Replacing Kerosine Based Lighting Systems (Hurricane/Kupi) with the White LED in Rural Area in Bangladesh through Solar Energy

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Abstract: More than one quarter of the world's population, who does not have access to electric light, live in the developing countries. Bangladesh is one of these countries, where the people in the remote rural areas have to rely on fuel basically kerosene based lighting to bring minimal lighting services in their homes. After completed a formal survey the paper reviews the quality of lighting, energy, health issues and financial issues due to the use of fuel based lighting in rural villages in Bangladesh. Recommendations are given on the amount of light needed as the first time electric lighting services in those remote places. The survey results show that LED technology can bring necessary light in these rural homes with least economical energy use and it is the potential technology to replace fuel based lighting in a sustainable way. Replacing fuel based lighting by white LED's can also contribute to the overall development of the underprivileged and underdeveloped communities by helping to improve the health, education and life expectancy of the people as well as income generation. The replacement of fuel based lighting can be done in a sustainable way by using the existing and environmentally friendly renewable energy sources like solar PV technology. This sustainable way of lighting many villages in Bangladesh is expected to improve the general living standard of the communities, contributing significantly to health, education.

1. INTRODUCTION

Electricity is a key ingredient for the socio-economic development of the country. Adequate and reliable supply of electricity is an important pre-requisite for attracting both domestic and foreign investment. The Government of Bangladesh has set the goal of providing electricity to all citizens by 2020.

Sufficient and reliable source of electricity is a major prerequisite for a sustained and successful economic development effort and poverty reduction. Bangladesh requires an economic growth rate of more than 7% p. a. in order to achieve this growth rate, availability of a reasonably priced and reliable source of electricity is a prerequisite. Bangladesh being categorized as one of the least industrialized nations by best utilizing its natural, human and agricultural resources the desired pace of GDP growth could be attained by increasing electricity generation at much higher rate, which is the key target for development.

Government of Bangladesh has made vision and policy statement regarding power sector improvement. It is government's constitutional responsibility to provide electricity to the people. In the vision statement it was mentioned that providing access to affordable and reliable electricity to the majority of the people of Bangladesh by 2020 is a fitting national goal to usher the next millennium & where 5% power should be come from Renewable Energy Technologies by 2015, 10% by 2020.

Approximately 100 million people in Bangladesh's (out of 140 million people) rural areas have yet to see the light of "Rising Tiger" as the media has literally described the recent economic growth. 70 million people in rural area are still dependent on biomass fuel, national grid facilities & but reliable and quality power is still beyond their reach and as rest still have no access to electricity. Only 18% of the total populations are now getting reliable & modern power. The government's ambitious plan to electrify the entire nation by 2020 is in large part based on providing these homes with decentralized renewable energy systems. Decentralized renewable energy systems consist of local energy generation and dissemination systems unlike a large national or regional grid. It is important to add that when the government says "rural electrification," it means providing electricity to a mere 10% of the households in a village. There are many types of such systems depending on local availability of resources (solar, biogas, biomass gasification, wind etc.). However, for this part of the country, solar energy is the best option because of year round availability of high solar radiation of 5.2 kwh/m^2/day.

Infrastructure Development Company Ltd (www.idcol.org), IDCOL is implementing the solar electrification programme in Bangladesh's remote areas far from the power grid since 2003 through 15 NGOs and Micro Finance Institutions (MFI) including Grameen Shakti, BRAC Foundation etc with financial support of different development partners like World Bank, KFW (German Development Financing Bank) and Global Environmental Facility (GEF) through the government of Bangladesh (GOB). The recent report said that over 200,000 (10, 00,000 lakh=1 million) as June'2008 rural households have been brought under the solar power system in the last five years by IDCOL as an alternative source of energy. And they have set a target to install one million Solar Home Systems (SHSs) by 2012 so that the government can achieve its target of providing electricity to all by 2020. In this project SHSs system, containing solar photovoltaic panel, battery, charge controller, solar lamp and switch - is a

convenient mode of supplying power for small electrical loads such as lights, radio, cassette players and black white TV. The NGOs are providing a wide range of power generating capacity of solar photovoltaic (solar pv) panels from 10 W_p to 120 W_p. For example, a 50 W_p PV panel can run four CFL lights and one black and white television according to the recent price for the whole 50 W_p SHS system between US $ 360 and US $ 430 and consumers can purchase a solar home system both in cash and credit. Recently one NGO started distributing 10 W_p systems at a cost of US$120 targeting the very poor families so that they can run two to three low powered lights.

But for the ultra poor people actually who's expenditure on fuel (mostly kerosene) for lighting is below Tk.10/day-have no option for getting the benefits of the said IDCOL project. But, LED – the next revolution in energy efficient lighting – would help people in the dark leapfrog into a new era of home lighting having lower price than 10W_p systems. This new LED based low powered small solar system revolution has helped the target group by reducing their dependency on dirty kerosene, which consumed much of their income and was injurious to their health.

This paper tries to explore this best lighting options; LED based small solar system for that target group in a sustainable way in Bangladesh.

2. METHODOLOGY

Two years ago, *'Sondipon'* (a Dhaka based non-profit organization & an social initiative of MK Envirotechnology), distributed LED (Light Emitting Diode) based solar home lighting systems to 25 homes in the remote village of 'Kushulia' under Shamnagor/Kaligon in Satkhira district of southern part of Bangladesh. The proposed LED based small home lighting systems in Kushulia consist of one 5 W_p solar photovoltaic panel, one 6V battery, and two 18 or 32-light LED lighting systems having different type of casing (3 models) to enhance the optical power of the directional LED's like well known hurricane model, wall mounted dish type model, plastic moulded type charger design etc-which provide four to six hours of light. "There was nothing here ten years ago except jungle, and we were only connected to the outside world when the road was built" explains Mr Monihar Rahman, the member of the local government authority in the village. My co-author Mr. Kazi Rabiul Islam, a permanent resident in the same area also and i traveled to this village to assess the impacts of this small LED based solar home lighting systems on the families-who earlier used to run the hurricanes by kerosene/kupi: the problems, benefits and the barriers to successful continuation of such a lighting systems in this part of the southern or any other part of Bangladesh. This assessment was for the benefit of not only for 'Sondipon' but also the adaptation of Renewable Energy Technologies in Bangladesh.

3. RESULTS

After ten to eleven months of use, only 3% of the LED based bulbs that were distributed have had some level of damage. Most importantly, the bulb holders have broken and individual LEDs have fused within the bulb (some reporting 10-15 fused LEDs in a bulb). This could perhaps be due to the poor skill of manufacturing of the bulbs. The various parts of the system were sourced from China and distributed as locally developed & assembled products. The solar panel is also damaged due to incidents involving mishandling by unauthorized person, cyclone and even rats eating the wires. These are all important factors to consider when designing future small LED based solar home lighting systems for rural areas. All of the users were adequately trained in the maintenance of the system during the installation of the systems. The villagers essentially only needed to keep one foot by one foot thin-film/crystalline solar panel clear of dust, because the dust can affect the efficiency of the system. One of the other question is of brightness of the system. At first sight, it appears that this really isn't enough light, but it is much better than of earlier kupi/hurricane. When asked about the amount light the bulbs emitted, approximately 80% of the respondents claimed it was adequate lighting but most agreed it could be brighter. At night, the effect was clear. In a sea of darkness, the small LED bulbs made a large difference. I could see the light created by the bulbs from far off and the light seemed adequate to extend work hours, keep the bugs out of the food while eating and even keep the scorpions and snakes at bay. It perhaps was not the best lighting for reading, but the LED bulbs still made a difference by alleviating some of the major concerns of the villages.

"We are very happy with the system and we would like more installations," said one of the villagers. Indeed, the lighting systems benefit the villagers immensely in terms of general lighting needs. The majority of the respondents of the survey said they used the LED based lighting system to extend their work hours at night The system was used specifically for their children's studying needs as well as necessary kitchen lighting for cooking. The occasional person even used the system to charge mobile phones and flashlights.

There are approximately 25 homes in this village with joint families having seven to eight children in each home. Formal surveys were conducted in 18 households, or 35% of all households in 'Kushulia', with the assistance of the village school teacher. The majority of respondents were decision makers within their households and 89% fell within the labor-contributing age range of 18 to 49; 28% of respondents were women. In addition, an informal survey was conducted of several homes during the night to assess

the effectiveness of the home lighting systems. One hundred percent of the respondents claimed that they had seen their children's study habits improve after the installation of the solar home lighting system. "When I first started teaching here five years ago, most of the children couldn't even write their names properly and they would fail tests even when only 50-60 percent marks were required for passing," stated the village school teacher. "It took me one year to just get them to memorize the prayer we do in the morning before starting school." Thanks to the extended hours of study provided by the lighting system, there has been a 70% improvement in retention of knowledge and on average students are studying one to three hours longer than they did before. "Our kids can study until late even after we have all gone to bed," said Ms. Rahela, one of housewife. This is particularly important in rural areas where children often have chores until sundown which allows them to be free to study only in the dark. "Would you prefer electricity from the grid or from such solar installations?" I asked every interviewee. "This LED-based system, of course, because there are no bills & first time investment is very lower comparatively to the others bigger system !" bluntly stated Mr. Rahman. Then there is also an issue of safety: "If I get in a fight with my wife, she may go outside and put her hands on the live wires," joked Mr. Molla, who received the lighting system just in time for the birth of his first child on last year. The truth is that in rural areas many of the wires are uncoated so they do present a threat to people, particularly curious children.

The dependability of the grid was also often questioned as presently in Bangladesh; facing 1000 MW/day power shortage against our peak demand 5500 MW/day and rightly so in a nation which struggles to provide reliable electricity for even its urban centers.

The LED bulbs reduced the village's dependency on expensive kerosene (US $0.85=1 liter). According to the villagers, the light emitted by the LED bulbs was brighter than their kerosene lanterns. Of the people we interviewed (approximately 60% of the households with the installations) there was a 75% or greater reduction in consumption of kerosene on average. A few households, including Mr. Sidique, saw their consumption of kerosene drop from 11 liters a month to absolutely none. This has major implications for climate change as well. According to recent report, of the 35 million homes still burning kerosene in rural areas in Bangladesh and 3 kg of CO_2 emitted per liter, there is immense potential to reduce the total 25 million tons of CO_2 being generated currently. Though this may seem meager compared to CO_2 emissions coming out of developed countries, it is vital in helping rural Bangladesh leapfrog past a carbon based economy.

Also, all of the interviewed villagers claimed that the home solar lighting system saved them money, because they no longer needed to purchase kerosene. This is important for households in this village where incomes are typically $45-$60/year before expenses, and the cost of kerosene can be as high as annually, proving to be a significant dent (up to 15%-20%) in the household budget.

At the end of the visit, the lingering question of financial feasibility remained. A single home lighting system consisting of one solar panel, two lighting arrangements with others accessories costs approximately $70. There were no clear pathways for progress.'*Sondipon'* hoped that the pilot project would spur the villagers to want to purchase the next system out of their own pocket money (which many do not have) or take a bank loan to finance the purchase. Seeing the benefits, approximately 90% of respondents said that they were willing to take a bank loan to finance the purchase of more home lighting systems. It is known that interest rates for loans to villagers are very high and even the villagers themselves joked that they would take the loan "but paying it all back was an afterthought." Perhaps a micro-finance scheme is required for the dissemination of such technology throughout rural Bangladesh & fortunately Bangladesh is the pioneer in the filed of micro credit system. The recent formalization of a policy by the government on micro-finance might help expedite such schemes.

Clearly in terms of the overall energy ladder of such rural home, small solar home lighting is filling only part of the gap.

Table 1.Light Comparison

(Considering 50,000 hrs of operation)

Lamp type	Home made kerosene	Incandescent lamp	CFL	White LED
Efficiency (Lumen/W)	0.3	(5-18)	(30-79)	(25-50)
Rated Life hours	Supply of Kerosene	1000 hours	15000 hours	50,000 hours
Durability	Fragile & dangerous	Very Fragile	V. Fragile	Durable & robust
Power consumption	0.06 liter/h	5W	4W	1W
Cost in US $	$ 2000	$280	$ 130	$ 70

4. CONCLUSIONS

There remains a need in rural Bangladesh for such solar home lighting. This need persists in remote villages where connection to a main grid is not viable for semi-nomadic populations away from their permanent home, and potentially also for users that experience grid intermittency. Beyond the well-known environmental and health concerns of fuel-based lighting, we have demonstrated a clear inferiority to solar pv solutions in technical and economic terms. Currently, solar home systems utilize compact fluorescent lamps (CFLs);

however recent advances in light emitting diode (LED) technology suggest that LEDs have increasing potential to become a more economical alternative due to decreased power requirements and longer lifetime. Moreover, continued improvements in LED efficiencies are nearly guaranteed; while the fluorescent technology is already mature.

Our survey populations in the village found that CFL bulbs (along with the other bigger systems supplied by the NGO under IDCOL project) were universally preferred to LEDs for room illumination, primarily due to a preference for diffusivity over the strong directionality of LED light. While diffusivity could be accomplished by incorporating simple diffusers into a configuration of smaller LED bulbs & some economic advantage might be lost. There may be an opportunity to reduce the cost of high-intensity LEDs by compromising the light quality, as quality was not strongly valued by the surveyed population. Still, it is unlikely that LED options will find widespread appeal in this and potentially other rural populations worldwide, until they become significantly cheaper than CFL alternatives. We find that LED lights could offer immediate benefits for application in flashlights, where their directional nature is advantageous, and their long lifetime and high efficiency could be exploited. In the best case scenario, a small battery charger could be integrated into existing solar home systems for use with rechargeable batteries for LED flashlights. Unfortunately, it is clear that without some change in the local market and distribution system, the benefits from such innovations and the widespread impact of while the results presented here on the technological and economic merits of LED lighting are clearly applicable to a broad range of markets, one must be careful in attempting to draw generalized conclusions from a qualitative case study, especially one of small sample size. We have performed a preliminary investigation of the utility and viability of LED technologies in serving the lighting needs of these populations in *'Kushulia'*, the results of which may or may not be applicable to other off-grid populations. Still, despite differences in available resources, distribution channels, and local culture, the observations and conclusions presented here give evidence of the potential for solar LED lighting to serve rural populations worldwide; while illustrating key challenges and barriers to widespread adoption of these technologies by an exemplary population in rural areas in Bangladesh.

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