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Are micro-benefits negligible? The implications of the rapid expansion of Solar Home Systems (SHS) in rural Bangladesh for sustainable development

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ABSTRACT

This paper examines the multiple benefits of the adoption of Solar Home Systems (SHS) and discusses the dissemination potential for sustainable rural livelihoods in developing countries. Based on a household survey conducted in rural Bangladesh, we first identify the impact of SHS on the reduction in energy costs and compare purchasing costs. We then examine household lifestyle changes following the adoption of SHS. Finally, we consider several price-reduction scenarios to examine the potential demand for SHS and to evaluate its future dissemination potential. The results of the analysis indicate that households with SHS successfully reduce their consumption of kerosene and dependency on rechargeable batteries, with the cost reductions accounting for some 20–30% of monthly expenditures on SHS. Moreover, most households with SHS can enjoy its benefits, including electric lighting, watching television, and the ease of mobile phone recharging at home. Further, the price reduction can make possible potential demand in more than 60% of households without SHS, while additional price reductions promote the purchase of even larger SHS packages. This study concludes that even though the scale of single SHS is small, the micro-benefits for each household and the dissemination potential are substantial.

1. Introduction

Currently, 1.456 billion people worldwide suffer a deprived supply of electricity, of which 99.8% live in developing countries (IEA, 2009). However, although electricity is a necessity for improving the livelihood of rural households, grid expansion often requires expensive financial investment in infrastructure (power stations, substations, transmission lines, etc.), such as in a developing country like Bangladesh. Grid expansion also implies an increased dependence on fossil fuels and incremental emissions of greenhouse gases (GHG). Accordingly, Solar Home Systems (SHS) based on solar photovoltaic (PV) systems for individual households are becoming more popular in non-electrified areas of developing countries as an affordable alternative for obtaining access to electricity. Unfortunately, the amount of sunshine combined with the relatively small size of SHS at the household level effectively limit electricity generating capacity. Accordingly, as the production of electricity is typically in the range 30–130 Watt peak (Wp), SHS would normally allow households to use only low-powered electrical devices such as electric lamps, radios and cassette players, (black and white) televisions (TV), and mobile phone rechargers.

Worldwide solar PV installation for off-grid regions increased up until 2008 (REN21, 2009). SHS projects have also steadily expanded in the developing countries of Asia, South America, and Africa in the last thirty years, especially after the 1990s, with the installation of some 931,700 SHS units in developing countries up until 2000 (Nieuwenhout et al., 2001). While recent figures on the number of SHS units in developing countries are not available, we would expect that the number of installations has continued to increase rapidly as the use of SHS becomes a popular electrification method in developing countries. For example, the rapid growth of demand for SHS can be readily observed in Sri Lanka (Wijayatunga and Attalage, 2005), India (REN21, 2009), and Bangladesh (IDCOL, 2010).

The rewards for households with SHS comprise two kinds of benefits, namely savings in energy costs and improvements in lifestyle. First, the installation of SHS can reduce the costs of fuel such as kerosene and paraffin, and allow the removal of the rechargeable batteries relied upon before the installation of SHS (e.g., Wijayatunga and Attalage, 2005; Mondal, 2010). Second, the contribution of SHS in rural households is also extensive in terms of convenience, improvement in the quality of life, safety, and better quality of lighting from electric as opposed to kerosene lamps (e.g., Martinot et al., 2001; Urmee et al., 2009).

That said, even though the costs of rural electrification with SHS are lower than those of grid expansion, high investment costs for the poor in developing countries usually characterise SHS projects. For instance, a 50-Wp system costs US$490–500 in India and

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US$480 in Sri Lanka, whereas a 40-Wp system could cost up to US$500 in Vietnam or Cambodia (Urmee and Harries, 2009). 50-Wp systems in Bangladesh cost about US$408 (Grameen Shakti, 2009a). Importantly, households wishing to install SHS must be able to cover most of the upfront cost, irrespective of the nature of the financial support available from donors or non-governmental organisations (NGOs) in the form of loans or grants.

On the supply side, there is the prospect of reducing the price of PV modules through reductions in the cost of equipment (van der Zwaan and Rabl, 2004; Albrecht, 2007). Moreover, the global PV market grows at 30% every year, and this will encourage cost reductions in PV modules (Albrecht, 2007). In fact, the market price of PV modules has been falling over the past twenty years, with prices decreasing at 20% per annum (per Wp) from 1976 to 1996 (van der Zwaan and Rabl, 2004). These evolutional trends will encourage price reductions in SHS. As SHS packages consist of other components, such as batteries and electric lights, in addition to the administrative costs, there will be further potential for price reductions in the future.

A question that arises in the context of the promotion of SHS-based rural electrification is whether households that purchase SHS can enjoy tangible benefits commensurate with the high cost of installation. Another question concerns whether it would be possible to boost the demand for SHS through reducing the price of the equipment. As a way forward, this study attempts to estimate the impact of SHS on energy cost reduction by comparing the expenditure on energy with the payments on SHS. If households with SHS can gain substantial benefits, even with the small-scale SHS currently available, the micro-benefits will have a considerable impact on rural society through the increasing use of SHS.

The main contributions of this paper are twofold. First, we identify the impact of SHS on the reduction in energy costs, and compare the purchasing costs of SHS. We examine the impact on energy cost reduction by comparing the expenditure on energy with the payments on SHS. If SHS can become a sufficient alternative energy source for the household, then the cost reduction impacts may be enormous. To date, few studies have analysed these cost reduction impacts numerically, with the exception of Wijayatunga and Attalage (2005), who showed that in Sri Lanka expenditure on kerosene decreased to zero for more than 90% of households following installation of SHS. Moreover, earlier studies evaluate the effects of lifestyle changes with a "before and after comparison" (e.g., Acker and Kammen, 1996; Gustavsson and Ellegård, 2004; Urmee and Harries, 2009; Linguet and Hidair, 2010). A comparison between SHS households and non-SHS households should also provide additional insights into the impact of SHS adoption on the standard of living, hitherto limited to work by Wamukonya and Davis (2001). Second, we examine the dissemination potential of SHS for households without SHS given the price reduction. Unlike the previous literature, we need to assess the potential demand for SHS from the viewpoint of potential users. To do this, our analysis provides some scenarios for SHS price reductions, and obtains the latent demand for SHS of households currently without SHS.

This study examines the benefits of adopting SHS and the future dissemination potential of SHS using a household survey conducted in 2009 in rural Bangladesh, a country where rural electrification with SHS has proceeded rapidly. The structure of the paper is as follows. Section 2 describes solar photovoltaics and the diffusion of SHS. Section 3 summarises the case activities of the three regions that field survey conducted for both families with and without SHS. Section 4 details the impact on energy cost reduction and then compares these benefits with the payments associated with the adoption of SHS. Section 5 discusses the lifestyle changes in the households from the viewpoint of the benefits of electric lighting, watching television, and mobile phone recharging. Section 6 illustrates the impact of the declining prices of SHS on the further diffusion of SHS for households currently without SHS. The final section concludes.

2. Solar photovoltaics (PV) in Bangladesh

Bangladesh has a low electrification rate, in that only 28% of rural households have access to electricity (IEA, 2009). However, while there is an urgent need to expand rural electrification to improve the standard of living in rural Bangladesh, the electricity sector suffers from acute problems in terms of insufficient power generation capacity and a lack of distribution infrastructure. About 88.8% of the country's electricity generation currently draws on domestic natural gas (Bangladesh Bureau of Statistics, 2009). However, Bangladesh's domestic gas reserves may be exhausted in the near future. In order to increase electricity demand in accordance with the rapid economic growth of the country, some 6.2% per year in 2008 according to the World Bank (2010), the Bangladeshi government is urgently required to improve the electricity supply. In this context, the high upfront cost of expansion of the national grid to isolated and rural areas is an impediment to extending the supply of grid-based electricity to additional rural areas.

Promotion of decentralised electrification based on renewable energy, especially solar PV systems, can be an effective alternative for supplying electricity to off-grid regions in Bangladesh. According to the Renewable Energy Policy of Bangladesh, published in 2008, renewable energy is recognised as having a strong potential for delivering electricity services to the entire country by the year 2020 (Government of the People's Republic of Bangladesh, 2008). Islam et al. (2006) comprehensively reviewed the potential of renewable energy and identified solar PV systems as the most effective electrification option from a resource availability perspective relative to wind or hydropower generation in Bangladesh. In addition, several studies have investigated the benefits of using solar PV systems in Bangladesh, including Biswas et al. (2001), Barua (2001), Wamukonya (2007), and Urmee et al. (2009). Solar PV is also considered the most viable option for electrifying rural households, with estimates suggesting there were some 645,033 SHS installed in Bangladesh to August 2010 (IDCOL, 2010).

This research was conducted at a site where Grameen Shakti is actively working to install SHS at the household level in Bangladesh. Grameen Shakti, an NGO and member of the Grameen Bank group, was established in June 1996 to specialise in the promotion of renewable energy in Bangladesh (Barua et al., 2001). Grameen Shakti's main activity is the solar PV program, and it had already installed 317,591 SHS units by 2009 (Grameen Shakti, 2009b). Fig. 1 depicts the diffusion speed of SHS until 2009, clearly showing that yearly installation has increased sharply, with a 50% increase in installations from 2008 to 2009 alone. To implement the program, Grameen Shakti selected remote areas without a conventional electricity supply and no chance of connection to the electricity grid in the next 5–10 years (Barua, 2001).

As shown in Table 1, Grameen Shakti sells a number of SHS packages under several different payment options. Typically, customers pay 15–25% of the total price of the package as a down payment, with the balance being paid off over a two- or three-year repayment period subject to a low interest rate (6–8%). Households may also pay the total price of the package chosen at once to obtain a 4% discount, but few households select this option.

3. Survey design[1]

Fig. 2 maps the surveyed districts, namely Comilla, Kishoreganj, and Manikganj. A door-to-door household survey was conducted in

[1] A summary of the survey design is provided in Komatsu et al. (unpublished).