Barriers to the Uptake of Off-Grid Solar Lighting Products in Bihar

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ABSTRACT
The federal government of India and the state government of Bihar, India’s least electrified state, have always focused on grid expansion to bring power to those living without grid access. However, grid expansion has been slow. In Bihar, 83% of people still live without electricity, relying on dangerous kerosene lamps to light their homes. In the 1980s, an alternative—a market for solar home systems and solar lanterns—started to develop in Bihar. Yet, this market has failed to thrive, despite three decades of intervention by the government and activity by private companies. Today, fewer than 4.2% of unelectrified Bihar households use a solar lighting product. Based on interviews with key stakeholders, this case study found that the biggest obstacle to market growth is the government kerosene subsidy, which halves the price of kerosene, and makes people less interested in solar lighting products. Lack of company financing, product quality issues, lack of customer awareness of the benefits of solar, and another counterproductive government subsidy for solar products are other challenges that hamper market growth. Interviewees also identified factors promoting the growth of the sector, including the large unmet electricity demand and unreliable electricity supply, and dropping solar prices. Overall, there is significant potential for market growth if strategies are developed by key stakeholders to help overcome the challenges identified in this case study, and build on the factors promoting the sector’s growth. Most importantly, the government needs to re-think their subsidy policies and adopt a stance to encourage market forces.

KEY MESSAGE
Readers of this case will
1. gain a basic understanding of the importance of off-grid solar lighting products and how these products can help improve people’s health and reduce environmental impacts;
2. understand why, despite significant potential, the growth of the off-grid solar lighting products market in Bihar, India’s least electrified state, has been slow;
3. gain an understanding of the challenges faced by off-grid solar lighting product companies in Bihar and the factors that drive growth of the sector; and
4. understand how Indian government subsidies in general, and subsidies for kerosene in particular, impact the adoption or impede the adoption of renewable energy alternatives.

INTRODUCTION
The International Renewable Energy Agency estimates that 1.1 billion people—one in every seventh person in the world—does not have access to electricity [1]. Most people without electricity access live in rural areas of low or lower-middle income countries and use kerosene lamps for lighting purposes. The use of kerosene lamps causes serious health problems for these people, including chronic illness due to fume inhalation, severe burns, and poisoning. For example, an Ecologic Institute report states that 2.5 million people in India suffer severe burns from overturned kerosene lamps every year [2]. People who use kerosene lamps regularly complain about poisoning caused by kerosene fuel ingestion, which is particularly a problem for young children [3]. Use of kerosene lamps also impacts the environment. Kerosene lamps emit carbon dioxide (CO2) and black carbon—both of which contribute to global warming. The use of kerosene lamps worldwide emits an estimated 270,000 tons of black...
carbon per year, which has a climate warming equivalent of about 240 million tons of CO₂—about 4.5% of the United States’ total CO₂ emissions [2].

However, policymakers and researchers involved in the electricity sector have stated that extending the centralized electricity grid to off-grid areas in many countries may not be economically feasible, and even if it is possible, will happen very slowly. This means that other solutions are needed to help uplift the millions of people in the world who suffer from energy poverty. One solution with great promise is off-grid solar lighting products, which are solar energy-based alternatives to both grid power and kerosene. Several international agencies, governments, nongovernmental organizations, and companies have been trying to promote this alternative since the 1980s. Due to their efforts, markets for off-grid solar lighting products have begun to develop globally. Today, off-grid solar lighting products, such as solar lanterns and solar home systems, are increasingly seen as a clean energy option that can help fill the large global electricity gap and improve people’s health, without harming the environment [3, 4].

An off-grid family may own one or more off-grid solar lighting products, depending on their needs and means. Solar lanterns (Figure 1), the simplest product type, usually serve basic lighting and mobile charging needs [4]. Solar lanterns are small, have a low wattage (0.1–10 watt) and are sold for as little as US$5 [4]. They typically have a small solar panel that plugs into and charges a light. The simplest models have a two-sided light on a stand (on one side is the light, and on the other is the solar panel). Solar home systems (Figure 2) are a larger, more powerful product that can power an entire house. The simplest version of a solar home system consists of a solar panel, a charge controller, and a battery. The solar panel is kept out in the sun during the day, generating electricity, and excess electricity is stored in the battery for night-time use. Depending on the size of the panel, a solar home system can power a few lights and charge a few mobile phones or can power larger appliances like fans and a television. The wattage of solar home systems ranges between 8 and 200 watts, and the cost ranges from US$20 to US$600 [4].

Today, approximately 89 million people in Africa and Asia are using these products, and the sector holds tremendous potential for further market expansion [3]. However, in India, markets for off-grid solar lighting products have grown slowly—despite the fact that almost 300 million people live without electricity, making this country the world’s largest off-grid market [3]. Even the northern state of Bihar (Figure 3) has not seen much progress in the adoption of off-grid solar lighting products. Bihar, a state of 100 million, has the lowest percentage (16.4%) of electrified households in India, meaning about 83 million
people have no access to the electricity grid—equal to roughly one-fourth of the current off-grid population of all 20 East African countries combined [5]. Despite Bihar’s large off-grid population—and large potential for use of off-grid solar lighting products—almost 83% of households in Bihar continue to use kerosene lamps. This represents the highest percentage of household kerosene lamp usage of any state in India. Bihar, the third most populous state in India, is also among the top five poorest states in the country. Only between 3.23 and 4.2% of unelectrified households in Bihar use off-grid solar lighting products (about 662,420 households out of a total of 15.8 million unelectrified households) [6]. This can be compared to Kenya, a country with comparable rates of rural electrification, where 30% of unelectrified households use these products [3]. The companion article on Kenya highlights how Pay-As-You-Go business models based on mobile banking, along with other factors, have helped in accelerating diffusion of off-grid solar lighting products in Kenya [7].

This case study will examine why, despite Bihar’s large market potential, the overall penetration of these products has remained low. Little research exists regarding Bihar’s off-grid solar lighting products sector. Literature about the off-grid solar sector in India outlines some general factors that hinder the sector’s growth in the country: off-grid companies find it hard to access financing [4, 8–11]; the quality of off-grid solar products is poor, creating a negative image for solar products among rural customers [9, 10, 12–14]; and rural customers have limited and irregular incomes, which hinders their ability to buy products [4, 14]. In contrast, the federal Ministry of New and Renewable Energy is providing subsidies that drive growth of the sector [10, 11, 13, 15].

Because little research exists about Bihar, this case study is based on original research and data collection. It draws on 13 semi-structured interviews, conducted in February 2017 with four key stakeholder groups—government, companies, experts, and financial institutions. While the majority of the interviews were conducted in Bihar, three interviews were conducted with representatives of international companies in Kenya who had previously worked in Bihar’s off-grid solar lighting products sector. The following case study uses the results of these interviews, along with additional data gathered from secondary sources, to discuss the challenges and opportunities faced by companies involved in the off-grid solar lighting products sector in Bihar. It begins with an examination of how the sector has developed in Bihar, which helps to understand both its challenges and the opportunities for overcoming those challenges.

**CASE EXAMINATION**

**History of the Bihar Off-Grid Solar Lighting Products Sector**

Off-grid solar lighting products first appeared in Bihar in the late 1980s, when the federal government started distributing solar products under an India-wide village electrification scheme. In 1987, the Bihar state government created the Bihar Renewable Energy Development Agency (BREDA), which was responsible for implementing the federal government’s village electrification scheme [16]. The agency was tasked with distributing a small number of solar lanterns to off-grid families [16, 17].

Off-grid solar lighting product distribution was negligible throughout the 1980s and the 1990s—until the federal government began supporting private companies and individuals to start “Akshaya Urja” (“renewable energy”) shops that sold solar lighting products. Shreya Jai, an Indian journalist who has researched and written
extensively about the sector, states, “In the mid 1990s, private sector companies entered the market for the first time when the federal government started promoting Akshay Urja shops” [18].

Although the uptake of these shops was low, it was the beginning of private sector involvement in the off-grid solar lighting product space. Several interviewees said that during the early 2000s, big domestic Indian companies like Tata started manufacturing and selling off-grid solar lighting products [18, 19]. At the same time, both small regional companies and international companies like Greenlight Planet entered the market in Bihar and started selling off-grid products to customers in various parts of the state. Sudipta Ghosh, Assistant General Manager of SELCO Solar Light Pvt Ltd, a large solar company in India that assembles and sells products in Bihar, said that today, every district in Bihar has several shops selling solar products [19].

In 2009, the federal government enacted various programs and schemes for promoting solar energy, including a few that deal with off-grid solar lighting products. Currently, the federal government runs two subsidy programs to promote the uptake of these products. In the first program, the federal government provides a 30% direct discount subsidy on all off-grid solar lighting products that state agencies procure and distribute to unelectrified households [16]. For example, in Bihar, this subsidy money is passed onto beneficiaries by BREDA, the agency responsible for distributing off-grid solar lighting products in the state. In the second program, the federal government provides a 40% direct discount subsidy on a solar product, and then provides a subsidized low interest loan for the additional 60% of the product cost [16]. This program is implemented through the government controlled National Bank for Agriculture and Rural Development (NABARD). Table 1 provides a breakdown of the number of solar home systems and solar lanterns sold and distributed in Bihar by both government agencies and private companies.

The interviewees also explained that Bihar’s current private sector market for off-grid solar lighting products is fragmented, with a large number of small companies selling these products through their shops [18, 20]. These shops may or may not exclusively sell solar products—some shops sell a variety of products, such as groceries or hardware, along with solar home systems and lanterns. Two interviewees provided estimates of the number of companies operating in the state, giving a range of 500 registered shops to 5,000 registered and unregistered shops [6, 20, 21].

Challenges Faced by the Sector

The private sector companies face numerous challenges that prevent full-scale expansion of the sector. According to the interviewees, the top five barriers that have hindered the growth and expansion of private markets for off-grid solar lighting products in Bihar are as follows:

1. The kerosene subsidy disincentivizes customer’s purchases (raised by 9 interviewees) [18, 20–27]
2. Financing for companies (8 interviewees) [18–20, 23, 25–28]
3. Issues with product quality (8 interviewees) [18–21, 24, 26, 29, 30]
4. Customers lack awareness of the benefits of solar (7 interviewees) [20, 22, 24–27, 29]
5. The counterproductive MNRE/BREDA subsidy for solar product giveaways (6 interviewees) [18, 21, 25, 26, 29, 30]

The leading reason the off-grid solar lighting product sector in Bihar has not grown significantly is the kerosene subsidy. India’s federal government subsidizes kerosene through a “public distribution system” (PDS) [31]. Every family in Bihar that holds a PDS card (which are typically given to low-income families) is eligible to receive 2.75 liters of subsidized kerosene every month. Through the PDS, kerosene is sold at Rs 14.96 (US.23) per liter, instead of the actual cost of Rs 29.91 (US.47) per liter [31, 32]. The federal government has been providing this kerosene subsidy to low-income families for cooking and lighting purposes for several decades (the exact start time is not known), but people in rural areas use it mostly for lighting purposes [33]. According to the latest Census of India, kerosene is the main source of lighting for 83% of households in Bihar [5]. Since the grid expansion is slow and kerosene is the only source of lighting for many households, politicians in India are wary of reducing this subsidy as they do not want to upset their voters.

Deepak Gupta, former Secretary of the federal Ministry of New and Renewable Energy in India, said that the kerosene subsidy hinders the markets for off-grid solar lighting
products, and if it was eliminated these markets would expand [23]. Archana Tiwari, the state project manager of the NGO Jeevika, which works with private companies and government agencies like BREDA in Bihar’s off-grid space said, “people think, why should we buy solar products when we are getting almost free kerosene. For solar products, there is a one-time initial investment, which people either don’t like to invest or don’t have the money to invest” [21]. Even Akhilesh Kumar, owner of Sree Krishna Enterprises, a small solar company in Bihar, said that since people in Bihar do not typically spend a lot of money on lighting due to the kerosene subsidy, it is hard to convince them to buy solar home systems or solar lanterns [24]. “This government policy has been a big reason why private companies like us are not able sell solar products to customers in Bihar,” he said [24].

In addition, federal government subsidies granted via BREDA and NABARD are harming the private sector off-grid solar lighting product market in Bihar. The subsidies only help a small number of people: NABARD and BREDA have managed to distribute just 62,420 off-grid solar lighting products during the history of the subsidies. However, these small subsidies have a large impact on the entire off-grid sector. Overall, the total kerosene subsidy provided by the federal government for the whole country is 12 times more than the subsidy provided to the entire off-grid solar sector (for off-grid lighting as well as other energy applications such as solar water pumps) [34, 35]. The subsidies make it hard for private companies to sell their products, as people do not want to pay a higher price for the same products that BREDA or NABARD distribute at a subsidized rate. While very few people receive BREDA and NABARD subsidized products, people think they may eventually receive one, and thus are less likely to purchase a nonsubsidized solar product. In this way, these small subsidies spoil the market. Archana Tiwari from the NGO Jeevika explained, “When we contract with private companies, it is difficult to explain to people why, for the lanterns, we are charging a higher price. When we work for BREDA, the lanterns are subsidized and we charge less,” she said [21].

Interviewees also identified company financing and the quality of solar products as challenges. Sudipta Ghosh of SELCO Solar states that, “Many of the companies need financing from financing organizations to make their overall operations sustainable, hire skilled people, and expand their operations. Getting finance from banks or micro finance institutions is not easy because of...
government bureaucracy, and also financial markets are not so mature in Bihar” [19]. A representative of NABARD, who wished to remain anonymous, added, “Forget about off-grid solar, even the grid solar is a negligible component of total lending by banks. Banks consider solar lending as a loss-making proposition. Banks sometimes reluctantly lend to the solar sector just to show a diversified portfolio” [27]. Banks consider solar lending to be a loss-making proposition because few off-grid companies in India are profitable [14]. Moreover, Indian banks “…require at least three years of positive cash flows, detailed credit histories, as well as profitability before they are willing to lend,” and most entrepreneurs in the off-grid solar lighting products sector do not meet these criteria [4].

Some companies in Bihar also sell low quality products that create a bad name for the whole solar sector. Archana Tiwari from the NGO Jeevika said that there are no federal or state government regulations or controls with respect to the quality of products sold by private companies in this sector [21]. She said, “When we meet people who have bought solar products, many of them complain of being cheated by private companies” [21]. An India wide study in 2016 discussed cases of sales agents providing low quality off-grid solar products and then disappearing when it came time to service them, stating that this has affected perceptions of these products in many communities in India [14].

Further, interviewees highlighted that many customers in Bihar lack awareness of the benefits of solar, and hence are not keen to invest in solar products. Kunal Amitabh, the Chief Operating Officer of Decentralized Energy System India Pvt. Ltd., a large solar company in Bihar said, “The kerosene subsidy and customer’s experience with bad quality solar products, along with a lack of understanding of the solar products, makes it very difficult for solar companies to sell their products” [25].

Factors that Help the Sector Grow
The above section makes it clear that serious challenges hamper the growth of private markets for off-grid solar lighting products in Bihar. However, the sector also holds tremendous potential for expansion in the future. Interviewees identified the following five factors as the most significant factors that are driving the sector and that may aid the sector’s growth in the future.

1. Unmet electricity demand (raised by 5 interviewees) [18, 21–23, 27]
2. Unreliable grid power (3 interviewees) [21, 22, 25]
3. Post 2005 decrease in solar prices (2 interviewees) [18, 22]
4. India’s solar mission promotes the off-grid market and products (2 interviewees) [18, 22]
5. Some women understand the drawbacks of kerosene and benefits of solar (2 interviewees) [21, 22]

The most significant factor that has led to growth of the off-grid solar lighting products sector in Bihar is unmet electricity demand. Bihar is India’s least electrified state, and the unmet electricity demand of millions of people in the state is an incentive for some people to buy solar products.

Even the small percentage of households in Bihar that are connected to the grid face power outages ranging between 2 and 22 h a day [6]. Three interviewees said that the grid power in Bihar is highly unreliable, especially in rural areas [21, 22, 25]. A representative of BREDA, who wished to remain anonymous, said, “Since the grid power is intermittent, some people prefer off-grid solar products” [22]. Unless the grid electricity situation is improved substantially in Bihar, the above two factors are likely to continue to act as drivers for the expansion of off-grid solar lighting product markets.

In recent years, the fall of solar prices globally, and in India post 2005, has also helped lower the cost of both solar lanterns and solar home systems in Bihar [6]. The decrease in solar prices, coupled with the federal government’s push for solar power by launching the National Solar Mission in 2010, has given a boost to solar off-grid and on-grid markets. The mission’s objective is to make India a global leader in solar energy, and as part of the mission, the government aims to install 100 GW of solar power by 2022 [36]. In order to achieve this target, the government has launched a slew of solar power projects across the country to install on and off-grid solar power. For instance, in the off-grid space, the federal government plans to install solar LED street lights in all rural, semi-urban, and urban areas in the Indian states of Uttar Pradesh, Bihar, Assam, Jharkhand, and Odisha—states where electrification rates are less than 50%. So far, the federal government through private companies has managed to install 442,936 solar street lights across the
country [37]. Moreover, the federal government has installed a total of 154 solar PV off-grid power plants across the country. Another key objective of the mission is to provide financial incentives and tax breaks to Indian manufacturing companies for manufacturing solar products. The government also made it mandatory to have at least 30% domestic manufactured content for grid connected solar projects. As of December 2016, 9 GW of on and off-grid solar power has been installed under the mission [37]. Thanks to the incentives provided by the mission, some private sector companies in India (and through that, Bihar) have become interested in entering the on and off-grid solar sector.

Finally, interviewees said that some women in Bihar understand the drawbacks of the use of kerosene and the benefits of using solar, and they are increasingly interested in buying solar lighting products. Archana Tiwari of the NGO Jeevika said that women suffer the most due to lack of electricity because they are exposed to the smoke coming out of kerosene lamps; women typically use kerosene lamps for cooking and doing household chores at night, and for some livelihood activities like sewing [21].

CONCLUSION
Despite large potential, the market for off-grid solar lighting products in Bihar has remained small. The federal government’s kerosene subsidy has been the biggest deterrent to the growth of the sector. Combined state and federal government subsidized solar product giveaways have also contributed to spoiling the market. In addition, private companies are not able to raise the financing required to expand, unregulated product quality and associated issues with customer trust hamper growth of the sector, and few customers are aware of the benefits of solar as a replacement for kerosene.

Overall, there is significant potential for market growth if strategies are developed by key stakeholders to help overcome the challenges identified in this case study, and build on the factors promoting the sector’s growth. Most importantly, the government needs to re-think their subsidy policies and adopt a stance to encourage market forces. In addition, off-grid solar companies in Bihar could learn from Kenyan companies’ Pay-As-You-Go business models (see the companion article on Kenya), which are based on mobile banking. Kenya does not have a kerosene subsidy; however, Pay-As-You-Go business models could still work in a kerosene subsidized market like India. Pay-As-You-Go business models have been successfully pilot tested in off-grid areas of Indian states such as Uttar Pradesh. In conclusion, the growth of this sector is indispensable, as it has the potential to improve the light and lives of the millions of people in Bihar who currently live off-grid.

CASE STUDY QUESTIONS
1. Of the challenges identified, which do you think could be most easily addressed? What strategies could government, private companies, and other stakeholders employ to address these challenges?
2. Of the factors driving the sector, which do you think present opportunities that could be built on to help the sector grow? What strategies could government, private companies, and other stakeholders employ to build on these factors and encourage growth of the sector?
3. The kerosene subsidy has hampered the growth of the off-grid solar lighting products sector in Bihar, and has also promoted use of kerosene, which has harmful impacts on peoples’ health and the environment. However, millions of people in Bihar who live in poverty depend on the subsidy to provide them with kerosene in order to light their homes at night. Is it ethical to remove the subsidy?
4. Some states in India have implemented a program where they remove the kerosene subsidy, and give the money earmarked for the subsidy to PDS cardholders directly. Then recipients can choose whether to purchase kerosene or another lighting alternative like off-grid solar lighting products. Do you think this type of approach could work in Bihar? What difficulties do you anticipate may arise with this approach?
5. Would a higher level of education for the average citizen in Bihar change the current situation and lead to faster adoption of off-grid solar lighting products?

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