



A comparative evaluation of household preferences for solar photovoltaic standalone and mini-grid system: An empirical study in a coastal village of Indian Sundarban

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ABSTRACT

Solar PhotoVoltaic (SPV) based systems have been widely accepted technology for rural electrification in developing countries. The standalone SPV home lighting system has increasingly been popular among rural households, while SPV mini-grid supply system is being promoted for rural electrification schemes. This study uses data from household survey to explore the impact of household characteristics on the preference for electrical energy from SPV systems. Econometric evidence shows heterogeneity in behavioural pattern for these two SPV systems. The flexibility in use and cost of systems might explain this difference. Household characteristics such as monthly household income, household size, occupational status of household head, number of room and type of house significantly influence household's decision for SPV standalone home lighting systems. For SPV mini-grid supply household's income and monthly expenditure on kerosene are significant predictors. The result reported in this paper might be a valuable input for policy makers to frame right policy mix with regard to provide subsidy on rural electrification programmes.

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1. Introduction

The challenge to provide electricity in rural areas is a common phenomenon. Grid connected power supply system has been the favoured approach for rural electrification. Normally electrification in rural areas is costlier than urban areas because of geographical adversity, low population density, low purchasing power, low consumption, payment default and many others. Thus, rural electrification schemes depend on huge subsidies in order to make them financially viable. All these factors have resulted in slower progress of rural electrification in many developing countries. Off-grid electrification can provide alternative solution for many rural areas, where power may be generated from renewable sources. Nouni [1] highlighted that renewable energy based decentralised electricity supply options could be financially attractive as compared to grid extension for providing access to electricity in small remote villages. In India about 30% villages still depend on kerosene for domestic home lighting. However, National Electricity Policy 2005 aimed to achieve 100 percent electrification by 2012 and set a target of thirty-unit consumption per household per month.

The least cost solution for a rural off-grid electrification may consist of solar home systems (SHS) or mini-grid connection [2]. Solar PhotoVoltaic (SPV) systems have been the fastest growing energy technology [3,4]. The standalone SPV Home Lighting System (HLS) does not need any major maintenance, consumer can use it independently and unaffected by external factors, while SPV mini-grids are managed by cooperative societies formed by the local government and beneficiaries. The SPV HLS system requires high initial investment which is a major barrier to be a sustainable instrument for rural electrification, despite huge subsidy being provided by the government. For SPV mini-grid supply, consumer needs to pay a monthly fee according to consumption, not follow the principle of “free for service”. Overall, financing SPV mini-grid supply is a challenge as the cost of per unit electricity is much higher compared to other available options.

Renewable energy has historically been supported by public policy endeavours like tax incentives, subsidies, favourable power purchase contract and so on, apart from its social, political and institutional determinants in developing countries like India [5,6]. Raja [7] examines the determinants that promote the adoption of SPV systems and found that government initiatives, demonstration sites and finance are decisive factor to the adoption of SPV systems in India. High capital cost of electricity generation has deterred private investment in solar power projects. The subsidized

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promotion by the government has made such projects viable. In addition to provide infrastructure, capacities must be developed on the availability of components, spare parts, creation of a pool of technicians for installation and maintenance, development of fee collection and maintenance of infrastructure [8].

Since last decade several opinion surveys [9,10] have been conducted to explore individual preferences for renewable energy. The cost minimization for domestic lighting indicates the use of non-local source, kerosene because the unit cost of lighting through local source like SPV are significantly higher [11]. The present study is the first of its kind, which investigates the comparative evaluation of households' preference for solar electricity from solar PV SHS and mini-grid supply. The objectives are to determine the role of socio-economic characteristics of the households on the preference for SPV systems and to contrast the preference patterns between these two supply systems. The study uses data from a typical village of Indian Sundarban. The paper concludes by identifying policy implications and provides further research directions.

2. Study area

'Sundarban' literally means 'beautiful forest'. Indian Sundarban is located between 21° 32' N – 22° 40' N and 88° 00' E – 89° 00' E. About 4 million people live in Indian side of Sundarban. The region is characterised by sensitive ecosystem, remoteness, and poor infrastructure. Access to electricity is one of the key issues linked with overall development of the islands. It is extremely difficult to extend transmission lines from main land to these islands due to very wide rivers or creeks resulting in technical limitations and prohibitive cost. People depend on the expensive as well as erratic supply of kerosene for home lighting. There are a few small diesel generator sets supplying electricity to the markets of some villages, but the availability of diesel is a problem. Renewable energy sources, particularly solar energy become popular source of electricity in Sundarban region. Since 1993, West Bengal Renewable Energy Development Agency (WBREDA) started working on rural electrification through renewable energy. So far more than 40,000 households have been benefited from WBREDA's initiatives through 16 SPV mini-grid supply, approximately 770 kW, and more than 35,000 standalone HLSs. There are several other SPV applications in smaller capacity range known as micro solar PV power system being used in small institutions, rural hospitals, forest offices etc. Household energy consumption in Sundarban region follows a homogeneous pattern and the living style is almost similar. A typical village Laxmijanardanpur under Pathar Prsatima Community Development Block of South 24 Parganas District in Indian Sundarban was selected as the target area for this study. The target village can represent other villages of Sundarban as there is hardly any dissimilarity in their characteristics. The village constitutes 753 households.

3. The structure of the model and methodology

The decision to adopt or not to adopt SPV HLS takes the form of dichotomous variables. The impact of households characteristic on the stated decision is examined by logit regression model [13,14] for each of the two systems, SPV HLS and SPV mini-grid. In order to perform the analysis, the following generalized logit model is defined:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = \alpha + \beta_i X_i \quad (1)$$

where L is the log of the odds ratio called the logit or log-odds which is a linear function of the explanatory variables. P_i is the

probability of preference of i th individuals, the vector X_i contains attributes of household characteristics and β is the corresponding unknown regression coefficients to be estimated. The probability P_i ranges between 0 and 1 and is nonlinearly related to the X_i attributes [14].

The cumulative logistic distribution function in (1) can be represented as:

$$P_i = E(Y = 1|X_i) = \frac{1}{1 + e^{-(\alpha + \beta_i X_i)}} \quad (2)$$

If P_i is the probability of household's preference for SPV systems, then $(1 - P_i)$ is the probability of not preferring:

$$1 - P_i = \frac{1}{1 + e^{(\beta_i + \beta_i X_i)}} \quad (3)$$

The odds ratio is defined as:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{(\beta_i + \beta_i X_i)}}{1 + e^{-(\beta_i + \beta_i X_i)}} = e^{(\beta_i + \beta_i X_i)} \quad (4)$$

The odds ratio is the ratio of favourable to unfavourable cases of preference in current context. This preference depends on the values of the explanatory variables. Taking the natural log of equation (4) we get equation (1).

4. Data and its analysis

The survey was conducted during October–December 2007. The data was collected from household's head through direct interview based on a structured questionnaire. The response of the household head can be considered as a proxy of the decision of entire household members.

Respondents were asked regarding their preference for both the systems, SPV HLS and mini-grid. The questions include socio-economic determinants, like respondent's level of income, occupation, number of family member, family composition, type of house and expenditure on kerosene. Individual's preferences for SPV standalone HLSs are estimated using the socio-demographic determinants. By using same determinants individual's preference for electricity from SPV mini-grid connection are also investigated. Hence, there are two dependent variables; one is the household where the SPV standalone HLS are installed and another one is the household's preference electricity connection from SPV mini-grid supply. In Table 1 we present the summary statistics of the variables preference for SPV systems to its various characteristics, where the values are presented in Indian Rupees.¹ Majority of the socio-demographic characteristics are recorded as dummy variables.

Total number of household member is an important variable determining energy demand as it is directly related with the requirement of energy [12]. Total energy demand increased with household size, but due to substantial economies of scale per capita energy demand decreases as the household size increases. Among the 753 observations, 26% households have installed SPV HLS in the village. For those who have not installed SPV HLS yet, about 40% of them expressed their preference for SPV connection through mini-grid supply. The average monthly income of a household is Rs. 2117. Around 54% of them fall in Rs. 1001–2000 income groups, while 19.3% household earn below Rs. 1000 per month (Table 2). The average household size consisted of around 6 persons, while 60.8% households have 4–6 members. The majority of the population 87.7% is engaged in cultivation. The average per head expenditure

¹ The exchange rate at the time of survey was \$1 = Rs. 48.

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