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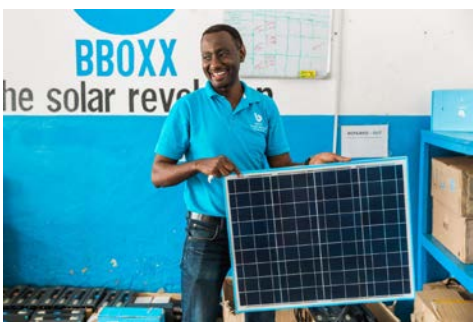
Based on a customer segmentation study of a major solar home system provider in Africa, this policy brief discusses the characteristics of this market and how companies can effectively target key customer segments. The brief also highlights the importance of leveraging social networks and promoting female participation to facilitate growth in this industry.



BBOXX staff in rural Rwanda.

UNDERSTANDING THE CUSTOMER BASE FOR SOLAR HOME SYSTEMS USING THE INTERNET OF THINGS

Ryan Kennedy, University of Houston

INTRODUCTION

As the price of solar panels continues to fall, off-grid solar power systems, like Solar Home Systems (SHS), are becoming an increasingly prominent part of strategies for expanding access to electricity (Jolly, Raven and Romijn 2012; International Energy Agency 2014). Unlike government programs for expansion of access to electricity grids, the management of off-grid solar systems rely on private service providers. These private companies, in turn, must understand and cultivate relationships with their end users. Using Internet of Things (IoT) data from BBOXX, a major SHS company in Africa, ISEP conducted a study of the customer base for SHS and the factors that make customers more likely to fall into particular behavioral patterns. The results emphasize the importance of low-demand high-reliability customers as the base for SHS systems. A finding that further supports the importance of off-grid solar solutions for rural electrification. They also emphasize the role of women and social networks in the development of this customer base.

More than one billion people still lack electricity in their homes (IEA 2017). According to the World Health Organization (2002), this lack of access results in about 1.6 premature deaths, due to indoor air pollution from use of firewood, biomass and kerosene. Moreover, this lack of access can inhibit the ability for children to study after dark, limit the time a household can dedicate to income generating activities, create fire hazards around the house, and limit access to information from TV, radio and cell phones (Chakrabarty and Islam 2011; Alstone et al. 2015).

To address this issue, the United Nations declared universal household energy access as one of the Sustainable Development Goals (SDG 7) and encouraged an annual investment of 1.058-1.266 trillion dollars into meeting this goal by 2030 (UNDP and UN Environment 2018). Much of this expansion is expected to come from developing countries extending access to the electrical grid to rural and underdeveloped areas.

Solar off-grid energy solutions, however, are also playing a key role in achieving these goals. Solar home systems (SHS) and solar mini-grids offer a range of advantages. Unlike their grid-based counterparts, which tend to rely on dirty coal-based electricity generation, or small petroleum and diesel generators, solar off-grid products use clean energy. This means that they do not contribute to the, already severe, air pollution problems in much of the developing world or to the global climate change challenge. Additionally, they do not place extra burdens on the usually underfunded and indebted energy providers. For most grid-based electricity providers, expanding access to households with generally low demand is not very profitable and can increase their high debt burdens. Off-grid systems are often designed to be profitable with relatively low demand, and, as we discuss below, this can become a core clientele. Moreover, off-grid systems can reach areas that are difficult to reach through grid extension. Some countries have physical barriers (e.g. islands or mountains) that make reaching some parts of the country with the grid extremely difficult. Other countries face barriers associated with distance and/or social conflict that make extension difficult. Off-grid solar systems, on the other hand, can work anywhere the sun shines and can easily be made available where the above-mentioned barriers inhibit grid extension. Finally, with the dramatic reduction in the cost of solar panels, and the low labor costs in developing countries, off-grid products can be profitable, even when focused on individuals with relatively low incomes and low energy demands.

"Much like the market for micro-finance, off-grid systems in the developing world are often targeted towards households in impoverished areas, who cannot get access to regular grid electrification. This makes an understanding of the market characteristics critical for successful expansion."

The fact that most of these off-grid efforts are being conducted by private companies, sometimes with help from government subsidies, presents some unique challenges. Much like the market for micro-finance, off-grid systems in the developing world are often targeted towards households in impoverished areas, who cannot get access to regular grid electrification. This makes an understanding of the market characteristics critical for successful expansion. Moreover, traditional methods of gathering market materials through surveys has proven less accurate when compared to direct measurement of customer behavior (Blodgett et al. 2017).

This policy memo reports the results of a project by ISEP and a leading SHS provider in Rwanda and Kenya, BBOXX, to analyze their customer base using Internet of Things (IoT) technologies. Using direct observation of customer behavior on three dimensions, we are able to split the customer base into seven groups and determine the demographic characteristics that make a customer more likely to fall into these clusters. The findings provide guidance for how off-grid efforts can effectively expand their market among their core customers.

OFF-GRID TECHNOLOGY AND THE INTERNET OF THINGS

One of the unique aspects of BBOXX's technology – which includes a 50W roof mounted solar panel, a battery and six DC outputs – is the application of IoT to enable to continuously monitor the use of their systems for better performance and maintenance. This technology also allows greater control of their Solar Home Systems (SHS), which lowers the risk to investors, allows for proactive maintenance, and leverages mobile data networks for data transfer and mobile payments (Bisaga et al. 2017).

For our purposes, the most interesting aspect of the IoT application is the data stream it produces. BBOXX's SMART Solar platform regularly updates a comprehensive database on customers' behavior. The resulting dataset, stored in the company's database, is the largest and most detailed of which we are aware in developing countries, with a large number of customers observed on a granular (daily) level. Our research uses daily data from 34,811 customers for a little over one year's time – from April 2017 to May 2018.

We look at three main dimensions of customer behavior. First, contract performance is the degree to which the customer is current on their electricity payments. BBOXX leverages mobile payments to allow users to pay-as-they-go for electricity. Second, we look at the customer's energy limit, which is their allowed consumption based on the number of appliances they have for use with the BBOXX system. Customers who purchase more appliances, and therefore have a higher energy limit, should, in principle, be more profitable. Finally, we look at the customer's energy utilization, which looks at the percentage of the time the system is switched on, and can be used to detect when customers are in a "grace period" due to late payments or other issues.

We analyze this data on the aggregate level, looking at the average on the three dimensions over the customer's contract time. We utilize an automated machine learning algorithm (k-means clustering) to segment the data into seven different customer types.[1]

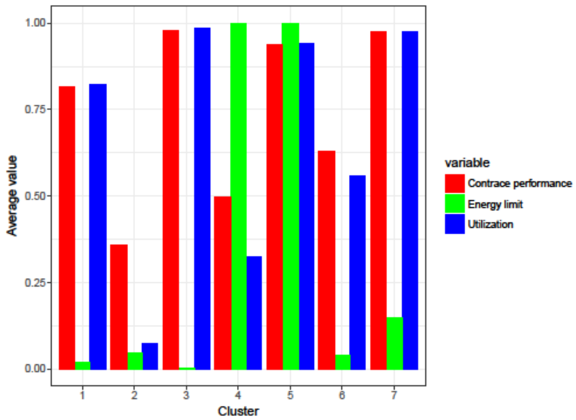
TYPES OF CUSTOMERS

Figure 1 shows the breakdown of the customer types (Figure 1a) and the number of customers in each category (Figure 1b). What these show is that the core customer for BBOXX falls into Cluster 3, with more than four times the number of members of any other category. Customers in this cluster score high on contract performance and utilization, but do not purchase many extra appliances (and, therefore, have a low energy limit).

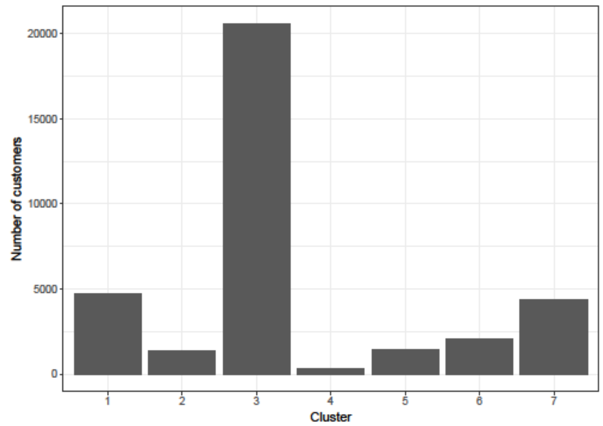
These results likely reflect the situation for many other off-grid solar providers in the developing world. Their core customer base is unlikely to have a high demand for additional appliances to work with the off-grid system. Rather, their core demand will be for enough power to run a light during the night, charge a mobile phone as needed, and, in warmer climates, run a fan during the day (Aklin et al. 2017). This is important to note for these companies, since it is an entirely different customer base from what one might think a revenue-maximizing grid electricity enterprise would want to acquire. While we will not go into detail about the results in this policy brief, we do note that simply trying to characterize customers in terms of maximizing on energy limits, contract performance and utilization can produce very misleading results.

[1] The number of clusters was determined by the gap statistic method (Tibshirani et al. 2001).

Figure 1: Customer segmentation among BBOXX customers



(a) Values of customer characteristics for 7 cluster model.



(b) Number of customers in each cluster

HOW TO RECRUIT CORE CUSTOMERS

One of the most emphasized findings in the study of micro-finance has been that women are more reliable customers of micro-finance than men (e.g. Boehe et al. 2013). We find a similar pattern for SHS systems in Rwanda and Kenya. When female members of the household are denoted as the customer, they are more likely to be a member of the core customer cluster (cluster #3) identified above. These are customers that do not purchase additional appliances, but pay their bills on time and use the systems that they have. Conversely, male customers are more likely to fall into the clusters that are low on all three dimensions or are moderate in terms of contract performance and utilization. Of course, it should also be noted that men still make up the large majority (about 86% in this sample) of overall customers.

We also note the importance of social networks in the recruitment of the core customer base. While it should not be surprising that word-of-mouth is a good way to sell a product, whether that results in higher-quality customers is an open question. The assumption behind why word-of-mouth helps with purchases is simply that it makes more people aware of a product and provides a signal of the products quality and utility. For the customer to perform better, however, suggests that there is some social network selection happening – either membership in a social network through which product information flows is correlated with the conditions facilitating quality customers or current customers are selecting members of their social network they think will be good customers for the product.

In either situation, we find that those who are recruited by word-of-mouth are more likely to fall into that core customer group (cluster #3). Moreover, they are less likely to fall into undesirable clusters that have low contract performance. For comparison, those who are recruited through the company's agents are also more likely to fall into the core customer group, but they are no less likely to fall into one of the more undesirable groups. This is consistent with agent incentives. Agents are trying to meet sales goals, so trying to get customers who purchase more appliances is beneficial to them, but there are simply more low-use customers in these areas. Agents are then acting as a less effective screen than customer referrals for the subsequent reliability of the customer.

Initiative for
Sustainable Energy Policy
Energy, Resources and Environment
Rome Building, 4th Floor
1619 Massachusetts Ave, NW
sais-isep@jhu.edu
@sais_isep
www.sais-isep.org

These results suggest some strategies for companies to pursue in expanding their customer base, specifically marketing to women and encouraging word-of-mouth recruiting. Both of these are not only traditionally effective marketing techniques, but, specifically, a way to recruit the kinds of customers the company wishes to target. It seems intuitive that these lessons apply to more off-grid companies than just BBOXX.

POLICY RECOMMENDATIONS

- *"Internet of Things" (IoT) technologies can provide a more detailed and accurate gauge of customer behavior than traditional marketing surveys.*

- *The core customer for off-grid systems in the developing world are those who are good at paying their bills on time and using their systems, but do not purchase additional products (at least not initially). These are exactly the types of customers that are less likely to be served by grid expansion because of their relatively low demand.*

- *In terms of expanding the base of these core customers, off-grid companies may want to emphasize marketing towards women and through word-of-mouth. These groups are more likely to fall into this core customer base and are less likely to fall into undesirable customer segments.*

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About ISEP

The Initiative for Sustainable Energy Policy (ISEP) is an interdisciplinary research program that uses cutting-edge social and behavioral science to design, test, and implement better energy policies in emerging economies.

Hosted at the Johns Hopkins School of Advanced International Studies (SAIS), ISEP identifies opportunities for policy reforms that allow emerging economies to achieve human development at minimal economic and environmental costs. The initiative pursues such opportunities both pro-actively, with continuous policy innovation and bold ideas, and by responding to policymakers’ demands and needs in sustained engagement and dialogue.

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