



Do determinants of adopting solar home systems differ between households and micro-enterprises? Evidence from rural Bangladesh



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ABSTRACT

Solar home systems are recognized as a promising technology to mitigate energy poverty, promote renewable energy, and achieve Goal 7 of the United Nations Sustainable Development Goals by 2030. This study examines the determinants of solar home system adoption, with a focus on similarities and differences between households and micro-enterprises. Our original data, collected in rural off-grid villages in southern Bangladesh, reveal that households prefer relatively higher generation capacities for multiple purposes, while micro-enterprises prefer lower ones mainly for nighttime lighting. We confirm positive effects of higher economic status and negative effects of the existence of a smoker on solar home system adoption, which is similar for both households and micro-enterprises. On the other hand, households and micro-enterprises are different in two respects: (1) micro-enterprises are more likely to respond to unit prices of other alternative energy sources than households are and (2) households are more sensitive to prospects of grid expansion in the near future than micro-enterprises are. These findings imply that to progress the government's goal of electrification for all by 2021, there are more effective ways for further promotion of solar home systems by distinguishing between the approaches to marketing for households and micro-enterprises.

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1. Introduction

Goal 7 of the United Nations Sustainable Development Goals refers to affordable and clean energy and consists of three major targets to be achieved globally by 2030: (1) ensure universal access to affordable, reliable, and modern energy services; (2) substantially increase the share of renewable energy in the global energy mix; and (3) double the global rate of improvement in energy efficiency [1]. Although a conventional approach with centralized carbon-intensive energy systems could address the first target (i.e., reducing energy poverty), it might worsen the current situation for the second and third targets by additional greenhouse gas (GHG) emissions with low end-use efficiency [2]. To fulfill all targets, decentralized energy systems based on renewable energy sources

will be needed [3].

Among renewable energy systems, solar home systems (SHSs) have been recognized as a promising technology to mitigate both energy poverty and GHG emissions efficiently [4–7]. An SHS is a stand-alone photovoltaic system that consists of a solar panel, battery, charge controller, and related devices, such as light-emitting diode (LED) lights. SHSs can be installed easily and are available almost anywhere that sunlight is available. The cost of solar photovoltaics (PV) has substantially declined, with PV module prices having halved between 2010 and 2012 [8]. Such advantages make SHS popular, especially in developing countries [4,6].

A good example of rapid SHS diffusion can be observed in Bangladesh [9–13]. Bangladesh is a low-lying, riverine country, located in the Ganges Delta, in which various types of natural disasters, especially floods, occur nationwide [14]. Since such geographic characteristics made it difficult to expand the electricity grid to remote rural areas, the country's national electrification rate was very low; for example, it was only 18% in 1993 [15,16]. To improve the situation, the government commenced an SHS project in 2003 with foreign aid, and about 4.1 million SHSs were installed

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by October 2016 [17]. Thanks to the success of the project, the electrification rate by SHSs and related solar devices in rural off-grid areas is estimated as 15%, the highest rate in the world [18].

However, as shown in Fig. 1, the number of annual installations of SHSs peaked in 2013 and started decreasing from 2014 [19]. Although the government aims to achieve electricity for all by 2021, it will be difficult to achieve the target without further promotion of SHSs or related solar devices in the future (see the next section for the details). To investigate whether the market for SHSs has saturated in Bangladesh and whether there would be difficulties in promoting SHSs further, we need to know the determinants of or barriers against SHS adoption.

Previous studies in developing countries highlight three main determinants for SHS adoption: (1) higher income; (2) higher land and non-land assets, including electric appliances, such as mobile phones, radios, televisions (TVs), and others; and (3) characteristics of households, such as larger household size and higher education level (see Khandker et al. [9] and Komatsu et al. [20] for Bangladesh; Urpelainen and Yoon [21] for India; and Lee et al. [22] for Kenya). However, almost no existing studies take other important factors into consideration, especially unit prices of other energy sources (e.g., firewood and kerosene) and subjective forecasts for grid expansion in the near future, which might affect SHS adoption decisions.

Another limitation of previous studies is that they focus on only households, although there is substantial demand for SHSs from micro and small enterprises, which represent a large share of the total number of firms and job creation in developing countries [23]. The situation is similar in Bangladesh, where micro-enterprises (MEs), the so-called “cottage industry” in the Bangladesh Economic Census, defined as those with fewer than 10 employees, account for 87.5% of the total number of establishments [24]. Since many MEs adopt SHSs in rural Bangladesh, both households and MEs should be analyzed in the same framework.

This study examines the determinants of SHS for households and MEs using original data collected in rural off-grid villages in southern Bangladesh. Our main contributions are twofold. First, to the best of our knowledge, this is the first study to quantitatively analyze the similarities and differences between households and MEs regarding the determinants of SHS adoption. The results can assist policymakers and SHS suppliers in designing SHS policies, and distinguish between the approaches to marketing for

households and MEs. Second, our results add new insights to the discussion on “energy ladder” or “energy transition” in developing countries, which is an energy shift from traditional sources (e.g., biomass) to modern, cleaner, and more efficient sources, along with economic development [2,25]. In particular, the inclusion of the two key variables of (1) unit prices of other energy sources and (2) subjective prospects for grid expansion in control variables enables us to examine to what extent SHS adoption is affected by these factors.

The structure of the rest of this paper is as follows. First, the background of SHS diffusion in Bangladesh is overviewed in Section 2. After explaining the survey methodology and analysis in Section 3, the results of the descriptive and regression analyses for households and MEs are presented in Section 4. Section 5 summarizes the results and examines policy implications for the further promotion of SHSs in Bangladesh.

2. Background: solar home systems in Bangladesh

According to estimates of nationally representative household surveys, the national electrification rate in Bangladesh improved from 18% in 1993 to 76% in 2016 (Fig. 2). However, there was a large disparity between the electrification rate of 94% in urban areas versus that of 69% in rural areas in 2016 [26]. This is because large-scale construction for grid expansion is difficult in naturally disadvantaged rural areas in which floods occur frequently. Therefore, SHSs that do not need large infrastructure are recognized as a promising and cost-effective technology to mitigate energy poverty in remote rural areas [13,27].

In fact, among 65% of the rural population who had access to electricity, 15% utilized SHSs or other solar devices while 51% were connected to the national grid [18]. Another recent report on the progress of SDGs by the World Bank [28] indicates that Bangladesh has the highest share of total population connected to off-grid solar supply (almost all are SHSs) around the world. Although the Bangladesh government aims to achieve full access to electricity by 2021, a simple linear regression in Fig. 2 predicts that it will be achieved by 2027 if the current pace is maintained. To achieve the target even earlier, more increase in the share of SHSs is needed, especially in remote rural areas.

In SHS promotion in Bangladesh, the Infrastructure Development Company Limited (IDCOL) plays a central role in implementing nationwide projects, such as the Rural Electrification and

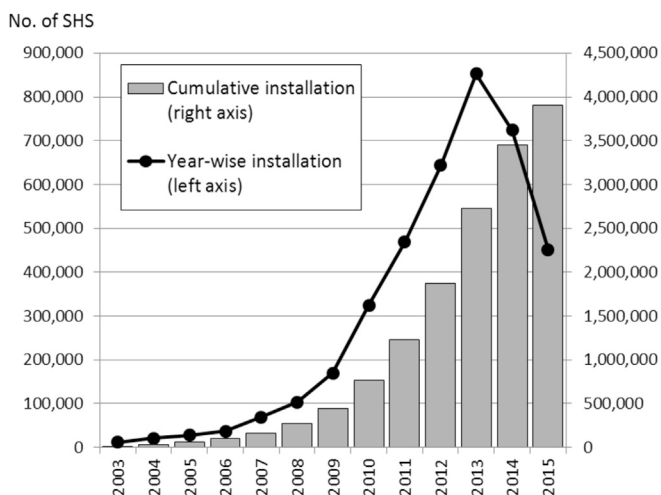


Fig. 1. Installation of Solar Home Systems in Bangladesh Source: Parvez [18] Note: The figure shows cumulative and year-wise installations of SHSs through government projects implemented by IDCOL.

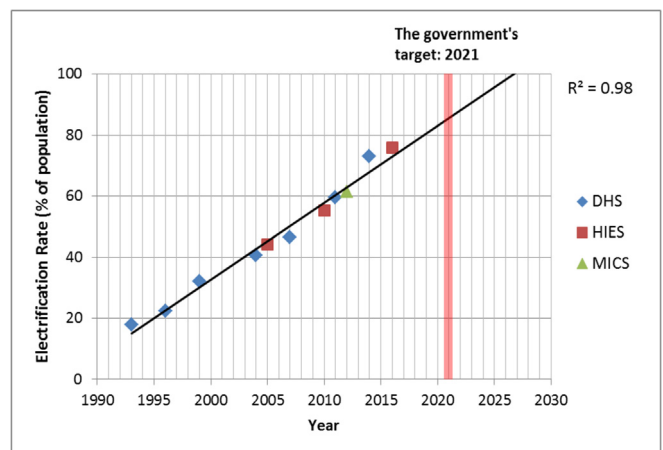


Fig. 2. Electrification rate (% of population). Source: Reports of the demographic and health survey (DHS), the household and expenditure survey (HIES), and the multiple indicator cluster surveys (MICS) in Bangladesh.

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