Modern Environmental Science and Engineering (ISSN 2333-2581)
January 2016, Volume 2, No. 1, pp. 55-58
Doi: 10.15341/mese(2333-2581)/01.02.2016/008
Academic Star Publishing Company, 2016
www.academicstar.us

Socio-Environmental Impact of LED Based Solar Urja Table Lamp at Rural Areas

Debanjan Sannigrahi and Nikita Kala

Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai, India

Abstract: Solar Urja Lamp (SoUL) is designed and developed by Department of Energy Science and Engineering, IIT Bombay for helping the students in their night study at rural villages of Madhya Pradesh, Maharashtra, Odisha and Rajasthan which are either electrified or non-electrified villages but depend on kerosene lamps for lighting. Those table lamps are the Standalone Solar Photovoltaic (SPV) system having 4 major technical components: the Light Emitting Diode (LED), a Controller (PCB), a Battery and a Solar Panel. The Lamp base of size 10 × 10 sq. cm. is fitted with Battery, Switch, Indicator LED and PCB. The lamp is designed by keeping the top fitted with LED at 12 inches height from the base for getting lumen efficacy of about 150 lux during general purpose lighting (lower mode) and also about 250 lux which is sufficient during study (higher mode). It is found that each lamp operates for 8 and 5 hours in lower and higher mode with power consumption 0.192 W and 0.352 W respectively. The dedicated team of Engineers visited 24 districts of 4 states and so far trained 780 people in 34 trainings of various NGO groups who in return produced table lamps and distributed to 7,35,352 students at a cheaper rate of Rs 120/-. The project gave fourfold socio-environmental impact in all the villages covered so far. The lamp has allowed students to study in the evening and to complete all school assignments. It has improved the indoor air quality by reducing the use of kerosene lamps which cause respiratory problem to the family members and also various fire hazards. This program has also created new job opportunities in lamp production for locals under the umbrella of NGOs. And finally, the rural families have saved money by reducing the purchase of kerosene gradually. The villagers now believe that SoUL has positive effect on their health, economy, welfare and environment.

Key words: environmental impact, light emitting diode, renewable energy resources, societal impact, Solar Urja Table lamp, SoUL

1. Introduction

India being developing country is not in a position to supply electricity in every nook and corners of its all villages. Major constraints are population explosion, huge requirement of finance for connecting all villages, variable topography like hills, forests, deserts, etc., less production of electricity than the requirement and considerable loss of electricity during carrying electricity through wire to a long distance. Even where electricity is available, people are facing problems due to frequent power cuts, lesser voltage, power thefts, lesser generation in power plants, etc. Energy management is a burning problem not only in India but throughout the globe. There is a huge gap in between the total electricity production and the demands of energy for satisfying the population of about 1.2 billion in India. Research is going on to tackle this problem either tapping renewable energy sources like solar, wind, biomass and nuclear powers besides traditional thermal and hydro power or conservation of energy by utilizing energy efficient machineries as well as gadgets both in industrial and household level. Use of Light emitting diode (LED) based lighting system is an important breakthrough of recent times in place of usual lighting systems both in domestic and street lights [1]. Around 25000 villages of India are located in remote and inaccessible areas and hence could not be electrified through conventional grid extension. The

Corresponding author: Debanjan Sannigrahi, B. Tech; research areas/interests: use of solar energy for the benefit to rural students cum village people. E-mail: debanjan.msoul@gmail.com.

Ministry of New and Renewable Energy (MNRE) is implementing the 'Remote Village Electrification Program' (RVEP) to electrify such remote villages by installing solar photovoltaic (SPV) home lighting systems in all the states [2]. More than 350 million people of India (29.7 % of total population) are below 14 years, i.e., mainly students who must be well educated and well trained for making success of 'Skilled India' campaign. But the lack of electricity in rural India during dark hours hampers the education and growth of those young [3]. Rural people (more than 40 percent families in India) generally use kerosene lamp or wax candles for lighting in evening hours. Kaplan [4] showed that burning of candle inside a closed room for few hours resulted accumulation of lead concentrations sufficient to cause fetal damage in kidney or to harm the mental development of children. According to International Energy Agency (IEA) report [5] about 250 million households comprising 1.3 billion people in the world lacked reliable access to electricity to meet basic lighting needs in 2010. Various types of kerosene — fueled simple and wick lamps are often the sole source of illumination for studying or income-generating work after sunset. But those kerosene lamps are important source of black carbon production which not only polluting the atmosphere but also increasing lung's diseases of rural masses. Lam et al. [6] estimated that about 4 to 25 billion liters of kerosene are consumed by household every year to fuel their lighting sources, almost one-tenth of the fuel burned in those kerosene lamps was converted to black carbon particles and thus about 270,000 tons of black carbon were emitted to the atmosphere each year from kerosene lamps. The extent of electricity consumption of a country is one of the indicators of socio-economic development. In India about 679 million people, i.e., 35 percent of world's population, is living without access to electricity [2]. Keeping these in view along with the necessity for student to get clean light at least during evening study, the Department of Energy Science and Engineering, IIT Bombay has taken up a project to produce and to distribute one million Solar Urja Table Lamps (SoUL) among students deprived of electricity for their study. The SoUL is a standalone SPV system (Fig. 1) having four major technical components: the Light Emitting Diode (LED), a Controller (PCB), a Battery and a Solar Panel, designed keeping in view the availability of various components in local market and easy packaging of produced lamps [3].

The Lamp base of size 10 × 10 sq. cm. is fitted with Battery, Switch, Indicator LED and PCB (Fig. 2). The lamp is designed by keeping the top fitted with LED at 12 inches height from the base for getting lumen efficacy good enough for reading and working purposes according to standard lighting requirement [7], i.e., about 150 lux during general purpose lighting (lower mode) and also about 250 lux which is sufficient during study (higher mode) . The light source used in SoUL is a cool white LED of 0.5 W with operating voltage of 3.2 V. This LED having a luminance of 150 lumen per watt, works in two modes within the operating temperature range -40° to 85°C. It is found that each lamp having 1 Wp solar panel, 0.5 Watt LED and 1200 mAh of battery storage is able to provide about light intensity of 250 lux (good enough for study) for about 5 hours of daily service in higher mode with power consumption 0.352 W while in lower mode it can give light intensity of 150 lux for 8 hours with power consumption 0.192 W only [3]. The present article deals with socio-environmental impact of these solar urja table lamps produced with the help of locals (NGOs) and distributed to needy students with the help of school teachers.

2. Experimental

The dedicated team of Engineers went to different

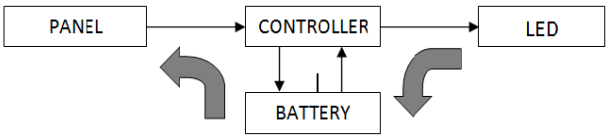

Fig. 1 SoUL, the standalone solar photovoltaic (SPV) System.

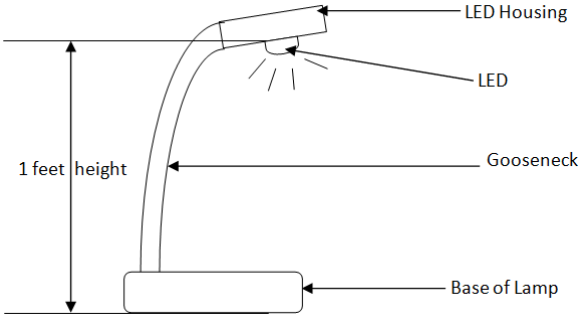

Fig. 2 Product design of SoUL.

remote villages of Maharashtra, Madhya Pradesh, Rajasthan and Odisha and gave training to prepare the Solar Urja Table Lamp (SoUL) to local people of various Non Governmental Organizations (NGOs) who in return produced lamps (Fig. 3) and distributed to needy students through schools at the cheaper rate of Rs 120/- per lamp. After working for about one year, feedback was taken from the users of SoUL for determining its Socio-environmental impact.

Fig. 3 Training to NGOs and Lamp Manufacturing on Progress.

3. Results and Discussion

During December 2013 to January 2015 a team of Engineers worked under the leadership of first author in 12 districts of Madhya Pradesh, 7 districts of Rajasthan, 3 districts of Odisha and 2 districts of Maharashtra (Table 1). After receiving the components from suppliers 34 trainings were conducted in 34 places and a total of 780 people (majority village ladies) belongs to different NGO groups were trained, who in return produced 7,36,641 Solar Urja Table lamps almost within one year. By receiving those lamps under "one student one lamp" policy 7,35,352 students were benefitted. Each trainee got about Rs. 25/- for production and distribution of each lamp to students through nearby schools.

Table 1 Village people and students benefitted from SoUL program.

States	No of districts covered	No of trainings conducted	No of people trained	No of SoUL	
				Produced	distributed
Madhya Pradesh	12	21	432	385853	383412
Rajasthan	7	7	196	178653	180153
Odisha	3	3	81	56880	56551
Maharashtra	2	3	71	115255	115236
Total	**24**	**34**	**780**	**736641**	**735352**

A survey was conducted among SoUL users (both students and their parents) to find out the socio-environmental impact. In fact users expressed their happiness as they got an opportunity to study and to work during evening hours under an electric lamp, even though traditional electricity was not there. Students could finish their school assignments during evening which motivated more to concentrate on study. Families got the relieve to keep the room more free from kerosene smell, carbon dioxide and black carbon than before. In return they used less kerosene lamps inside room, thus saving about one-third expenditure on purchasing kerosene. Additionally, one liter Kerosene emits approximately 2.5 kg of carbon dioxide

(CO_2) gas. Buragohain [2] reported that in an evaluation study carried out by National Council of Applied Economic Research in six states, viz. Assam, Meghalaya, Jharkhand, Odisha, Madhya Pradesh and Chhattisgarh, the installation of solar photovoltaic home lighting systems gave 4 to 5 hours light during winter and summer which improved significantly children's education and standard of living while reduced considerably the use of kerosene. There is evidence that exposure to the lamps, which are used indoors and in close proximity to people, impairs lung function and increases the risk for respiratory disease, cancer, eye problems, and infectious disease including tuberculosis [8]. Rienstra [9] also reported that using poor quality lighting from kerosene lamps increased the risk of household fires, personal injuries such as burns and the risk of chronic respiratory diseases due to harmful emissions. The trainees were very happy as they got a chance of extra income by making lamps and distributing those to students of their locality. As such the program was found to record positive socio-environmental impact.

4. Conclusion

Solar Urja Table Lamp allows rural students to study easily than they could do by candle or kerosene lamp light. It has helped to complete their school assignments even after sunset by safe guarding their health as well as eyes. Rural families are also getting an opportunity to complete their house works and to take part in their economic activities. There is significant reduction of air pollution due to considerable reduction in kerosene use for indoor lighting. The SoUL project has given fourfold (Educational, Safety, Health and Economical) benefits to the users. Societal as well as environmental improvement is the underline factor for SoUL.

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