



A business model for success: Enterprises serving the base of the pyramid with off-grid solar lighting



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ABSTRACT

Basic electric service is essential to sustainable development, yet for remote rural areas, connecting to an electric grid can be economically and geographically unfeasible. Firms have sought to bring basic electric service to isolated and impoverished rural areas using off-grid solar lights and solar home systems, but often meet challenges common to base of the pyramid (BOP) markets. This article examines the intersection of theories related to successful business models for enterprises serving the base of the pyramid and studies of off-grid renewable energy enterprises. It identifies relevant and overlapping themes, and creates a framework for a successful business model that includes four primary components: community interaction; partnerships; local capacity building; and addressing barriers unique to the off-grid market, including financing, education, and development of distribution networks.

1. Introduction

Globally, more than 1.2 billion people lack access to electricity, or approximately 17% of the global population [26]. In India, 20% of the population lacks access to electricity, while in Sub-Saharan Africa, that number is close to 70% [25]. The consequences of the most common alternative forms of energy are by no means benign. The pollution caused by burning kerosene (used for lanterns) and biomass (used for heat and cooking) causes significant negative health effects, including respiratory irritation, pneumonia, bronchitis, and death [70,2,11,54]. Studies suggest the high majority of those living without electricity are poor individuals in developing nations without access to the electric grid [30]. For this reason, the challenge of energy access cannot be separated from the challenge of serving isolated, rural areas, or of working with individuals living in poverty, without ready access to commercial institutions and markets. These specialized markets are generally defined as the “base of the pyramid” (BOP) [35,27].

Numerous studies have explored the importance of energy access to improved education and economic development [10,42,44,9]. Access to electricity creates a virtuous cycle of improved health and education, increased productivity and gender equality, and economic development [10,33,66,4]. For example, access to electricity increases the likelihood that children will be able to attend and complete schooling; it also helps retain excellent teachers which enhances the overall quality of education [71,72]. Increased education may lead to increasing employment and higher levels of productivity, which lead to economic gains, greater food security, and better health care [71]. Alstone et al. [4] have shown

a high correlation between energy access and the human development index. Energy access is widely considered a necessary—though not sufficient—condition for improving human development [12]. For these reasons, access to affordable and clean energy is one of the new United Nations Sustainable Development Goals [61].

In rural areas lacking access to the electricity grid, off-grid solar lighting products can provide an interim solution at a lower cost than existing alternatives. Off-grid solar products, which include individual solar lanterns, solar charging docks for mobile phones (often included with an individual lantern), and solar home systems are cleaner, safer, and cheaper over time than the monthly cost of kerosene, the primary alternative used for lighting in developing nations [28,29]. Importantly, in comparison to alternatives such as biomass, kerosene, and diesel fuel (used in generators), solar products significantly reduce carbon and other greenhouse gas emissions [3].

The market for small solar lighting and charging units and small solar home systems has increased exponentially since 2012 [4,15]. Estimates suggest that a \$31 billion market exists for solar lights and household-level solar home systems [27]. One of the challenges of selling off-grid solar products, however, is working in a “base of the pyramid” (BOP) market, the market segment constituting over half of the world's population which is characterized by an annual incomes of less than \$3000, and a lack of formal institutions and commercial entities [35,36,51,71,48,49,68].

Within the BOP, gaps in supply chains, deemed “institutional voids,” result in significant challenges in manufacturing, distribution, and marketing [32,45]. However, Parmigiani and Rivera-Santos [45]

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have shown that the impacts of institutional voids vary based on characteristics of the enterprise. Accordingly, they have suggested that more research needs to be done in individual subsistence markets to determine how firms react to and overcome specific institutional voids facing the industry.

The purpose of this article is to answer the call posed by Parmigiani and Rivera-Santos, explore the evolving market for off-grid solar lighting products, and identify and describe key characteristics of successful business entities serving the BOP with off-grid solar products. The article first reviews the specific characteristics of the market, including challenges related to financing, distribution, and education in local communities where the products are to be sold. Next, unique characteristics of BOP markets are identified, as are significant barriers and key issues common to efforts to bring renewable energy technologies and basic energy access to areas lacking these basic services. Overlapping themes and common recommendations identified from relevant streams of literature are identified, and based on this review and analysis a set of conclusions, including a business model framework for serving the off-grid solar lighting market, is offered.

2. Market analysis: off-grid solar lighting products

For millions of people living in remote rural areas, high voltage transmission lines are prohibitively expensive, making off-grid and distributed resources essential for energy access [24,40]. The International Energy Agency (IEA) has estimated that, in order to provide universal access to basic energy services, including access to electricity, 55% of additional generating resources will need to come from off-grid or micro-grid projects [24]. Fully extending transmission lines to remote rural areas represents the highest possible marginal cost both because of the distances involved and the difficulty of traversing undeveloped landscapes. Extending an electric grid across developing nations is suitable for urban areas and about 30% of rural areas, but simply not cost effective for remote areas [24].

The inability to offer grid-connected services leaves off-grid solar applications as an obvious alternative. Many have likened the potential for growth in the off-grid lighting market to the exponential growth observed in the adoption of cellular phone technologies. In Africa, the number of new subscribers for low-end mobile phones has increased 30% a year for the past ten years, illustrating the potential for adoption of new technologies, even in extremely low-income populations [60]. Similarly, conservative estimates of the growth in firms selling solar home systems range from 40% to 70% [60]. Considering that the alternative market for poor-quality energy access, including kerosene, is estimated at \$37 billion annually, there remains enormous potential for market growth for solar lighting products.

For households without access to electricity, kerosene lamps are the most common alternative lighting source [28,29]. Kerosene has a number of drawbacks, including significant negative health effects from the pollutants emitted by burning lamps, and the danger of house fires from tipped lamps [34]. Kerosene can also represent a significant portion of the monthly income for families and individuals living at the BOP [47]. Rural poor individuals are doubly disadvantaged, because they pay a premium for kerosene relative to their urban counterparts [28].

The benefits of access to solar lighting are numerous. Because they do not have ongoing fuel costs, off-grid solar lighting systems are generally less expensive over time than kerosene, allowing individuals to recoup their initial investment costs in a matter of months [47,28]. The absence of harmful emissions is a benefit to users on an individual level, and on a global level because of the decrease in greenhouse gasses emitted from burning kerosene [59]. Solar lights can also extend individuals' ability to engage in income-generating activities and increase the time for children to be able to study [59].

Despite the benefits, as in most subsistence markets, persistent challenges inhibit the development of the market for off-grid solar

lighting. First, although cheaper in the long-run than kerosene, the upfront costs of solar lighting products can be prohibitive to people living at the base of the pyramid [1,21,33,47]. Enterprises seeking to become successful in the off-grid solar lighting market must find ways to provide financing for customers, either through micro-finance, traditional government subsidies, installment payments, or newer, innovative models such as a "pay as you go" plan, in which the consumer pays for usage and mobile technology is used to monitor, turn on, or shut off the product [28,60]. Access to financing is also crucial on an enterprise basis, as financing is necessary to fund distributors, smaller enterprises, and local entrepreneurs [28,6].

Another key barrier to the successful development of markets for off-grid solar lighting is the lack of a distribution network, particularly the "last mile" capacity to deliver products in remote rural areas [27,29]. Similar voids hampering the growth of the market are a lack of capacity to repair and service products after sale [33,62]. After-market service and disposal of products, which may contain hazardous materials, have been found to be key to the adoption and sustainability of renewable lighting enterprises [1,47,29].

Because solar lighting represents a new technology, trust and information sharing are essential in gaining approval and adoption [8,19,63]. A number of studies suggest that a lack of knowledge about solar products and a lack of trust in their reliability represents a significant barrier to adoption [47,28,29,56]. Inadequate quality controls and unreliable goods in some areas have magnified mistrust and created a reluctance to adopt solar lighting products [29]. Solar home systems in particular require technical expertise in sizing and design, installation, and maintenance, which creates significant barriers to both adoption and continued use [58,59].

3. Serving the BOP

Although no single definition of the BOP exists, it was originally characterized as the 70% of the world's population that lives on less than two dollars a day [31,48]. More recent definitions have tied the definition of the BOP to those individuals with an annual income of less than \$3000 purchasing power parity (adjusted to 2005 U.S. dollars) [35,71]. This puts the BOP above the poorest individuals (those living on less than a dollar a day) but below what may be considered the "mid-market" segment, which ranges in annual income from \$3000 to 20000 (WRI & IFC, 2008). BOP markets are commonly, though not exclusively, located in rural areas, and are found primarily in Asia, Africa, Eastern Europe, Latin America, and the Caribbean (WRI & IFC, 2008). However, it is not simply income or geographic location that characterizes a BOP market; BOP and subsistence markets exhibit significant differences from more affluent markets, which call for unique and individualized business models and strategies [18,37,49,50,52]. Because the majority of individuals without energy access exhibit subsistence-level income, it is crucial for businesses seeking offer off-grid solar products in these markets to study the unique aspects of the BOP; more affluent markets, even those within developing nations, simply do not share the same characteristics, and business strategies must be adapted to these unique challenges.

A key identifying characteristic of BOP markets is a reliance on informal institutions, including relationships and networks, rather than formal economic structures and institutional governance [16,37,51]. Because subsistence communities often lack commercial organizations and institutions, successful BOP ventures need to develop a network of partners both public and private, including local entities that can help build trust and stand-in for a lack of institutional stability [68,51]. The need for local partners increases as the BOP venture moves into more remote communities that are physically and economically distant from their sponsoring or central institutions [52].

The lack of formal structures and institutional voids in the areas of regulations and contracting significantly impact commercial operations in BOP markets. Organizations serving BOP markets will often need to

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