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Adoption of solar home lighting systems in India: What might we learn from Karnataka?

Santosh M. Harish [a,*], Kaveri K. Iychettira [b], Shuba V. Raghavan [c,1], Milind Kandlikar [c,d]

[a] Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213, USA
[b] Delft University of Technology, 545 Korvezeestraat, 2628 CZ Delft, The Netherlands
[c] Liu Institute for Global Issues, 6476 NW Marine Drive, University of British Columbia, Vancouver, Canada BC V6T 1Z2
[d] Institute for Resources, Environment and Sustainability (IRES), 2202 Main Mall, University of British Columbia, Vancouver, Canada BC V6T 1Z4

HIGHLIGHTS

- Solar lighting system (SLS) adoption in Karnataka largely through commercial sales.
- Most surveyed households adopted SLS due to grid supply unreliability.
- Rural banks critical in introducing consumers to firms and financing systems.
- Banks also play support role in ensuring after-sales maintenance.
- Institutional structure may limit choice of firms and products.

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ABSTRACT

Karnataka has been among the most successful markets for solar lighting systems (SLS) among Indian states. In order to understand the dynamics of systems adoption and operation, that have fostered market based adoption of solar lighting, we interviewed rural households from six districts that had purchased solar lighting systems using loans at market rates, the rural banks that provided loans and the solar firms that marketed the technology. We found that a large proportion of households in our sample were connected to the grid but chose to install solar lighting because they considered the power supply from the grid to be unreliable. Households in our sample reported savings on electricity costs and reduced kerosene usage for lighting. In addition to providing credit, banks also play a key role in ensuring good service and maintenance; the viability of the SLS market is thus critically dependent on the role that the banks play as intermediaries between consumers and solar firms in rural areas. Government programs should be carefully designed to match the incentives of firms, banks and consumers if the successes of the 'Karnataka model' are to be repeated and amplified.

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1. Introduction

Access to reliable electricity continues to be elusive for a vast majority of rural households in India, and 45% of them remain unelectrified (Census of India, 2011). Even those that are electrified, often receive grid supply of poor quality with frequent blackouts and brownouts. There is a persistent gap between investments needed to meet rural demand and actual allocations that are largely aimed to provide power to cities. Given the constraints in resources, the power supply scenario in rural areas is unlikely to improve in the near future. One way to expediting access to reliable electricity is by decentralizing the production and distribution of electrical power. Due to their modularity, flexibility and low deployment times, Solar Lighting Systems (SLS) easily lend themselves to decentralized distribution.

Almost 95% of the approximately 10,000 villages (less than 2% of all villages) covered under the Remote Village Electrification Program of the Ministry of New and Renewable Energy (MNRE) have been provided with SLS (Niez, 2010). These programs have been reliant on very high capital subsidies (to the tune of 90%). The Jawaharlal Nehru National Solar Mission (JNNSM) that was launched in 2009 targets the deployment of 20 million SLS and solar lanterns by 2022. A description of this and the history of

* Corresponding author. Tel.: +1 302 438 5252.
E-mail addresses: sharish@andrew.cmu.edu (S.M. Harish), k.k.iychettira@student.tudelft.nl (K.K. Iychettira), shuba.raghavan@gmail.com (S.V. Raghavan), mkandlikar@ires.ubc.ca (M. Kandlikar).

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electrification policies of Government of India can be found in Raghavan et al. (2010).

However, worldwide decentralized solar lighting has received a mixed report card. Commonly cited barriers in the literature include the high initial costs and lack of consistent financing; high risks assumed by financial institutions while assessing credit worthiness; a lack of understanding and experience related to solar lighting on the part of financing institutions, and inadequate service infrastructure from the firms. For a more detailed discussion, see Acker and Kammen (1996), Nieuwenhout et al. (2001), Karekezi and Kithyoma (2002), Adkins et al. (2010), and Timilsina et al. (2012). Furthermore, limited longevity of lighting systems due to insufficient maintenance reduces their value proposition (Acker and Kammen, 1996; Velayudhan, 2003).

Despite these barriers, SLS is seeing a revival of interest. A sharp drop in the global price of solar photovoltaic panels has led to the mushrooming of dozens of firms aiming to deliver solar lighting to the rural poor (The Economist, 2012; Singh, 2012). One instance of this trend is the state of Karnataka in India, which has been a pioneer in the adoption of solar lighting for rural electrification, with several solar firms operating exclusively in the state, some for a long time. Saliently, the solar market in Karnataka has been almost entirely based on commercial sales involving both credit and cash based purchases. The relative success of solar lighting in rural Karnataka, and failure in most other states in India, makes it an important case to understand. Based on interviews with rural households that have adopted solar energy for lighting in Karnataka, solar firms that operate in the state and the local rural banks that were lead solar financiers, we describe and analyze the 'Karnataka model' for solar lighting.

The paper is structured as follows. Section 2 provides an overview of the adoption of SLS in Karnataka. In Section 3, we present the methodology used in this work. In Section 4, we provide an overview of the key stakeholders to provide context to findings of the study presented in Section 5. In Section 6, we discuss the issue of replication and the role that government policy could play. Although JNNSM's off-grid programs seem to have been developed based on the lessons learnt from Karnataka and elsewhere, we discuss how these may instead have decelerated adoption in Karnataka.

2. Background

In 1980, the government of India initiated a program to use solar photovoltaic applications to electrify villages and households that were not grid connected. By 1996, a decade and a half later the government's program had led to the adoption of 36,000 SLS and 37,000 solar lanterns, an extremely low penetration given the number of unelectrified households and villages at that time (Miller, 2009). Even in 2011, only 916,000 rural households used solar energy as their primary source of lighting, representing 0.5% of the total rural households in the country (Census of India, 2011). Thus, despite almost three decades of programs, pilot projects and several impressive case studies, the diffusion of SLS in India has progressed at a snail's pace even with high capital subsidies. This pattern of slow diffusion reflects the state of other distributed renewable energy sources that are also struggling to provide large scale solutions to the problem of energy access.

While there are no official statistics available for market based sales (without government support) in the different states, a few hints are available based on the list of distributors identified by MNRE. Karnataka, along with West Bengal, has the most number of solar companies operating, as per the list in Table 1. The number of distributors, or dealers, is also among the highest. The distributors include dealers to whom the sales are outsourced (for instance, one company in Maharashtra has 213 dealers). To give some perspective, Table 1 also includes statistics on the number of rural households who use solar or grid electricity as the main source of lighting from Census 2011.

Table 1
States with the most number of MNRE empanelled companies.

State	Solar distributors recognized by MNRE (2010)			Number of rural households with main source of lighting from Census 2011 (% of total rural households in state)	
	Number of companies	Number of dealers	Average dealers per company	Solar	Electricity
Karnataka	11	255	23	19,187 (0.3)	6,819,812 (87)
West Bengal	11	87	8	160,497 (2.9)	5,529,496 (40)
Uttar Pradesh	10	213	21	141,108 (2.3)	6,054,978 (24)
Maharashtra	9	297	33	48,506 (0.5)	9,605,299 (74)
Bihar	9	86	10	104,118 (5.9)	1,754,673 (10)

Among the top five states from the MNRE list, Karnataka has the largest fraction of (grid) electrified rural households. The number of households using solar as their primary lighting source is much lower than the reported sales of a few companies, or the number of solar loans provided by one of the banks interviewed. This itself suggests (as was borne out in our study) that most households adopting solar have grid supply as well. In other states, it is likely that a significant fraction of households were provided by solar lighting as a part of government programs in unelectrified villages and through heavy subsidies, not the market. As an aside, Bihar and Uttar Pradesh provide truly sobering statistics on the challenge of providing electricity access in some parts of the country.

The growth of the market in Karnataka has had phases of organic slow growth and acceleration induced by external interventions. In mid-1990s, the firm Selco started making direct sales without government support or subsidies to rural households in Karnataka. Soon, regional banks became involved and began to structure appropriate loans to meet the end-users' financing needs at market rates of interest. The uptake was catalyzed by UNEP's Indian Solar Loan Program that was routed through the rural branches of some of the major banks in the state (Painuly, 2007). The UNEP program reportedly encouraged small but significant innovations in the loan product—lower down-payments, longer loan terms and lower interest rates, and in addition, provided technical support and training for banks (Painuly, 2005). The work by the early firms and the banks demonstrated that it was possible for private firms and rural banks to design financing mechanisms that would enable greater diffusion and uptake. With time, several other solar service providers and regional rural banks entered the sector.

During the same period, grid connectivity has also increased markedly, up from 4.8 million rural households (72%) in 2001 to 6.8 million (87%) in 2011. Almost all the villages in the state of Karnataka are electrified.[2] While solar lighting systems have typically been installed in unelectrified areas elsewhere, the Karnataka market seems to have been driven by the unreliability in grid supply. Because kerosene was the most common backup

[2] More than 99% of the villages covered under the RGGVY program in Karnataka already had basic grid infrastructure installed and were intensively electrified (i.e., last mile connectivity for households) http://rggvy.gov.in/rggvy/rggvyportal/completed_frame.jsp.

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