



# KEROSENE TO SOLAR SWAP

## Policy Brief #2

# Building a Market for Off-Grid Solar Lighting

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## Introduction

This policy brief looks at the current market situation for off-grid solar technologies in India and the current barriers to an enabling business environment for solar.

This paper is the second in a series of three policy briefs examining the links between the use of kerosene fuel and off-grid solar applications for lighting in rural India. Policy Brief 1 examines the existing system of kerosene subsidies in India, the key issues facing this system and the implications of kerosene subsidies for the dissemination of clean, alternative off-grid solar lighting (Garg, Sharma, Clarke, & Bridle, 2017). Policy Brief 3 analyzes the current policy environment governing kerosene and off-grid solar use and sets out a suite of detailed policy interventions that, if implemented, could achieve a systemic transition from kerosene use to solar for lighting (Bridle & Clarke, 2017).

These papers jointly suggest initial policy solutions to enhance off-grid solar penetration. They address the barriers to an enabling market and make a case for kerosene subsidy reform.

## Overview

**Today, 135 million households in India still have no access to electricity.** The vast majority of those who do have access experience a highly unreliable electricity supply (see Figure 2).

The Government of India (GoI) has made efforts to enhance access to the electricity grid through various schemes, which include 24x7 Power for All and Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY). **But despite the ambitious plans for ensuring grid access, similar aspirations are not reflected in plans for off grid.**

Census 2011 found that 73 million rural Indian households depend on kerosene for lighting (Office of the Registrar General & Census Commissioner, India, 2011). Though this number may have decreased in the interim, this dependence on kerosene remains a challenge. Kerosene's lower lumen lighting not only limits educational and income-generating opportunities, it is also responsible for a host of serious negative health impacts (Garg et al., 2017). Improving access to clean, sustainable, affordable and high-quality products is critical for the economic and social development of communities in India currently relying on kerosene to light their homes.

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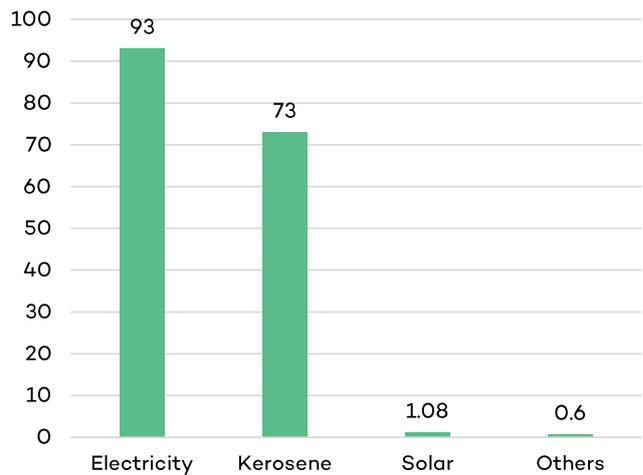
**Off-grid solar lighting products provide many benefits, not the least of which is providing clean alternatives to kerosene lighting.**

Solar lighting technologies are designed to be used in challenging contexts. They are increasingly cost effective; have virtually no ongoing cost; and provide a cleaner, brighter alternative to kerosene.

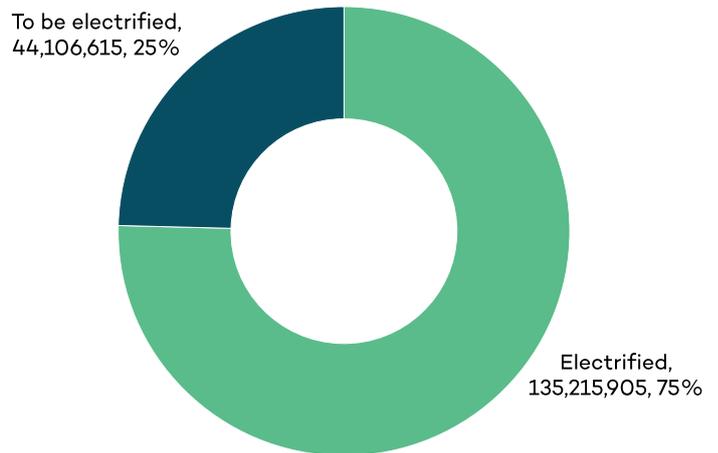
Additionally, **for every consumer that switches from kerosene to solar, the Govt saves around INR 600 (not including leakage costs) per year.** This is a significant figure given the millions of households currently using kerosene (Jain & Ramji, 2016).

The global market for solar applications has expanded dramatically in recent years. This is largely due to falling unit costs, improvements in the energy efficiency of technologies, and innovations in payment systems and financing options.

In India, more than 2.92 million solar off-grid lighting products (solar lantern and solar home systems, or SHS) were sold on a commercial basis in the last 1.5 years. **This translates to an estimated 12.7 million people reached with clean energy, and a replacement, to date, of more than 2.8 million kerosene lights (Global Off-Grid Lighting Association [GOGLA], 2015).** Innovative business models such as “pay-as-you-go” financing options allow consumers to buy or lease products by paying small increments over time (increments which, ideally, are lower than ongoing kerosene bills). This addresses concerns about high initial purchasing costs. Despite all this, penetration of these technologies among rural consumers in India—the world’s largest single market for the technology—remains low (see Figure 1).



**Figure 1.** Rural households’ primary lighting fuel (millions)(Office of the Registrar General & Census Commissioner, India, 2011)



**Figure 2.** Households not connected to electricity grid (millions) (Garv Dashboard, July 2017)

## The Key Benefits of Off-Grid Solar Technologies

There is growing evidence that solar off-grid systems play a direct role in the enhancement of quality of life—thanks to the savings made; improved safety; longer days for study, work, business-activities and socialization; and better health. Key benefits include the following aspects:

**Potential financial savings:** In India, typical expenditure on subsidized kerosene for lighting is approximately INR 576 per household per year (Garg et al., 2017). Making a conservative assumption of a 1.5-year life span for a basic solar lantern (retailing at INR 500), and assuming this lantern replaces two out of three litres of kerosene consumption per month, households with subsidized kerosene stand to save around INR 76 per annum by switching to solar. If kerosene is not subsidized, or for those households that do not have access to subsidized kerosene, the saving increases to INR 760. Savings also increase if products are assumed to last for a longer period; however, it should be noted that there are less (or no) savings for more expensive (costing INR 2,300 and above), more powerful and longer-lasting lanterns. Policy Brief 1 provides a more detailed analysis of the economics of kerosene versus solar use (Garg et al., 2017).



**Health and safety:** Every year, kerosene lamps contribute to indoor air pollution that leads to nearly 500,000 premature deaths in India (World Health Organization [WHO], 2014), and UNICEF's recent predictions for 2030 suggest indoor air pollution will globally cause more premature deaths than HIV and malaria combined (UNICEF, 2016). Additionally, kerosene burns are one of the leading causes of child injury (UNICEF, 2016); a recent study showed that indoor air pollution caused by kerosene can be 10 times worse than outdoor air pollution (Kankaria et al., 2014); and the primary cause of child poisoning in developing countries is accidental kerosene ingestion (Lam et al., 2013).

Off-grid solar technologies eliminate all of these risks. Children can study safely, while parents can take comfort in the fact that the technologies are totally safe, clean and unpolluting. Respiratory and eye problems are instantly reduced.

**Education:** Studies have shown that poor quality of light (or no light) in homes has a direct impact on educational outcomes. However, school children who have access to solar lighting study, on average, for one hour longer per night than those who do not (Ashden, 2013). **In India, clean lighting solutions have provided around 1 billion hours of night study time for 2.5 million children** (The Climate Group [TCG], 2015).

**Economic development:** Using solar lighting has the potential to create income-generating opportunities or grow existing businesses. In India alone, at least 20,000 people are directly employed by the off-grid lighting sector (CLEAN, 2015). United Nations Environmental Programme (UNEP) 2014 *Light and Livelihood* study indicated that the potential jobs-to-population ratio for alternative lighting technologies (and associated value chains) is 30 jobs per 10,000 people living in rural areas, compared to one job per 10,000 people in the case of the kerosene value chain.

**Comfort and well-being:** Better, cleaner light extends the day in households using off-grid solar solutions. This means families can socialize and go about their daily lives with greater ease and for longer. Financial savings or increased income opportunities mean that families have more money available for better healthcare provision and other life-enhancing services.

**The environment:** The switch to cleaner forms of lighting also has significant positive impacts for climate change and the environment. A full global transition to energy-efficient off-grid lighting would result in saving 6.7 billion litres of kerosene, 3.7 billion candles and 896 million batteries annually (UNEP, 2010). Kerosene use produces carbon dioxide and black carbon, with each kerosene lamp emitting on average 200 kg of carbon dioxide and black carbon combined per year. **UNEP (2010) estimates that the substitution of solar lighting for all traditional lighting in India would save about 34 million tonnes of carbon dioxide annually.** Over the last 1.5 years, 1.05 Mt of carbon dioxide emissions have been mitigated due to the uptake of solar lighting that was bought and sold on a commercial basis.

## The Market for Clean Off-Grid Lighting in India

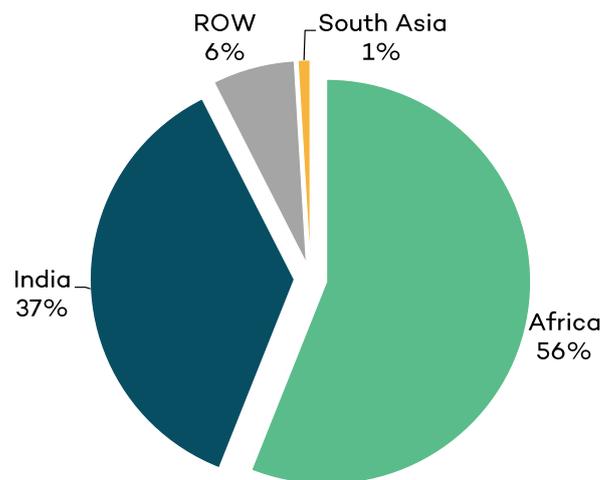
Under the GoI's Power for All scheme (to rapidly expand access to reliable grid electricity by 2019), grid connectivity is expected to improve. **However, TCG (2015) estimates that 75 million households will still lack access to grid electricity in 2024.** Given this estimate, and since 90 per cent of those who currently lack grid connectivity live in rural areas, a significant reduction in the 83 million rural households currently under-served by the grid therefore seems unlikely (TCG, 2015).

The International Finance Corporation (2012) report *Lighting Asia: Off Grid Lighting Market* estimates that 2 million to 3 million solar lanterns and 1 million SHS were sold in India before 2013. From July 2016 to December 2016, India recorded the most number of sales worldwide (GOGLA, 2016) (see Figure 3). **Despite millions of products already sold, the current market penetration of solar lanterns and SHS in India remains very low, at approximately 5–6 per cent of the total estimated market** (TCG, 2015).

However, the market penetration of solar applications is expected to continue to grow due to the falling cost of photovoltaic modules and batteries, increasing access to finance and increased awareness of the various benefits of

such technologies. For off-grid solar applications to meet the needs of approximately 135 million Indian households that will continue to lack grid access in the next decade, growth in availability and sales will need to increase significantly.

Solar lanterns are basic, relatively affordable applications that represent a first rung on the energy access ladder. In India, lanterns retail from INR 500 for a simple lantern to INR 2,400 for a high-end five-watt lantern providing 160 lumens and nine hours of lighting per night as well as phone-charging capabilities. SHS, however, are higher-grade products designed to act as effective substitutes for grid electricity, with multiple installed ceiling lights and switches, so they retail from INR 4,300 for a 10-watt system to INR 23,000 for a 100-watt system. Most households in rural India can be adequately lit by a three-light system retailing for approximately INR 7,000. The larger systems are designed for large commercial electricity users and back-up commercial lighting power.



**Figure 3.** Sales of off-grid solar products by market, July to December 2016

Source: GOGLA, 2016

## Business Models

A number of typical business models have been used by private sector players, both in India and beyond, to create markets for and to distribute off-grid solar applications. These include:

- **Distribution through proprietary agent networks:** The solar company sells its products through diffuse networks of generalist or specialist solar distributors. Some companies are also vertically integrated and have developed proprietary distribution networks, or are using franchise models throughout the supply chain.
- **Catering to the “public market”:** Companies focus predominantly on bidding on government tenders, both at the state and national levels, for bulk purchase of solar lighting systems in varying sizes.
- **Institutional partnerships:** The enterprises partner with rural banks, microfinance institutions (MFIs), community saving groups or non-governmental organizations to market its products to partner organizations’ customer base or membership network. Finance is often provided by the partner organization.
- **“Energy-as-service” models and “pay-as-you-go” solutions:** Under these related approaches, solar providers focus on offering an energy service (like a micro-utility) rather than a product, meaning households pay for electricity as they consume it. In leasing models, end-users do not own the products but are guaranteed a replacement product if it fails. Under pay-as-you-go models, end users provide periodic repayments counting towards the eventual ownership of the product (and thereby matching energy consumption and payment for energy over time). These models are mainly used to finance larger lantern systems or SHS.

## Current Off-Grid Solar Market Barriers

Despite the transformative potential of off-grid solar lighting applications to socially and economically enhance the lives of millions in rural India, use of these applications still remains limited. This can be explained by several key barriers that currently exist in India standing in the way of a flourishing off-grid solar market. These include:

1. An uneven playing field among competing lighting options
2. Solar promotion policy that gives away free lamps and impedes market development
3. Bottlenecks and restrictions for solar financing
4. A lack of trust and inadequate quality assurance



To create a business environment in which off-grid solar markets can thrive, government policy (at state and national levels) needs to tackle these barriers directly. Such policy solutions are the subject of Policy Brief 3 (Bridle & Clarke, 2017).

## An Uneven Playing Field

As discussed at length in Policy Brief 1, the continuation of large-scale per-unit kerosene subsidies in India significantly compromises the value proposition of solar lighting alternatives for households (Garg et al., 2017). In countries such as Kenya or Tanzania, where there are currently no kerosene subsidies, the payback period for an entry-level solar lantern, retailing at about USD 13, can be as little as three months given the cost of other lighting alternatives. However, in India it is approximately 11 months (Bloomberg New Energy Finance & Lighting Global, 2016). Because of the availability (in most cases) of cheap kerosene, the costs of financing solar technologies (or the amortized upfront cost of such technologies over a period of time) is most often higher than the cost of kerosene in the same period, especially for higher-grade lanterns and SHS (see Policy Brief 1). This is borne out in sales in India: in Kenya, where 32 million people do not have access to the grid, 947,000 solar lighting products were sold in the year to June 2015. In India, which has an off-grid population 10 times the size of Kenya, only about twice as many products were sold (Bloomberg New Energy Finance & Lighting Global, 2016).

In a positive step, India has reformed its complicated and non-uniform tax laws by implementing the goods and services tax (GST). Multiple taxes and import duties have been replaced by a single tax slab of 5 per cent along the value chain. The GST only marginally increases the costs by 5 per cent, as compared to the previous tax regime. By doing so, it will encourage local manufacturing, as those who import solar equipment like inverters will pay a hefty import fee.

## A Lack of Market-Based Solar Promotion Policy

In an effort to rapidly increase access to off-grid solar technologies in rural households, central and state governments in India have experimented with a variety of solar promotion schemes, including effectively giving away units to poor communities. There have been several such government-led initiatives to distribute solar lanterns for free, or at highly subsidized rates. Recently, in Chhattisgarh, solar lamps were distributed free to 1.3 million households in 95 rural areas. In 2016, in Kerala, around 43,000 lamps were distributed.

Efforts to promote off-grid solar applications through the distribution of free (or very low cost) units, however, can destabilize budding solar markets and significantly impair enterprises, while at the same time indefinitely jeopardizing the public perception of off-grid solar products. Negative unforeseen consequences include:

- **Killing competition** – Subsidized systems monopolize markets on a large scale and prevent any other technologies and suppliers from competing.
- **Creating dependence** – If government programs come to dominate the market, once the program ends or the subsidy is suspended, the market may disappear completely.
- **Focusing on distribution not service provision** – The mass procurement and distribution of near-zero cost solar products very often leads to an under-provision of aftersales service, leaving many units unrepaired and damaging customers' trust and views on the reliability of such products.
- **Undermining buy-in** – Evidence shows that households tend to place greater value on goods and services that they have used scarce resources to buy and in which they are invested. Distribution of near-zero cost systems can lead to under-utilization and misuse, which can again affect consumer perceptions of the products.
- **Perpetuating quality problems** – Products should be able to compete with alternatives on a level playing field. While there is not a level playing currently in India, programs such as those outlined above risk the mass distribution of products that have not had to compete with others in terms of reliability. This perpetuates certain quality assurance issues faced by off-grid solar units (see the quality assurance section below).



In general, the mass distribution of low-cost products can necessarily only be a temporary measure to enhance clean lighting access. In all cases, the creation of a sustainable, self-sufficient market will be needed to ensure that clean energy access is achieved and sustained over the long term.

## The Financing Bottleneck

Policy Brief 3 (Bridle & Clarke, 2017) examines, in detail, the issues around financial barriers to greater off-grid solar uptake. However, these issues are also relevant here.

Unlike kerosene use, for example, the use of solar applications has a large upfront cost for poor households in the absence of financing or payment-smoothing mechanisms—services that can be provided, in theory, by financial institutions (e.g., rural development banks, MFIs, etc.), solar distributors or other third parties. Often, the financing of loans also requires high financial inclusion among the poorest rural consumers; the latter has increased rapidly in recent times (see Bridle & Clarke, 2017 [Policy Brief 3] for more detail on these issues). Yet banks are often not present in remote rural areas and also find poor rural consumers (often without collateral) as risky. This significantly constricts the ease of financing for poor rural consumers. The financing of small loans for individual customers by banks and MFIs then end up enduring high transaction costs. For these reasons, SHS and solar lamp retailers, like Selco and Simpa are trying innovative payment mechanisms, particularly for retailing solar home systems. These mechanisms include mobile money, aggregating small borrowers into group loans, pay-as-you-go models, monthly instalments, etc. But these models have seen relatively slow uptake in India, and there are only a handful of companies trying these models.

Another innovative financing model currently being attempted by off-grid manufacturers, retailers and financial institutions is to monetize carbon credits to mitigate the financial risks and use the money to enhance their respective clean energy programs. Banks like Grameen Bank of Aryavrat, Bank of India and MFIs like Muthoot and Fullerton have been using benefits from carbon credits to improve their clean energy programs by using the funds for increasing rural outreach, creating awareness, enhancing product portfolio, aftersales, etc.

By focusing on an enabling environment for corporate and customer financing in countries, four companies operating in Kenya and Tanzania have attracted 50 per cent of total global investment in the off-grid lighting industry to date (Overseas Development Institute, 2016). Unsurprisingly, these two countries have shown the world's strongest sales growth rates for off-grid solar units. Strong corporate finance has allowed these companies to be able to extend credit to customers on a large scale (Overseas Development Institute, 2016). In India, even for those firms that are authorized to extend credit to end-users, raising debt financing to fund these allocations of credit remains challenging.

### Box 1: Mobile Money in Africa

“Mobile money” payment technologies allow customers to make payments remotely, thereby avoiding the need for in-person payments or collection. Mobile money is particularly advanced in East Africa and is employed for pay-as-you-go as well as energy-as-service models. In contrast to India, the rapid development of mobile money in East Africa reflects a generally favourable environment for the extension of credit for asset financing to bottom-of-the-pyramid consumers in this region. Two of the largest companies leveraging mobile money are M-KOPA and Off-Grid Electric.

M-KOPA is an off-grid service provider and financing platform that combines embedded GSM and mobile payments to finance assets for bottom-of-the-pyramid consumers. For solar applications, it brings together finance and mobile technology to connect off-grid, low-income homes to clean lighting systems. To date, M-KOPA has helped 250,000 homes across East Africa to access off-grid systems.

Off-Grid Electric delivers stand-alone solar systems to last-mile customers. By using mobile-money-enabled payment systems, products become accessible and affordable. Building a relationship between customer and company ensures a strong focus on daily service and distribution at an affordable price.



## Quality Assurance and Consumer Protection

Low-quality off-grid solar products, in a relatively new market like India, have the potential to damage the reputation of the sector significantly, and as a whole, in these markets. Such products can negatively influence consumer attitudes over several years, and thereby impede the use of solar applications in rural communities over time. There is plenty of anecdotal evidence of consumers being provided with faulty, low-quality equipment with little after-sales recourse. And the risk of market spoilage by low-quality products continues to be a key barrier to greater solar penetration in India.

Quality assurance standards can help ensure solar units meet common minimum standards for product performance. In India, however, quality assurance frameworks (and enforcement of them) remain underdeveloped. A key building block of policy to promote solar needs to be the relatively simple establishment of internationally harmonized quality assurance standards, including warranties, grievance mechanisms and enforced after-sales obligations for consumers.

## Conclusions

Policies designed to promote greater penetration of off-grid solar applications in India should be clearly aimed at tackling the barriers to a flourishing solar market that are described in this policy brief. This will help unlock the enormous potential of solar lighting for the enhancement of quality of life and poverty reduction. Policy Brief 3 (Bridle & Clarke, 2017) delves into considerable detail in elaborating on the suite of policy interventions that can be used to engender a large-scale transition from kerosene to solar in rural India. However, the key areas of simple solar promotion policy are clear.

Key policy reform initiatives should include:

- Embracing market-based solutions to solar sector promotion, including limiting the use of the mass distribution of near-zero cost and highly subsidized solar lanterns.
- Improving the harmonization and enforcement of quality assurance frameworks and after-sales obligations for solar products and providers, as this will build trust in the sector.
- Taking measures to promote solar providers' access to capital (e.g., through rural development banks) and to enhance financial inclusion and payment services options in India. This could include ongoing and highly successful financial inclusion and electronic money initiatives such as those being undertaken by the GoI.
- Leveraging the sophisticated Direct Benefits Transfer subsidy payment infrastructure to give households the option to use subsidy payments for either solar or kerosene. This notion is discussed in detail in Policy Brief 3 (Bridle & Clarke, 2017).



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