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Sustainable Solar Energy Lightning Solutions for Rural India

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Abstract: *An easily available and accessible energy source has proven to be a necessity in the present lifestyles of the modern day world. Despite energy sources being an integral part of our lives, 23% of the total population worldwide doesn't have access to adequate energy supply. Even providing an adequate amount of energy capable of lighting up the households with LED lanterns for several hours and charging our devices will bring about a tremendous change in people's lives. The aim of this paper is to develop a sustainable and viable method to provide continuous, economical and accessible source of electricity for lightning purpose for the marginalized population. This paper proposes to establish Solar Based Energy Centres for charging purpose especially for lightning solutions. The basic premise is that few extra hours of light will improve the quality of life and economic standards of the people. This model has an edge over the others as it is not led by profit maximising motives but rather of social welfare, while simultaneously leaving space for further developments in the strategies of distribution and financing of the model.*

Keywords: *Corporate Social Responsibility, Rural Electrification, Sustainable Electricity, Sustainable Rural Lightning System, LED, Charging Station.*

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I. Introduction

On 28th April, 2018 the Prime Minister of India announced that 100% of the villages in India are electrified (LiveMint, 2018a). This provides an image that there is free available electricity for all in India. But to understand this statement deeper it is important to understand the definition of electrification. According to LiveMint (2018b), "A village is considered electrified if 10% of the households and all public places like schools, health centres have electricity". BBC (2018) wrote in its article that the figures provided by World Bank shows that around 200 million people in India still do not have access to electricity. This shows that India is still looking for an alternate sustainable arrangement for electricity for rural India.

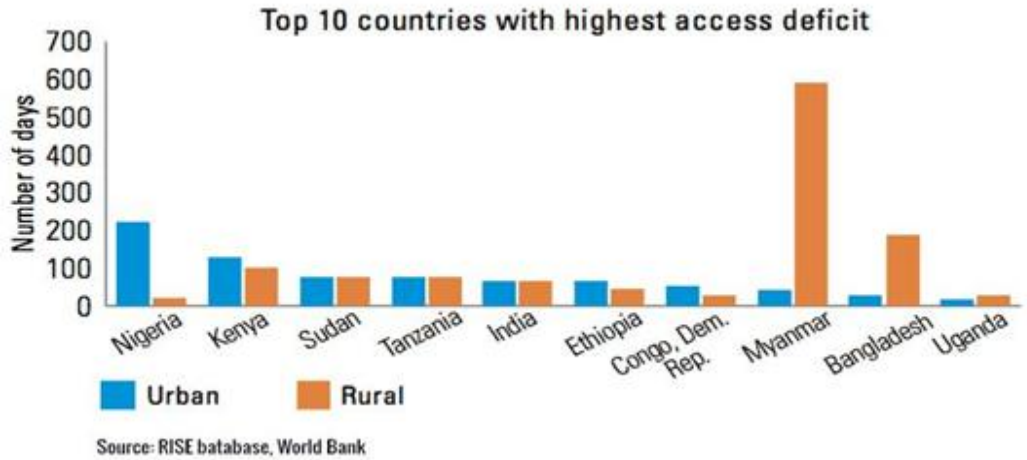


Figure-1: Top 10 Energy Deficient Nations Worldwide (TanzaniaInvest.com, 2017)

A large number of problems faced by the rural population of a country including a lack of access to information, inappropriate communication channels, low quality educational and medical facilities, weak

economic growth and a low standard of living can be extensively impacted in a positive way by ensuring an adequate supply system providing electricity in the rural areas (Szabo, 2011). But, inspite of various advantages this presents, coming up with efficient ways to provide continuous supply of electricity in rural parts of a country, remains a challenge for the governments and executives. Due to a lack of the presence of globally accepted rudimentary solutions to this problem the pace of progress in this area is decreased a substantial amount. While deciding an approach to tackle this problem, variables like population density, availability of present resources, aimed social inclusion levels, the sort of settlement (centralized or not) must be taken into careful consideration (Fong, 2014).

The proposed model for providing energy to the village should incorporate ways to provide viable, economical and readily accessible energy resources which ensure that basic lighting and electricity is provided to even the remote settlements which are often off grid. The services should be provided collectively in one centre which is in close proximity of the community. A cost efficient model could be set up by decreasing the use of centralised batteries thereby reducing the need to replace batteries in the future. To achieve sustainability and enable expansion, the unit/initiative is designed to be operated by local residents on financial principles (Hiremath et al., 2007).

AIM OF THE PAPER

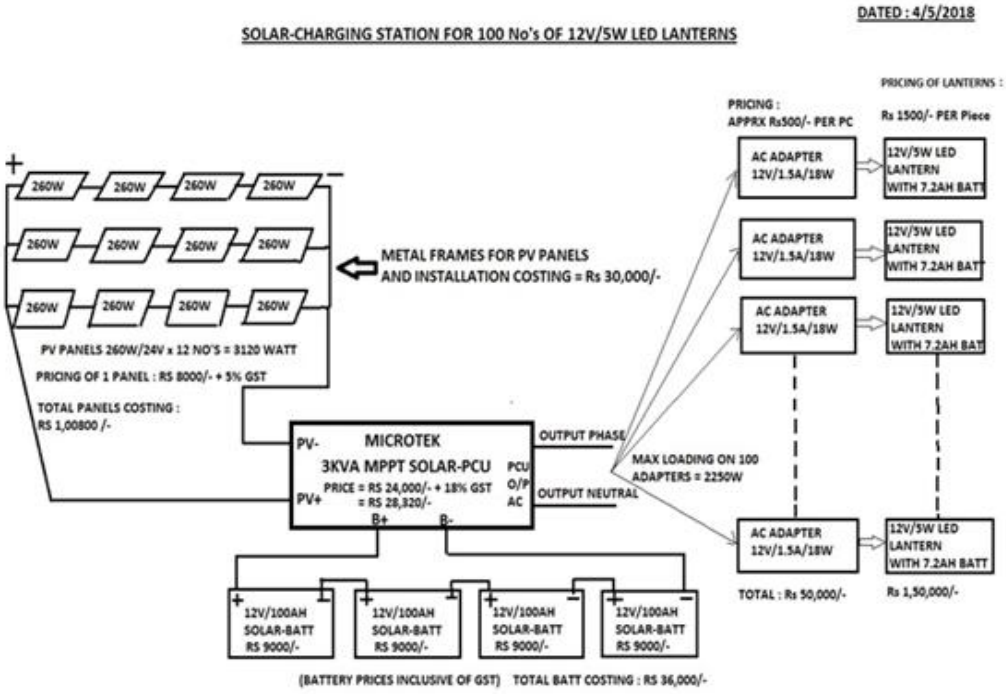
Access to a consistent and dependable source of electricity has the potential to resolve numerous problems faced by the population inhabited in the rural regions and bring them into the mainstream modern society. Electricity can be easily converted into the other forms of energy if required, by many devices, and is thus considered to be the most important and useful source of energy (Fong, 2014). The aim of this paper is to develop a sustainable and viable method to provide continuous, economical and accessible source of electricity for lightning purpose for the marginalized population in the rural area. Since, electricity could be used for many applications, hence, it is important to concentrate on any one aspect of it for the purpose of the study. This paper is based on the solar energy application for lightning purpose only.

WHY LIGHTNING SOLUTION?

To have lighting after dark is one of the necessities of the modern day world. A lack of electricity for lighting forces the villagers to resort to unclean fuels like kerosene based lamps, which produce extensive amounts of CO2 and have a significant impact of the carbon footprints. Nearly 2.2 billion litres of kerosene is used every year which produces 5.5 million tonnes CO2 when burnt (TERI, 2018). Electricity, when available to the rural households will lead to health benefits due to cleaner air, increased opportunities for development of the community and the village economy, extended 4-5 working hours, an increase of an estimated 30% in the productivity levels of individuals and will boost the standard of living of the population (Dawra, 2016). Not only this, but it will transform the family life by providing extended hours to spend time with the family and enabling the children to study after dark along with increased safety.

THE MODEL

The discussed Energy Centre (EC) model operates on the basis of a solar photovoltaic system of 3120 Watt which will work on the principle of Public–Private–People participation and with an intention of involving the people/communities at grass-root level. The model works on establishing solar charging stations to charge LED based lanterns and will have some spare capacity to charge other devices on 'Service Charge' basis. In this paper we will be focusing on the lighting aspects, i.e., lantern charging and renting, and mobile charging. To make up for the operation as well as maintenance costs of this model, which will include cost of battery replacements etc., a reasonable fee will be charged from the users on monthly basis. The funds will also be used for the expansion of this model as well as further improvements.



The EC will ensure electricity provision for an estimated 500 people, forming 100 households. The solar resource proves to be highly advantageous and cost efficient due to its abundant and accessible nature in India. It has been chosen for this model as photovoltaic systems significantly reduce the operational and maintenance cost; have modular technology and the market for this is competent with sufficient attainable products and required services.

The model will require an investment of Rs. 4,60,000 (Refer to Table 1). The consumers will be asked for a reasonable fee for the lantern renting services being provided, which will generate revenue of Rs. 45,000 per month (Refer to Table 2). The maintenance, operation costs and sinking fund will be an estimated Rs. 8,000/month (Refer to Table 3).

Table-1: Cost of the Project

S No.	Equipment	Cost
01.	Equipment Cost (Solar Panel, MPPT Solar PCU, Solar Batteries & AC Adapters-	Rs. 2,40,000
	100 for Lanterns and 50 extra charging sockets)	
02.	Installation cost	Rs. 30,000
03.	100 lanterns @ Rs 1500	Rs. 1,50,000
04.	Electrical Fittings	Rs. 25,000
05.	Civil Work	Rs. 20,000
06.	Training and Transportation	Rs. 20,000
	Total Cost	Rs. 4,85,000

Table-2: Revenue Model

Source	Revenue Per Unit	Number of Units
Revenue from Lantern Renting	Rs. 300 per month	100 Units
Revenue from Lantern Charging	Rs. 200 per month for eight hours charging every day	25 Units
Revenue from Mobile Charging	Rs. 100 per month for four hours charging every day.	100 Units
Total Revenue per month	Rs. 45,000	

Table-3: Payback Model

Total Revenue per month	Rs 45,000
Pay back per month to NGO (For 5 years, @ 6% to repay entire Rs. 4,85,000)	Rs. 30,000

Sinking Fund to maintain the system and replacement of lanterns (For 5 years, @ 6% to create a fund of Rs. 1,30,000)	Rs. 8,000			
Remuneration to the operator for first 5 years (per month)	Rs. 7,000			
Remuneration to the operator after first 5 years (per month)*	Rs. 45,000			

* After first five years the cost of replacement will increase and also the cost of maintenance will also increase. The operator will be getting all the money after first five years which will cover the replacement cost and also the profitability will increase after first five years.

SUSTAINABILITY OF THE PROJECT

Amongst the various options proposing ways to provide electricity to marginalised rural communities, the solar photovoltaic system is highly cost efficient and economical, working up to 15 years. A concessional agreement will be made between the locals and some NGOs which enable the local population to run the EC (The details are given in Table-3). The NGO will provide funds to maintain and operate the EC to the operator, which will be a local resident of the community, at minimal or no rate of interest. The funds will be repaid to the NGO with the help of the fee charged from the users for the provision of services from the EC. Since ownership of the EC and the required equipment remains with the NGOs, as happens in concessional agreements, if the operator doesn't stick to the conditions of the agreement, the NGOs can end the agreement and reallocate the EC to another region or reassign the EC to another operator

Even though the model is a viable option to provide energy in a sustainable way, it will not appeal to the private investors, who seek to generate huge and quick profits. Consequently, it will need investment funding and funds for the expansion and development of the model, from the government, various NGOs or funding agencies. Efforts can be made to review the design of this model in order to eliminate most of the operational and maintenance cost, thereby making the EC more appealing the private investors.

CHALLENGES

A major challenge faced while installing the photovoltaic units in any community is to find the means by which the customs, cultural values and beliefs of the local population are upheld while simultaneously the standard of living of the villagers is being uplifted. To devise strategies to overcome this challenge, a deep insight to the requirements of the locals and innovative ideas aiming to integrate solar power in people's everyday life are needed.

Apart from this, there is a tremendous pressure for the EC to be cost efficient as in most rural regions people tend to be protective of their money and usually don't have the funds required to invest in or make use of a solution to their problems which requires high technological inputs. They often resort to compromising with their own needs and satisfaction in order to achieve optimum consumption from their resources. The practice of borrowing is not highly accepted in these regions.

II. Conclusion

Solar power has always been considered as a viable solution to provide a dependable source of electricity in rural areas. With major advancements in the field of technology, the cost of installation and maintenance of such photovoltaic units has dropped down and now this source of energy only faces the challenge of investments and distribution among the public. The modular nature of photovoltaic technology and decentralized nature of solar power, makes it the most suitable source of electricity in rural areas. The provision of electricity in such areas result in a solution to many of the adversities faced by the inhabited population in the form of better education systems, raised productivity levels, health benefits, increased working hours for local business holders etc.

Solar lighting is not only a highly cost efficient, sustainable and accessible source which provides numerous health benefits that comes with cleaner air, by facilitation the replacement of kerosene lamps which are used in the households, but it also provides increased safety in the households and locality. A study even found that an increase of 30 percent can be seen in the levels of productivity of the individuals and the income of the household by provisioning extra lighting after dark for merely a few more hours. This model has an edge over the others as it is not led by profit maximising motives but rather of social welfare, while simultaneously leaving space for further developments in the strategies of distribution and financing of the model.

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