The Socioeconomic Impact of Solar Lighting on the Rural Poor in India

— A Case Study of Panasonic Corporation's Solar Lighting CSR Initiative —

Lowell John Gretebeck

INTRODUCTION

Global Energy Poverty

Globally, over 1.2 billion people — including 3.3 million in Asia — do not have access to basic electricity to support daily household activities of cooking, child study, and income generation. In the absence of reliable electricity, people in developing countries depend on kerosene, batteries, and candles to provide for their lighting needs. Extensive research-to-date confirms that these non-electric energy sources are unhealthy and costly for 2.6 billion people, comprising 40% of the world's population, who live on less than $2 dollars a day (World Bank, 2010).

It is widely accepted by development professionals that access to efficient and affordable energy is a prerequisite to poverty alleviation and sustainable development (Halff, 2014). Energy is a vital determinant of poverty alleviation because it supports essential life activities of cooking, heating, and lighting; furthermore, solar lighting enhances child education and household micro-business activities. Academic scholars, in a comprehensive report issued by Sokoine University of Agriculture (2011), write, "Energy is only one determinant of poverty and development, but it is a vital one. Energy supports the provision of basic needs" (p. 80–81).

India Context

The World Bank - IFC (2012) reports that over 75 million or 33% of the households in India are off the national electric grid and are typically overly dependent on kerosene for lighting. Of these households, 94% are located in rural India where the electrification rate remains at approximately 52%. This report further notes that households using kerosene are typically poor and it is therefore financially prohibitive for these families to consider the use of alternative energy sources. Kerosene is considered the primary energy source in the seven poorest states, including Bihar, Uttar, Pradesh, Jharkhand, Orissa, Assam, West Bengal and Rajasthan. The IFC further reports that off-grid and under-electrified households in India spend USD 2.2

billion on kerosene annually, with 82% of this amount spent in poor rural areas. Furthermore, the government of India provides one of the highest subsidies for kerosene, resulting in a high level of dependency on this energy source (p. 39).

As incomes rise, however, the percentage of Indian households using batteries tends to increase, despite the fact that the use of batteries has significant drawbacks. As reported, the cost per kWh is estimated to be five times the cost of electricity that is provided through national electric grids. Moreover, battery-charging stations (BCS) run on diesel generators that produce unhealthy levels of Co2 annually (p. 38–39).

The solar lighting market in India is characterized as underdeveloped or nascent, with less than 2 million solar lights currently in use. In terms of market penetration, it is estimated that only 4% of homes use solar (World Bank - IFC, p. 41). There are various reasons for this low level of market penetration, including minimal local manufacturing capacity, over-abundance of poor quality products with a high level of spoilage, lack of product quality certification, high upfront costs, a lack of financing structures, fragmented market with few leaders, underdeveloped distribution and repair channels, and a low level of public awareness regarding the benefits of solar lighting.

Despite these obstacles to solar light market penetration in India, government officials and development experts generally agree that long-term market success is favorable if we are able to overcome and rectifying these stated challenges. The data suggests there is significant upside potential for solar light penetration because only 54% of the households in India currently have access to electricity (World Bank, IFC, p. 87).

RESEARCH METHODOLOGY

Through this study, the scholar sought to answer the following key research questions: 1) What are the problems that are most commonly associated with current energy use among the "poorest of the poor" who are off the national electric grid? 2) What are the most significant socioeconomic impacts of solar lighting at the household level? 3) What is the impact of solar lighting on child education in terms of daily study hours and school performance? 4) In what ways has the use of solar lighting enabled families to improve their financial status with respect to increased savings and the reallocation of energy savings to other budget areas, including child education, nutrition, healthcare and savings.

In undertaking this study, the researcher used a "mixed" quantitative and qualitative methodological approach. As such, qualitative interviews with individuals and focus groups were considered an important complement to the quantitative solar impact survey instrument.

Quantitative data was collected through a semi-structured questionnaire. The three sections of the questionnaire provided detailed information about household characteristics and demographics, household energy use, and solar lighting benefits. The survey instrument consisted of approximately 30 questions and was translated into Marathi, after which time it was implemented by local NGO staff approximately eight months after solar light use. Due to the low level of reading and writing literacy of the recipients, CRHP staff assisted heads of households in completing the survey.

CRHP staff visited the rural distribution areas prior to the survey implementation to personally meet with the local residents to obtain additional information about energy use patterns and to more fully understand changes that occurred as a result of solar use. Discussions were held with more than 30 families who were recipients of solar lights. The participants were homogeneous in terms of gender, occupation and social backgrounds, thus encouraging open discussion. Participants were also encouraged to freely talk about their lighting needs, past experience with solar use, and share opinions about key challenges facing their village community.

SOLAR LIGHT DISTRIBUTION

Equipped with 5 small LEDs, the Panasonic Solar Lantern－Model BG-BL103－was designed to be fully charged within the timeframe of approximately six hours, contingent upon clear and sunny conditions. After a full charge, the unit has an estimated lighting time of 6 hours when set on High, as compared to 15 hours on Medium and 90 hours on Low. In addition to providing light during evening hours, the lantern has an additional feature to charge mobile phones with a capacity of 700mAh in approximately 2 hours. Panasonic reports that the International Electro-technical Commission（IEC）awarded the product with an ingress protection rating of IP34 for dust and water resistance, which speaks to Panasonic's high level of manufacturing quality.

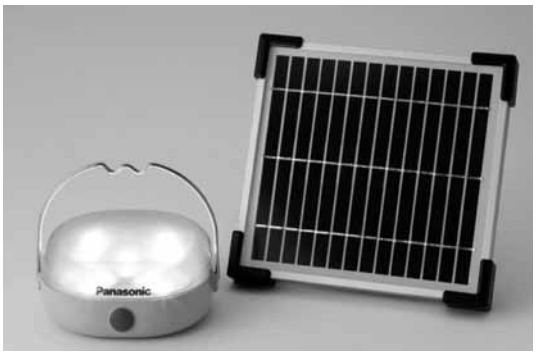

Figure 1
Panasonic Solar LED Lantern－BG-BL03
Source: http://panasonic.net/sustainability/en/lantern/2013/10/solar-led-lantern.html

A well-known and reputable non-governmental organization located in Jamkhed, Ahmednagar District in the state of Maharashtra, The Comprehensive Rural Health Project (CRHP), was selected to facilitate the distribution of 250 Panasonic Solar Lanterns in March 2015. Approximately 80% of the solar lamps were provided to poor families who reside in 10 targeted rural village areas. Distribution preference was given to one-parent households and to homes with children attending school. Also, families that reported income of less than $5 dollars per day was given priority in distribution. The remaining 20% of the solar lights were designated for the CRHP Hospital and a nearby Domestic Abuse Shelter. The stated purpose of the solar light donations is to support vulnerable households with children and women. A corollary objective of the distribution is to improve the quality of education, health and living conditions of the rural poor who do not have adequate access to electricity.

In an effort to avoid conflict at the community level, CRHP staff met with village leaders to explain the rationale for Panasonic's solar light donation and to further reach a consensus on a distribution plan. Thereafter, all recipients were provided with a comprehensive orientation on solar light use and maintenance, thus ensuring proper long-term use. Also, the recipients were asked to participate in a follow-up impact study within nine months of the distribution date.

SOCIOECONOMIC CHARACTERISTICS OF THE TARGET AREA

Rural Poverty

The rural area near Jamkhed was selected as the target distribution site because of a defined need to support families and institutions in the region. Despite pockets of new growth and development, many of the rural areas of Maharashtra remain underdeveloped. The area is plagued with poverty, which is the direct result of a prolonged drought and the migration of farm workers to nearby cities of Pune and Mumbai. Maharashtra ranks third among below poverty line states, with a rural poverty rate of 24 percent.

Figure 2
Target Distribution Area: Maharashtra State

Much of the rural area near Jamkhed remains off the national electric grid or, if connected, experiences irregular electric service. Government reports indicate that while most villages are connected, the same cannot be said with respect to household connectivity. Related, income data suggests that many people in the rural areas simply cannot afford electricity even if readily available.

Household Characteristics

The 250 households who received solar lights reside in ten rural villages within approximately a two-hour drive from Jamkhed. Similar to other rural Indian villages, these households are often composed of extended families, which may include nieces, nephews, distant relatives or grandparents. The average number of adults per household equals 2.9, as compared to 2.7 children. Eighty-three percent of the 250 respondents are directly engaged in agriculture, with the remaining 17% employed across a broad range of occupations, including teaching, healthcare and garment factory work.

Of the 250 survey respondents, only 3% report automobile ownership, while 30% possess a motorbike and 80% have a bicycle. This data indicates that rural mobility is limited and that residents are highly dependent on limited public transportation to get around. As an indication of an upward trend in financial mobility, 51% of respondents reported television ownership. In comparison, cellular phone ownership is relatively high at 86%, and is considered the main source of news and information.

Another significant socioeconomic characteristic is that of the quality of home construction, whereby 37% of respondents reported living in dwellings constructed of cement, followed by 28% with bricks and 27% with mud and thatch. Follow-up site visits confirmed that many of the residents reside in rudimentary housing structures, which is an indicator of poor socioeconomic conditions.

Family Income and Expenditures

Two hundred fifty households reported their monthly income and expenditures on food, healthcare, education, clothing and lighting. The average monthly income across the full data set of respondents was equal to 5,432 India Rupee, equivalent to approximately $ 81 dollars or 8,500 Japanese Yen ― at current exchange rates.

On average, families in this study reported spending approximately 48% of the family budget on food, followed by child education with a 24% budget allocation. This considerably high percentage of income allocated to the purchase of basic food is typical for families living in poverty. The remaining 28% of household expense was evenly spent on medical care, clothing and lighting.

Major Socioeconomic Problems

To gain a better understanding of the socioeconomic challenges facing the target

recipients, individual households were asked to identify the two most significant problems facing their family or community. Two hundred forty-six households or 98% of the survey respondents reported that inadequate lighting was one of the most critical problems, followed by a lack of quality jobs at 80% and clean water at 13%, respectively.

As a part the socioeconomic review, individuals were asked to rate their level of satisfaction in six areas: toilet facilities, clean water, child education, healthcare, access to electricity and housing. As shown below in Figure 3, the greatest area of dissatisfaction was reported in household lighting at 99%, followed by adequate housing with an 89% dissatisfaction level and and toilet facilities at 73%. In contrast, survey respondents expressed a high level of satisfaction in the areas of education and healthcare provision.

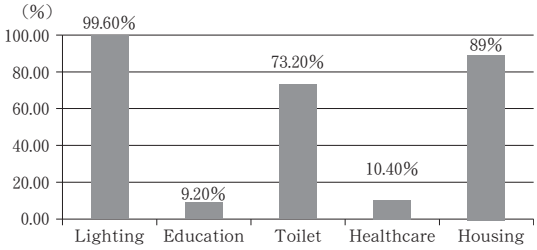

Figure 3
Level of Dissatisfaction

BASELINE ENERGY USE DATA

Current Energy Sources

By means of the survey instrument, residents reported the use of a variety of lighting sources, including wood, kerosene, candles, batteries and electricity. Despite the fact that many households in the dataset report the "availability" of electricity, it is not considered to be the most used or readily available. Households cited two significant factors that prohibit extensive use of electricity: first, rural homes regularly experience brownouts or power outages; secondly, the cost of electricity is high when compared to alternative sources such as wood and kerosene. Therefore, the data reveals that kerosene remains the most common energy source for lighting, with batteries and candles representing a smaller percentage. Generally, residents report the use of multiple energy sources, especially during periods of brown-out, to provide an average of 2.5 hours of lighting each evening.

When asked to identify problems associated with the various non-electric energy sources commonly used, 98% cited poor light quality, followed by 44% who identified bad smell and health concerns. On site interviews confirmed the above findings, with

a majority of those interviewed reporting on these issues of poor light quality and health concerns.

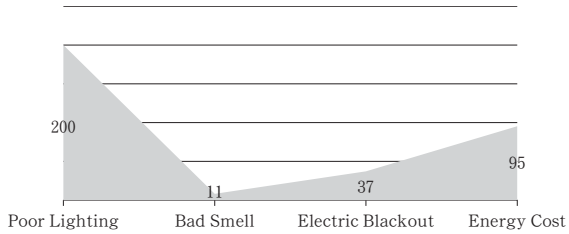

Figure 4
Problem Identification

Average Monthly Energy Cost

The average cost of energy each month closely corresponds with household size, meaning that larger households naturally have a higher level of expense. Based on the data reviewed, smaller families, with two children, spend approximately $7 dollars a month for energy, while larger households spend $8 to $15 dollars. This level of expenditure needs to be evaluated within the context of total income earned each month, estimated at $81 dollars. Calculated, energy costs comprise approximately 9% to 18% of the family budget.

SOLAR LIGHTING IMPACT ASSESSMENT

Solar Benefit Identification

The survey instrument identified the greatest perceived benefits of solar after a nine-month period of use. Participants were asked to rank (1 to 5), the benefit level of solar lighting for each of 5 categories. As shown in Figure 5 below, the highest ranking was the category of increased child study hours with a 3.36 score. Somewhat lower in ranking were health benefits with a score of 2.68 and increased savings at 2.58. In contrast, family socialization and safety scored considerably lower. After these main benefit categories were clearly identified, more comprehensive discussions were carried out at the grassroots level in an effort to triangulate survey results.

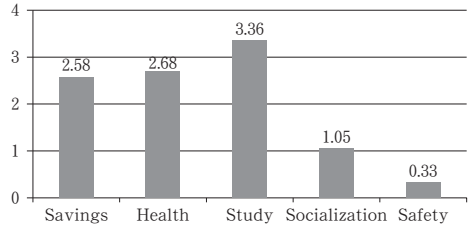

Figure 5
Benefits Identification

Financial Impact

One of the most significant impacts of Panasonic solar lighting is financial savings due to reduced expenditure for kerosene and battery recharging. While other empirical studies have narrowly focused on the impact of savings alone, this research expanded the analysis to understand changes in overall spending patterns for recipient households. The results show a reduction in expenditure on kerosene and battery recharging that is equivalent to 20% to 40% of monthly energy costs, depending on household size. This savings has a profound impact on poor families who live on a daily income that is close to the World Bank's designated poverty threshold of $1.90 dollars that was set in October 2015 (World Bank, 2016). Below this global poverty line, it is generally agreed that families, including many in this study, would not have sufficient income to pay for basic food, clothing and shelter. Of the 250 target households, a majority of the families saved an average of 115 India Rupee or approximately $2 USD per month. Follow-up discussions held with solar recipients confirmed these findings, with a majority of people stating that solar use allowed for savings that had a positive impact on the family budget.

Taking our analysis one step further, this study concluded that money saved was thereafter reallocated to other budget priorities, which resulted in improving the livelihood of families in the areas of nutrition, education and healthcare. Forty-eight percent of the households reported that the amount of savings, due to the use of solar, was primarily used to purchase additional food and water, while 34% allocated additional money for the purpose of child education. A lesser percentage of 6% of the households used energy savings to cover healthcare costs, and 12% designated the amount for long-term savings. Similarly, field interviews confirmed these findings that solar use took pressure off the family budget, and allowed for additional funds for food and child education.

Figure 6
Energy Savings Reallocation

Another financial issue reviewed was the average "payback period" as a result of solar use. Assuming a cost of approximately $50 dollars for the Panasonic Model

BG-BL03, a savings rate of ＄2 dollars each month would translate into a payback period of approximately 24 months. Additionally, considering a three-year lifespan for the Panasonic solar product, a family could easily pay for price of a unit as a result of savings over a two-year period and still enjoy the full financial benefits during the third year of use. In short, long-term sustainability of solar lighting, on the one hand, and the allocation of additional resources to alleviate poverty, on the other, is surely possible with intentional planning.

Education Impact

A central hypothesis of this research is that solar lighting will have a positive impact on child education. On average, our solar impact survey shows that household solar use approximates 2.4 hours per day; moreover, households with children report that child study hours increased an average of 1.8 hours per day as a direct result of solar use. Prior to solar, it was reported that poor lighting provided by kerosene lamps actually limited study time that was possible each day, particularly due to the high cost of kerosene, as well as bad smelling fumes and an increased risk of fire. Many parents commented that the use of kerosene lamps, coal, and wood caused children eye irritation and often led to coughing and respiratory problems.

Gap between Perceived Benefits and Actual Use

Although not identified as the greatest benefit, 42% of the survey respondents said they actually used solar lighting for emergency purposes during evening hours. When asked during follow-up interviews about this issue, mothers said that solar lighting was often used for children to use outside toilet facilities at night and to walk to neighborhood homes when dark. Similarly, 52% of the households regularly used solar lighting for cooking, even though this category was also not identified as one of the key benefits.

Linked Impacts on Health, Environment and Information Access

Two significant linked impacts that came out of the study included the categories of improved long-term health, as well as environmental care. In follow-up discussions, there appeared to be a new awareness that the use of kerosene, in particular, has a negative impact on long-term health and is detrimental to the wider environment. Furthermore, solar light recipients commented about the need to care for the global environment in which we live, which mandates a reduction in wood burning and kerosene use.

Another linked impact as a result of solar use was that of improved information access. The research data reveals that over 70% of the cellular phone users reported a significant increase in use to obtain news and information. As explained, this improved access to information is possible because the Panasonic BG-BL103 LED

Lantern comes with cellular phone-charging capability. Eighty percent of the survey respondents make regular use of this charging function.

SUMMARY

The use of solar lighting has dramatically reduced household dependency on kerosene and batteries. This has resulted in increased savings, which enables poor families to designate more financial resources for nutrition, education and healthcare. In addition, we can conclude that solar lighting has a profound impact on child education, particularly as children are now able to study more hours each day. Next, our research reveals that solar improves the quality of living as households face fewer health-related problems.

This research also informed that Panasonic's *100 Thousand Solar Lantern Project* has resulted in a greater awareness and acceptance of the benefits of solar lighting among community participants. A majority of households reported keen interest to purchase solar lamps in the future, citing both financial and health-related benefits. Clearly, residents now better understand that solar electricity is a viable option for rural households because initial investment costs are low with a two-year payback period.

A final cautionary observation is that while there is favorable market penetration potential for solar lighting in India, many barriers still exist. Obstacles to widespread solar use include the lack of financing, aftersales support, and underdeveloped supply chain structures.

FINAL RECOMMENDATIONS

In an effort to promote a greater awareness of the use of solar, local and international NGOs — in cooperation with local governments and CBOs — should be proactive in education programs focused on the benefits of solar use, with a particular focus on child education and financial implications at the household level. On the corporate side, information and marketing efforts are needed to promote awareness and build a basic knowledge foundation about new products that are available. Next, expanded market penetration and long-term sustainability of the solar use will require the set up and training of local technicians to provide after-sales service. Training will be required of people at the grassroots level in the areas of installation, repair, maintenance and spare parts procurement. Finally, governments, international and local NGOs, community-based organizations, and corporations should take an active role in quality assurance and consumer information efforts.

ACKNOWLEDGEMENT

This research was possible due to the cooperation and support of Panasonic Corporation (Japan) and The Comprehensive Rural Health Project (India). It has been a privilege to walk together on this journey to better understand the impact of solar lighting and how we can improve the livelihood of the "poorest of the poor", especially children, in India and other parts of Asia.

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Panasonic Corporation (Japan) has taken the lead among international companies to provide quality LED lighting in numerous developing countries through a unique Corporate Social Responsibility (CSR) program known as the The 100 Thousand Solar Lanterns Project. Since the initiative was launched in 2013, the company has donated more than 50,000 solar lights to households that have limited or no access to electricity in developing nations, including Cambodia, India, Vietnam and Myanmar.

The purpose of this empirical research is to assess key socioeconomic changes after Panasonic solar lighting was provided to 250 families living in rural Maharashtra in 2015. The working hypothesis of this research is that solar lighting will have a direct, positive impact on the socioeconomic variables of education, health, income, family socialization and safety.

In coordination with a community-based organization in rural Maharashtra, the researcher developed an assessment methodology to study various socioeconomic changes, measured against key baseline data. Two hundred fifty household recipients completed a detailed questionnaire; thereafter, the data was compiled and analyzed in accordance with SPHERE International Guidelines. Following this quantitative data collection phase, qualitative on-site interviews were conducted with solar light recipients to confirm the quantitative survey results and to provide relevant insight into research findings.

The results of this academic inquiry support the primary hypothesis that solar lighting has an efficacious impact on improved child education. On average, children study hours increased 1.8 hours per day, resulting in improved school performance. Still another positive impact of solar lighting is a reduction in monthly home energy costs by more than 25 percent. Additionally, the use of solar lighting reduced household dependency on kerosene and battery recharging, enabling families to increase spending on education, nutrition, and medical care.

Keywords: solar lighting, poverty alleviation, Panasonic, India