral multi-tiered standards where successive thresholds for supply attributes allow increased use of electricity appliances. The key attributes relevant for household electricity are: (i) capacity, (ii) duration (including daily supply and evening supply), (iii) reliability, (iv) quality, (v) affordability, (vi) legality, and (vii) health and safety. The multi-tier standards for household access to electricity supply are summarized in Table 2 below.

TABLE 2:
MULTI-TIER MATRIX FOR MEASURING ACCESS TO HOUSEHOLD ELECTRICITY SUPPLY

ATTRIBUTES			TIER 0	TIER 1	TIER 2	TIER 3	TIER 4	TIER 5
	1. Peak Capacity	Power capacity ratings[28] (in W or daily Wh)		Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW
				Min 12 Wh	Min 200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh
		OR Services		Lighting of 1,000 lmhr/ day	Electrical lighting, air circulation, television, and phone charging are possible			
	2. Availability (Duration)	Hours per day		Min 4 hrs	Min 4 hrs	Min 8 hrs	Min 16 hrs	Min 23 hrs
		Hours per evening		Min 1 hr	Min 2 hrs	Min 3 hrs	Min 4 hrs	Min 4 hrs
	3. Reliability						Max 14 disruptions per week	Max 3 disruptions per week of total duration <2 hrs
	4. Quality						Voltage problems do not affect the use of desired appliances	
	5. Afford-ability					Cost of a standard consumption package of 365 kWh/year < 5% of household income		
	6. Legality						Bill is paid to the utility, pre-paid card seller, or authorized representative	
	7. Health & Safety						Absence of past accidents and perception of high risk in the future	

A separate multi-tier framework is defined for access to electricity services. A gradually improving electricity supply enables increased and improved access to electricity services. Therefore, a second matrix measuring access to household electricity services mirrors the supply matrix, based on the type of appliances used in the household (Table 3).

TABLE 3:
MULTI-TIER MATRIX FOR MEASURING ACCESS TO HOUSEHOLD ELECTRICITY SERVICES

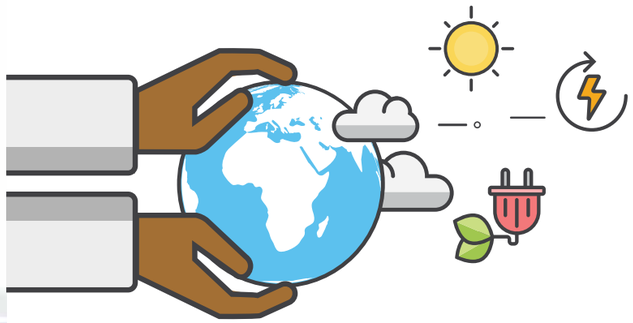
	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Tier Criteria		Task lighting AND Phone charging	General lighting AND Phone Charging AND Television AND Fan (if needed)	Tier 2 AND any medium-power appliances	Tier 3 AND any high-power appliances	Tier 2 AND any very high-power appliances

For the purposes of this study the multi-tier framework is modified as shown in Table 4 below by introducing intermediate tier levels (i.e. Tier 0.5, Tier 1.5 and Tier 2.5). This done to match the framework to the products and services delivered by the businesses interviewed in this study.

TABLE 4:
THE ADAPTED MULTI-TIER MATRIX FOR PURPOSES OF THIS SOLAR PV BUSINESS MODEL STUDY

Multi-tier Framework [modified‡]	Power capacity Wp	Tier criteria
Tier 0.5‡	~ 0.5	Task lighting ONLY
Tier 1	3	Task lighting AND Phone charging
Tier 1.5‡	~ 8 - 15	General lighting AND Phone charging
Tier 2	~ 30 – 50	General lighting AND Phone charging AND Television
Tier 2.5‡	~ 80 – 200	Tier 2 AND Any medium-power appliances
Tier 3	up to 400	Medium-power productive use/income generation appliances

3. DELIVERY MODELS



3.1 RETAIL/OVER THE COUNTER MODEL

The retail model is implemented through a multi-level supply chain comprising importer/supplier, distributors, retailers and field sales staff and/or commission based sales agents. A large country wide network of distributors and retailers is required to make sure the products are easily accessible to customers anywhere in the country. Transactions along the supply chain are mostly cash based, although some suppliers do offer short term credit (up to 30-days) to their distributors.

The retail model is the most common delivery model for Tier 0.5 (task lighting) and Tier 1 (task lighting and phone charging) products. It has proven to be an especially effective model for the Tier 0.5 market segment (products in the 6-10$ price range). Product sales are typically in the range of tens to hundreds of thousands of task lights per supplier per year (tier 1 task lighting and phone charging products represent only a small percentage of these).

As products typically have a two to three years life span with only a few having a battery replacement option, customers have to purchase a replacement light every 2-3 years. It is therefore likely that repeat customers contribute significantly to product sales.

Intense below the line marketing (face-to-face) is required when a product is initially introduced and a large rural sales force is required during this time. In most cases sales personnel will be from the area they are marketing in (i.e. to be effective, they would need to know the area, speak the local language, understand the customs and attitudes and be able to elicit trust). It difficult to find experienced or qualified sales personnel in rural areas and this often results in high costs for recruitment, training and deployment and a high staff turnover. The alternative of using non-local staff is equally difficult as there are very few incentives for them to work in these remote areas.

Considering the 6-10$ product price, it is difficult to have a supply chain primarily consisting of purely commission based sales agents. The value of the commission would be too low for the effort required. Although these sales agents make direct sales, this is not their primary function. Sales agents deployed under this model mainly focus on marketing (i.e. increasing the visibility and awareness of the product and brand) and recruiting and supporting distributors and retail outlets to ensure that the products are always available and accessible to customers. Marketing is typically focused on central gatherings (e.g. market days, religious meetings, village meetings, and co-operative / member group meetings). The most common pay package for this type of sales agent consists of a retainer, a target based incentive and an amount to cover field related costs. The survey of EEP supported projects is very clear that businesses struggle to find the ideal balance between retainer and incentive.

Supply chain costs can make up 30 - 50% of the product price and this cost has to be built into the product price for the model to be effective. However, it is found to be difficult to accurately predict the cost of recruiting, training, deploying and maintaining a rural sales force.

After an optimum volume and spread of sales, and a positive customer experience, word of mouth usually takes over. Customers then actively look for the product at retail and distributor outlets. Product quality and timely honoring of warranty claims is necessary to build and maintain this positive experience.

Some key challenges facing solar PV business implementing the retail model are:

- Undercutting at retail level: when retailers/ distributors opt for lower margins to increase inventory turnover. The price difference across retailers often creates consumer distrust.

- Counterfeit products: Counterfeits reap where they have not sown, taking advantage of the work done to create market awareness and trust in a given product.

- Poor quality products create market spoilage especially when introduced to a new market (they make it difficult to sell good quality products).

Most East African countries have counterfeiting agencies and mandatory standards, but additional industry self-regulation is required.

3.2 PAYG CONSUMER FINANCING MODEL

Under the Pay-As-You-Go consumer financing model, the supplier of the solar product also provides consumer finance for the product. PAYG is the most common delivery model for:

- Tier 1.5 (~ 8 - 15Wp, General lighting and phone charging)

- Tier 2 (~ 30 – 50Wp, General lighting, phone charging and TV)

- Tier 2.5 (~ 80 – 200Wp, Tier 2 and any medium-power appliances)

Some companies have also recently introduced PAYG for tier 1 products (task lighting and phone charging lanterns), with daily fees in the range of 0.3$/day.

The PAYG model has demonstrated greatest success with Tier 1.5 products where the repayment fee is in the range of 0.5$/day. PAYG sales in this range are in the hundreds of thousands of systems per supplier per year. For Tiers 2 and 2.5 products, repayment fees are in 0.8 – 1.2$/day range. PAYG sales for this category are in the tens of thousands of systems per supplier per year.

The repayment fee is dependent on the cost of the system and repayment duration; for more expensive systems the repayment duration would need be longer for the repayment fee to be lower. The effectiveness of the PAYG model is dependent on the amount of daily/weekly/monthly repayment fee charged i.e. the extent to which this fee matches the disposable income of the target market segment (the lower the fee, the larger the potential market). The 2014 IEA Africa Energy Outlook indicates that households spend up to 10% of their income on electricity; with poor households spending the larger percentage. This would suggest that the PAYG model is currently serving customers in the 3 - 12$/day income range, who would not typically be considered as bottom of the pyramid customers. -

The PAYG model also seeks to reduce the entry barrier by reducing the amount of deposit required. However, this approach could be considered counter intuitive as a customer's ability to put down a large deposit is a good measure of their ability to meet their subsequent repayment commitments. The reduction or removal of this filter therefore significantly increases default risk.

Since PAYG customers make their payments directly to the supplier (usually via mobile money), a distribution model based purely on depots (to hold stock and parts and make them accessible to sales agents or installation/maintenance technicians) can be used. A supply chain structure similar to the one used in retail model can also be deployed. As systems are in the 150 – 1,000$ range, decent commission payments can be made to sales personnel. It is therefore possible to have purely commission based sales agents deployed for in this model. To ensure that sales agents target customers who are able to pay, part of the commissions are linked to customer repayment rates.

The marketing approach for PAYG is similar to that used under the retail model. However, in addition to marketing at central gatherings, supplementary door-to-door marketing is also required. Therefore, in addition to commissions, it may be necessary to consider some travel allowance. Truly off-grid markets are often difficult to access.

For larger PAYG systems, installation support is required. Therefore an additional network of local technicians, to provided installation and maintenance/troubleshooting services, has to be established.

A responsive customer service system is also required to register customers, address technical challenges, coordinate and deploy technicians and follow up on defaulters (customers tend not to make repayments when their system is not working). For smaller PAYG systems, the cost of repossession can be significant and it may not be possible to resell/reuse the system. Some PAYG companies instead try to offer defaulters a financial incentive (e.g. reimbursement of their deposit) to return the system to a depot or distributer.

The PAYG model is inherently risky as it is based on providing consumer finance to customers for whom there is little or no financial history information. PAYG businesses assess risk by analyzing the payment patterns and customer characteristics of their existing portfolio and using this to quantify the default risk for the future portfolio. To cover this default risk, high 'interest' rates have to be charged to PAYG customers.

The PAYG model creates a significant cash flow burden on the business. The more expensive the system being offered and the longer the repayment period, the greater the cash flow burden. However, PAYG companies have found innovative ways to address this by converting PAYG loans into securities and selling them on to investors . PAYG businesses mobilizing foreign currency investment also have to account for forex exchange fluctuation risks (because equipment is procured in $ but repayments are made in local currency). The longer the repayment duration, the greater the associated forex risk.

3.3 CONSUMER FINANCING (VIA PARTNER FINANCIAL INSTITUTIONS) MODEL

The main difference between the PAYG model and consumer financing via a partner financial institution is the separation of roles i.e. the solar PV supplier provides the products and associated services while the partner Financial Institution (FI) provides consumer financing and collects repayments. This addresses the cash flow burden associated with the PAYG model as the supplier is paid by the FI upon delivery and installation of the system. This approach also significantly reduces the default risk as the FIs know and have the financial history of the customers they are lending to. FIs are experienced in vetting applicants and using different types of collateral instruments. As a result FIs can offer financing at lower interest rates and longer terms than PAYG companies.

This model suited for Tier 2 (~ 30 – 50Wp, general lighting, phone charging and TV) and Tier 2.5 (~ 80 – 200Wp, Tier 2 and any medium-power appliances). Traditional consumer financing is potentially more effective than PAYG when repayment fees exceed the 0.5$/day range and when repayment duration is >18 months.

The marketing costs for this model are also low compared to other models since FIs already have a regular and structured way of engaging with their customers. PV suppliers simply use this existing structure and process. FI branches can be used as temporary depots to hold systems until they are picked up by customers/installers. This can potentially reduce distribution costs. As with the PAYG model, a responsive customer service system is required. When systems fail customers are often unwilling to make repayments which represents a financial and reputational risk for the FI.

FIs prefer to standardize their product offering across all their branches, therefore when a partnership is established the PV supplier needs to be able to deploy sufficient sales and installation personnel to serve all FI partner branches. If the FI has a large and dispersed countrywide network of branches this can be a challenge and opportunity for the solar PV supplier.

This model has previously been tried in East Africa with little success. However, with standardized high

quality plug and play solar PV systems, and larger dedicated solar PV companies, this potential is currently in the process of being re-explored. Sales through this model are currently in the thousands of systems per supplier per year.

3.4 MINI/MICRO-GRID MODEL

Mini-grids would typically be in the 10kW-10MW capacity range with micro-grids in the 1-10kW range (those below 1kW can be considered nano-grids). Grids can either supply AC or DC electricity (DC grids are usually in the micro/nano – grid range). In East Africa, private solar mini/micro-grids typically serve 20 – 400 customers. These grid systems are technically most effective when a large number of customers can be connected within a 1km radius. However a mix of mini, micro and nano-grids can be used for sparsely populated clusters of customers.

Most micro-grids provide up to Tier 2 level of service. Some micro-grids can technically provide up to Tier 3 but not optimally. Mini-grids can provide Tier 4 and higher. The main advantage of grid systems over stand-alone solar systems is that they enable customers to increase their power and energy consumption without having to invest in additional capacity. The entry barrier is also relatively low (connection/joining fees in the range of 0.1-40$).

Solar PV based grids have a high capital cost, but technology advancements (e.g. remote monitoring and control, pre-paid metering, mobile money based transactions) have made it possible to manage grids with little or no onsite staff, thereby significantly reducing operational costs (excluding overheads). However, most mini/micro-grid sites are remote and there are still unavoidably high costs associated with field visits (when required).

Electricity tariffs are designed to recover capital costs, cover operational costs and generate a margin. Different strategies are used, but ideally a fixed fee would be charged to recover capital expenditure, in addition to an electricity consumption based fee charged to cover operational costs and generate a margin for the business. However, the calculated fixed monthly fee can sometimes be higher than the monthly fee for electricity consumption. On private grids household monthly electricity expenditure is 3-8$ while that for small businesses is 10-16$. EEP mini-grid developers estimate that they need a minimum of 6$/customer per month to be viable, but in most grids deployed in East Africa the average revenue per user (ARPU) is brought down by a high percentage of small, inconsistent or dormant users. Seasonality of income is also a significant contributor to inconsistent electricity use.

Micro/mini-grids need a large number of medium to large electricity users per site to be viable. However, while users of refrigerators, freezers, electrical machinery and tools (e.g. for grinding, cutting, drilling, welding and milling) are ideal customers, developers need to determine whether it is worth the additional capex to increase the grid's capacity to serve these customers. Highly efficient appliances therefore have a key role as they reduce the capex required to provide a defined level of service. These are typically more expensive than standard machinery, tools and appliances and consumer financing support is therefore required.

Electricity tariffs also need to be simply packaged and well communicated. If not, it is easy to create a perception amongst users that they are being misled (customers struggle to track and manage units).

To ensure a large number of early adopters when the grid is being set up and to properly communicate the available tariffs, sales personnel are also required for door to door marketing. Tariff bundles based on typical appliance use seem to work well (e.g. a TV bundle that would allow a user up to 4 hours of TV and a couple of lights and the ability to charge 2 phones). This is because the consumer has the assurance of getting a clearly defined level of service when he makes a payment.

Pay back periods for mini/micro grids are long, between 3 – 7 years, with AC grids having longer pay back periods than DC grids. This makes it difficult for developers to mobilize commercial finance. In addition, to be a commercially interesting venture, a mini/micro-grid business needs tens to hundreds of thousands of customers (about 30 – 500 sites). Considering access to finance and commercial viability challenges, it is challenging for private mini/micro-grid developers to scale to these levels.

3.5 FEE FOR SERVICE MODEL

The fee for service model is similar to the mini/micro-grid system, with the difference being that electricity services are provided through stand-alone systems as opposed to a distribution network. The model is well suited to providing electricity to dispersed communities, where large distances between customers make mini/micro-grids unviable. In its simplest form it is applied as a lantern rental model, where customers are provided with a rechargeable lantern and pay a fee for charging the lantern.

Ownership of the systems is not transferred to the customer and the business/project is entirely responsible for maintenance and replacement of the systems. To be sustainable, the model requires large clusters of customers in a given area of operation. A significant upfront cost has to be borne by the developer and consequently the payback periods are long (unless the systems are partly subsidized). For this reason, it has yet to be implemented in East Africa as a fully commercial model.

The model is suited for:

- Low income customers i.e. those for whom a Tier 0.5 - 1 service level would suffice but cannot afford the 6-10$ required to purchase a task light
- Provision of micro-grid services (Tier 2.5 - 3) in areas where customers are too sparsely populated and to customers who would be unable or unwilling to purchase a large solar system

The model may not be suitable for Tier 1.5 – 2 especially where fee for service payments are comparable to PAYG repayments; customers would be more inclined to have their payments contribute to owning the system.

With some East African governments (e.g. Rwanda and Kenya) now considering solar home/business systems as an off-grid electrification option, this could prove to be a suitably effective and sustainable implementation model for areas where grid extension or mini-grids are not technically or economically viable.

4. MODEL COMPARISON

Different models are suited to different market segments as demonstrated by the comparison of delivery models and product/service pricing in Table 5 and Figure 2 below:

- The retail model is best suited for task lighting products (tier 0.5);
- The PAYG and consumer financing models are suited for general lighting and phone charging systems (with or without TV) (tier 1.5 & 2) and;
- The fee for service model is suited for tier 0.5 and tier 1 (especially where income levels as very low and customers cannot afford to make an outright purchase of a task light). It is also well suited for tier 2.5 and 3 (when PAYG becomes too expensive for large solar PV systems)

The micro-grids surveyed as part of the study can provide 5 - 100Wp per customer on average. Household customers who typically consume <50Wp pay 3-8$ per month, while small businesses would pay 10-15$ per month on electricity. These monthly costs are lower than PAYG system costs for a similar level of service. Mini/micro-grids can therefore provide the spectrum of electricity services at a lower cost than the other business models. Their major disadvantage is that they can only be implemented in locations with high population density.

Although it has potential, the fee-for-service model is very difficult to run sustainably on a fully commercial basis. Some level of subsidy will be required to reach deliver a certain volume of systems, at which point sufficient revenues can be collected from existing customers to sustainable finance operations and expansion. It is also important to note that where there are overlaps between PAYG and fee-for-service solutions, customers prefer to pay to own the system as opposed to endlessly paying fees for electricity services.

As shown in Table 6 below, the retail and PAYG models are delivering relatively large volumes of pico-solar and solar PV systems to the market. Both models also create a good number of sales, customer service and technical jobs (mostly for rural youth) as well additional income generating opportunities for rural distributors and retailers.

PAYG companies have charted a path for the solar home system lighting market in Africa and demonstrated the role of consumer financing in significantly increasing uptake of off-grid solar PV solutions. The risk appetite for PAYG businesses is relatively high, as illustrated by the fact that they have much lighter handed customer vetting processes than traditional financial institutions. Generally PAYG customer delinquency and default rates information is not publicly known, although assumed to be below 3%. This makes it difficult to determine how long these companies will continue to have such a high risk appetite.

Although solar PV sales through consumer financing (via financial institutions) are currently low, there are indications that this could change. Most financing institutions have already adopted mobile money transaction systems and the success with PAYG could see them venturing in a bigger way into what they consider as their area of specialization. Furthermore, with the increasing availability of high quality products and dedicated solar companies, financing institutions don't have to worry as much about customers defaulting due to non-performing systems.

FIGURE 2: MODEL COMPARISON – SUITABILITY OF MODELS

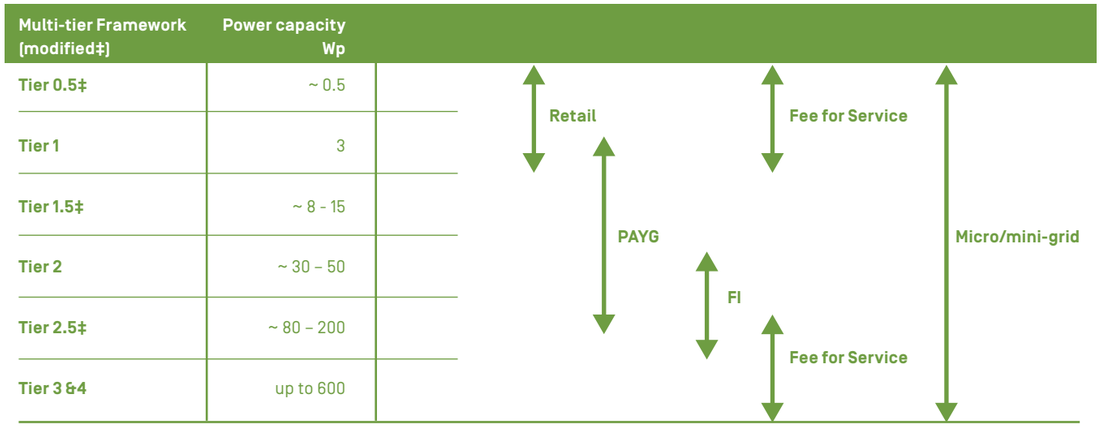


TABLE 5:
COMPARISON OF SOLAR PV DELIVERY MODELS BY MARKET SEGMENT AND CONSUMER PRICES

Multi-tier Framework [modified‡]	Power capacity Wp	Delivery Model	Retail Price $	Deposit $	Daily fee $	Monthly cost $
Tier 0.5‡	~ 0.5	Retail	5.5 - 10			-
		Fee for Service		0 – 1.2		0.3
Tier 1	3	Retail	30 - 60			-
Tier 1.5‡	~ 8 - 15	PAYG		19 – 35	0.2 – 1.25	6 – 38
		Fee for Service		6 – 9	0.15 – 0.2	4.5 – 6
Tier 2	~ 30 – 50	PAYG		62	0.6	18
		Consumer Financing (via FI)	400		0.8 – 1	25 – 30
Tier 2.5‡	~ 80 – 200	PAYG		18 – 25	0.8 – 1.2	25 – 35
		Fee for Service		55 – 80	0.2 – 0.5	7 – 14
Tier 3	up to 400	Fee for Service		90	0.6 – 0.7	18-20

TABLE 6:
COMPARISON OF SOLAR PV DELIVERY MODELS BY ANNUAL UNIT SALES/NUMBER OF CUSTOMERS AND JOBS CREATED

Delivery Model	Units Sold/Customers per business	Full-time jobs created	Other jobs
Retail	50,000 – 300,000	40 – 50	40 – 50 distributors 500 – 3,000 retailers
PAYG	30,000 – 100,000	1,000	1,000 commission based agents and technicians
Consumer Financing (via FI)	2000	30	30 part time technicians
Micro-grid	500	10 – 50	10 – 20 Point of sale agents and local technicians
Fee for service	1,000	40	10 part time technicians

5. CROSS-CUTTING ISSUES

5.1 EMPLOYMENT

All solar PV delivery models require rural personnel to undertake marketing and provide technical services (installation, maintenance and troubleshooting of systems). Most models also require the establishment of customer service system. Solar PV businesses therefore provides a unique employment creation opportunity for rural youth e.g. a PAYG company selling 100,000 systems/year would require about 800 rural sales personnel (considering an average of 10 system sales per month per sales agent) and an additional 200 - 400 rural technicians.

Even though most sales jobs will be commission based and thus not be permanent, the training and experience gathered by the youth will be invaluable for their future endeavors and will stimulate the entrepreneurial spirit in some. Since there is a general need for rural sales and technical personnel in the solar PV subsector, and companies are separately developing and delivering their own training courses, it may be worthwhile considering standardizing the development and delivery of such courses.

Such courses could focus on key topics e.g. how to make a sales pitch, targeted marketing (knowing where and who to sell to), planning and scheduling sales activities (knowing how to effectively cover a target area) and reporting. The courses would be generic, with companies recruiting these trainees only having to provide additional training specific to their product and delivery model.

Additional mentoring once sales staff have been deployed is also necessary. Those who are new to sales will need a duration of support and encouragement, for experienced sales staff, management training is also required to help them coordinate, manage and support small teams of sales agents

5.2 POLICY AND REGULATORY FRAMEWORK

The key role that the private sector can play in rural electrification through stand alone or mini/micro-grid solar PV solutions is often overlooked or misunderstood by government. Estimates for the cost of extending the grid to connected off-grid rural customers range from 1,000 – 3,000$ per connection. Considering that these customers will spend 2.5 – 30$/month on electricity, other electrification alternatives need to be considered.

Public electricity utilities are typically instructed by governments to serve rural customers. However this translates to high operations and maintenance (O&M) costs for them and little revenue. The bulk of revenue for large electricity utilities is primarily from large commercial and industrial consumers. Utilities therefore have little commercial incentive to serve small rural consumers, subsequently the level of service provided to them is generally poor.

In addition, lack of clarity/accuracy from government regarding rural electrification plans leaves potential customers and solar PV providers in limbo. Complementarity between government electrification initiatives and plans and private sector solutions should be sought as it will enable the fastest and most cost effective approach to achieving electricity access.

When it comes to implementing mini-grids, the public and private sectors have different and complementary strengths. The government/electrification authorities can mobilize large amounts of public funding (e.g. through levies, grants or government borrowing) to implement mini-grids at scale (in terms of number of systems and the size of systems). In addition, this type of public investment is considered a social investment; governments are not looking for a financial return on investment. On the other hand, the private sector's strength lies in speed, efficiency, cost effectiveness and the ability and flexibility to innovate (i.e. quickly adopt or adapt new technologies as they emerge). One could therefore expect that the most effective mini-grid models would be based on well-designed public-private partnerships.

Ways through which the public and private sectors could collaborate on mini-grids includes:

- Interconnecting private mini-grids to the main grid if/when the main grid is extended. This way private developers could continue to serve the customers on their grid (with cheaper main grid power) and would also have the opportunity to sell RE power to the grid operator. As private mini-grid developers cannot compete with electricity prices offered by the main grid, the extension of the main grid is currently considered a business risk rather than an opportunity. A regulatory framework to guide this would need to be established as the regulator would require that customers be charged national tariffs (including the lifeline tariffs) which may not be cost reflective for the private developer.
- Private mini-grid developers are compensated; when the grid is extended or the government implements a mini-grid to serve the same customers
- An off-grid power purchase agreement model i.e. the private sector focuses on generation while the public utility (which can manage and extend electricity cross-subsidies) focuses on distribution. This way the private investors are guaranteed a return on investment while mini-grid customers can benefit from electricity cross-subsidies.
- Government undertakes national studies to identify potential mini-grid sites and provides a clear plan on where the government will implement mini-grids or extend the grid (and when) and which sites will be available for private sector.

6. HOW FINANCIAL SUPPORT COULD BE TARGETED

The models discussed in this study, even those already achieving scale, might still require financial support for uniquely different reasons as elaborated below, particularly targeting initial, set up costs or sector generic issues (as opposed to funding for running costs):

- For the retail and PAYG model, identification, training, recruitment and support of rural based staff/agents providing sales or after sales services would be difficult to do effectively with purely commercial funding. Acknowledging that some of the skills that these rural based staff/agents would learn would be applicable to other entrepreneurship or employment opportunities is good justification to support such capacity building activities with grant funding

- Considering that PAYG businesses assess risk by analyzing the payment patterns and customer characteristics of their existing portfolio and use this to quantify the default risk for the future portfolio, in new countries/markets soft funding to establish this initial portfolio of customers would help in minimizing the commercial risk to the PAYG business

- Soft funding for innovations in PAYG delivery models and/or products that significantly reduce the repayment fees would contribute to making off-grid solar PV solutions affordable for low income segments of the population

- Off-grid markets are remote and difficult to reach. Therefore distribution networks are key to ensuring that off-grid solar PV solutions can be easily accessed by the target market. However, there is a natural tendency for businesses to focus on easy markets i.e. those that have good road infrastructure, where there is high economic activity, where there are established and successful distributors and retailers (e.g. those that do not require credit terms). The implication is that certain regions in a country remain unserved or underserved and incentives are sometimes required for support businesses implementing retail and PAYG models to develop, support and grow distribution networks in these areas.

- The fee-for-service model can be very effective in providing electricity access in areas that are not viable for grid extension or mini-grids (due to low population density). Since the model is based on deploying stand-alone systems, it can be implemented almost anywhere a need exists and can be sized to meet the specific consumer needs. The fee-for-service model has also demonstrated the ability to provide higher levels of service at costs lower than PAYG model (thereby providing an alternative for consumers who cannot afford PAYG) as well as providing continuous maintenance services. The challenge of providing soft financing to fee-for-service companies is determining the amount of soft financing required for these companies to be self-sustainable and whether the required amounts can be provided through a single grant funded program (which would have budget and time constraints).

- To be commercially interesting, a mini/micro-grid business needs tens to hundreds of thousands of customers. Considering access to finance and commercial viability challenges, it will be challenging for private mini/micro-grid developers to scale to these levels without a sustained stream of soft-financing. Private mini-grid developers currently source for grant funds on an ad hoc basis (submitting applications/proposals whenever and wherever funds are available). However, the current donor good will for mini/micro-grids will run out before developers reach their target number of customers. Some dedicated long-term source for soft funding (not unlike rural electrification funds) will be required to support private mini-grid developers if they can demonstrate that they are more effective than public utilities or rural electrification authorities.