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Solar lighting for street vendors in the city of Dehradun (India): A feasibility assessment with inputs from a survey

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ABSTRACT

An attempt to assess solar lantern based lighting option for street vendors (often without access to grid electricity) in the city of Dehradun through a questionnaire based survey is presented. Survey results indicate that the vendors are more likely to adopt a lighting device on rental mode that offers the benefit of low operation cost and high reliability.

The study points that the city has potential for 10 Central Charging Stations of 1200 W_p capacity each. Each station would cater to the lighting needs of 100 vendors. Based on the vendors willingness to pay for lighting services, estimated minimum acceptable daily rental to an entrepreneur operating a station is Rs 3.97. This is about 45% of the average daily rental of Rs 8.90 that the vendors are willing to pay. For daily rental ranging between Rs 4.00 to Rs 9.00, the mark-up for the entrepreneur would range from 16 to 160%.

Introduction

Many cities around the world have launched their own schemes to combat the issues of greenhouse gas (GHG) emissions and subsequent climate change. On similar lines, the Ministry of New and Renewable Energy (MNRE), Government of India has launched Solar Cities Programme (SCP) during the Eleventh Five-Year Plan (2007–12) (MNRE, n.d.-a). Under SCP, it is envisaged to develop 60 cities of India as Solar Cities. A Solar City will aim to adopt renewable energy sources and energy efficiency measures for a minimum 10% reduction in projected demand of conventional energy by the end of five years (MNRE, n.d.-b). The city of Dehradun is one of the cities sanctioned under SCP as it has good solar radiation availability throughout the year (MNRE, n.d.-a). As per the database developed by the collaborative effort of the National Renewable Energy Laboratory, USA and MNRE, average daily global horizontal irradiance (GHI) of Dehradun City (latitude 30.31°N, longitude 78.35°E) is 5.23 kWh/m^2/day (MNRE, n.d.-c).

A variety of solar energy applications may be considered under SCP. Providing solar lighting to street vendors is one such potential application. Around 10 million street vendors are estimated to be operating in India (Bhowmik, 2010). In many Indian cities, about 2% of the population is reported to be involved in street vending (MHUPA, 2009). Street vendors are self-employed workers in the unorganized retail sector selling goods on the streets without having any permanent shop or built-up structure (MHUPA, 2009). Street vendors enable decentralized and convenient distribution of goods to the public. Street vendors sell fruits, vegetables, food items, cloth/hosiery, electronic and a variety of other household items (Saha, n.d.). Street vendors can be classified as mobile or stationary vendors based on the mobility of business location.

With no permanent built-up structure, limited access to reliable and reasonably priced grid electricity is a major challenge to street vending (S^3IDF, 2006). Vending after sunset necessitates artificial lighting. Usage of LPG Petromax, kerosene lamp, CFL-battery combination, etc for lighting is quite common across India (Rao et al., 2009). The drawbacks reported to be associated with such lighting practices are high operational cost, frequent repair and maintenance, inadequate lighting, pollution, etc (S^3IDF, 2006). Fossil fuel (kerosene, LPG, etc) based lighting lead to emissions of 244 million tons of carbon dioxide annually from the developing world (Pode, 2010).

The lighting devices promoted under SCP are solar lanterns, solar home lighting systems, solar street lights and solar traffic signal lighting (MNRE, n.d.-b). Among these devices, solar lantern seems the most suitable option for fulfilling lighting needs of street vendors. It is non-polluting and portable and thus suits outdoor lighting (Mahapatra et al., 2009). Replacement of fossil fuel based lighting with solar lighting can also help combat climate change as it doesn't emit any greenhouse gases during operation. Solar lantern has almost zero operational cost (if owned) and is easy to use. Also, it is almost maintenance free. A photovoltaic (PV) module, a storage battery, a charge controller, a CFL or LED with fitting, cables, switches and appropriate housing together constitute a solar lantern (Rubab and Kandpal, 1996).

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A prevalent dissemination model of solar lanterns in the world has been through ownership (Adkins et al., 2010; Pode, 2010; Wong, 2012). Generally, in ownership model, the user owns the solar lantern by purchasing it from promoting agency at subsidized price or by directly purchasing it from the market. The other model is based on the establishment of a Central Charging Station (CCS). A CCS consists of PV modules, Integrated Charge Controller-cum-Junction Box (ICCJB) and solar lanterns (Fig. 1). PV modules receive solar energy in the form of radiation and convert it into DC electricity and ICCJBs control and coordinate all inflow and outflow of energy and feed AC electricity for charging solar lanterns plugged in the sockets of junction box. MNRE is also promoting CCS mode of solar lighting under SCP (MNRE, n.d.-b). Under the CCS model, rental and fee-for-service schemes are possible. The salient features of the two schemes under CCS model are presented in Table 1.

Considering Dehradun City's coverage under SCP and street vendors' limited access to grid, an attempt has been made to assess the feasibility of promotion of solar lanterns among street vendors of the city through a questionnaire based survey.

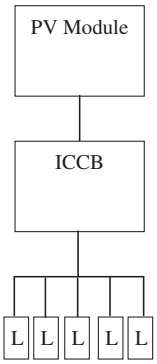
Questionnaire based survey

For solar lighting among vendors, state government and vendors are the key stakeholders. From the government's inclusion of Dehardun City under SCP, it is inferred that the government's interest would be addressed by promotion of solar lighting of the city. Thus, the study focuses on the interests of the vendors. For acceptance of solar lanterns among the street vendors, the same must offer definitive tangible advantage(s) over other existing and potential alternatives for lighting (Rogers, 1995). The relative advantage(s) could be in the form of higher illumination level, lesser capital and/or operational costs, ease of handling/operation, etc.

An implementing agency would primarily be interested in technical and financial feasibilities of the solar lighting proposition for which information on various parameters would be needed. The information needed would essentially depend on vendors' experience with current lighting practices and their perceptions which could be captured by a questionnaire based survey (Adkins et al., 2010; Veeraboina and Ratnam, 2012; Velayudhan, 2003). Thus, to obtain much needed authentic data from the vendors, a questionnaire based survey was conducted.

Methodology

The study involved initial walk through survey of the lighting practices of the vendors followed by a detailed survey. The results of the survey have been analyzed to assess the feasibility of solar lighting system for fulfilling lighting needs of the vendors.



ICCB–Integrated charge controller cum junction box; L –solar lantern

Fig. 1. Block diagram of CCS.

Survey

A week long walk through survey was conducted across the city of Dehradun in June 2013 to make a preliminary estimate of the number of vendors and to understand the business pattern of vendors and their current lighting practice before designing questionnaire for the detailed survey. Based on the observations and inputs from initial walk through survey, a detailed structured questionnaire was developed. The questionnaire was constructed to explore vendors' need for lighting, current lighting practice, economics and challenges associated with existing lighting practice and opinion on perceived better lighting options. In Dehradun sunset time varies by approximately two hours between summers and winters (Gaisma, n.d.). As lighting duration during evening is dependent on sunset time, summer (April–October) and winter (November–March) periods were considered separately.

Sampling and data collection

The sample size for the questionnaire based survey was decided on the basis of a formula suggested by Yamane (1967). As per this formula, for a population N, confidence level of 95% and population proportion P as 0.5, the sample size is

$$n = N/\left[1 + N(e)^2\right] \quad (1)$$

where e is the level of precision in fraction. For a population of 1300 and level of precision as ±7%, the sample size was estimated as 176. For the purpose of conducting the survey, the vendors were divided as per their location in the city and from each location about 13.5% of the population of existing vendors was randomly selected for the survey. After walk through survey and subsequent questionnaire modification, detailed survey of vendors was undertaken. Out of about 180 vendors contacted for survey, only 150 completed questionnaires were finally available for subsequent analysis.

Results and discussion

Survey outcomes

The data obtained from the survey of 150 vendors have been analyzed and presented in Table 2. On average, each vendor is using 1 lighting device and the average duration of lighting varies from 2 h 30 min in summers to 3 h 42 min in winters. Lighting duration is longer in winters as sun sets early during winters. LPG petromax, CFL-battery and street light are the prominent sources of lighting among the vendors. The share of usage of LPG petromax, CFL-battery and street light are 39%, 32% and 21% respectively. Remaining 8% is shared by candles, kerosene petromax and unauthorized rental electricity from nearby shops. All the vendors using LPG petromax are operating in ownership mode. As there are challenges associated with LPG procurement with respect to its supply and price fluctuation in open market, it has not been able to attract entrepreneurs to establish rental mode of LPG petromax usage. Among 48 CFL-battery users, 18 users own the system whereas the remaining 30 CFL-battery users are operating with rental mode of lighting. Under rental mode, an entrepreneur is supplying charged CFL-battery to the vendors for 4 h of lighting every evening and collects it back after usage. The entrepreneur charges the batteries at his residence with grid electricity after collecting the same back from vendors. The users operating in rental mode are paying a daily rental of Rs 15 per day to the entrepreneur. Under this scheme, the entrepreneur is taking care of all repair and maintenance issues.