Solar Energy Kiosk as a Field Laboratory

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ABSTRACT

The Centre for Research in Energy and Energy Conservation (CREEC) has established a Solar Energy Kiosk in Kabanga, Mukono district (Uganda). The aim of the kiosk is to increase electric energy access to people living in off-grid areas. The kiosk also works as a field laboratory to assess the performance and user perception of pico-PV products. This paper presents preliminary results on field lamp performance, user perception and the benefits of using solar lanterns. The research showed that breakage of cables and batteries were the main causes of lamp failures in the field. Light quality and lamp handling were the essential features on the lamps for the users while no smoke and no fire hazards were their greatest benefits. The information gathered can help solar lantern manufacturers understand their products' performance under field conditions and make use of user perception to enhance product features and quality to suit the market needs and affordability.

1 INTRODUCTION

The electrification rate of Uganda is 12% which is one of the lowest in Sub-Saharan Africa[1]. In rural areas, where more than 85% of the Ugandan population still live, only 1% of the households are connected to the national grid[2]. The electricity supplied by the national grid is mainly generated from three energy sources: hydroelectric power (65.4%), thermal power (31.5%) and biomass (3.1%)[2].

An estimated 1% of rural households use off-grid electrification technologies such as petrol or diesel generators and solar photovoltaic systems[3]. The rest of the population (90%) find alternative energy sources to fulfill their energy needs.

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[1] http://era.or.ug/publications/newsletters/

[2] http://www.reegle.info/policy-and-regulatory-overviews/UG

[3] https://energypedia.info/wiki/Uganda_Energy_Situation

The remarkably low coverage and slow advancement of the national grid is reportedly caused by the high cost of grid extension, sparse population, high population growth rate, low ability to pay and remoteness of most rural villages[4]. The majority of the population therefore still relies on traditional energy sources. The most prevalent traditional energy sources are firewood, charcoal or crop residues which 97% of the population use for cooking[3]. For lighting, 85% of the population use kerosene lanterns or candles[5]. Apart from polluting and increasing greenhouse gases in the atmosphere, these energy sources pose a risk of fire hazards and respiratory and eye infections among their users. Globally, 1.6 million people die every year from indoor pollution caused diseases. The main affected areas are Africa, India and South Asia[6]. This problem can be overcome by the adoption of modern energy sources e.g. solar energy. The solar energy kiosk (Figure 1) is one of the initiatives by CREEC to increase access to modern types of energy.

2 THE SOLAR ENERGY KIOSK

The Solar Energy Kiosk is an energy service center, powered by a stand-alone 1 kWp (Kilo Watt-peak) solar photovoltaic system, established to fulfill people’s basic energy needs. It is housed in a 20 ft shipping container modified to accommodate people. The services offered in the energy kiosk are mobile phone charging, internet access, scanning, printing, photocopying and lending of solar lanterns.

Figure 1: Solar Energy Kiosk in Kabanga, Mukono district

Figure 2: Solar lamp users in front of the energy kiosk

[4] http://www.energyprogramme.or.ug/why-power-villages-rural-electrification/

[5] http://www.humanipo.com/blog/1367/KCB-partners-with-Village-Energy-to-offer-Ugandan-homes- solar-power

[6] http://www.who.int/indoorair/publications/fuelforlife/en/

There have been a total of 124 lamps in the energy kiosk but an average stock of 75 lamps is maintained, all Lighting Global certified. Lighting Global is a joint International Finance Corporation and World Bank program that works towards improving access to better lighting in areas not yet connected to the electricity grid. The lighting products in the energy kiosk are shown in the table below placed under three price-based categories.

Table 1: Lighting products in the Energy Kiosk

Price range	Lamp type	Wp of panel	Run time in hours	Special features
Budget < US $ 30	D.light S1	0.5	4	inbuilt panel
	D.light S10	0.5	4	inbuilt panel
	Firefly 5	1.0	6	
	Firefly 10	1.5	7	phone charging
	Sun King Solo	0.7	4	
	ToughStuff	1.0	4	
Mid US $ 30 – 70	D.light S250	1.3	6	phone charging
	Sun King Pro	2.5	7	phone charging
Premium > US $ 70	Fosera PSHS 2800	1.5	7	phone charging

2.1 How it works

The people of Kabanga and neighbouring villages rent solar lanterns from the energy kiosk at a fee. The lanterns are rented out in the price range of USD$ 0.12 – 0.28 per day. They are then brought back to the energy kiosk for recharging preferably on a daily basis. The kiosk is located near the main secondary school which is a central location for easy access. To get the user's perception of the lantern, customers fill out questionnaires on the strength, quality, preferred features of the solar lanterns and their willingness to pay for the product. This information can be passed to interested solar lantern manufacturers for enhanced product design.

3 SOLAR ENERGY KIOSK AS A FIELD LABORATORY

3.1 The aim of the field laboratory

The aim of the energy kiosk as a field laboratory is to determine the performance of pico-PV products under field conditions and obtain end-users' perceptions of the products. This helps identify the quality of pico-PV products and their ability to withstand field conditions for a certain period of time. It will also help identify features on the lanterns that suit the local market.

3.2 Methodology

To collect information from the various users of the pico-PV products, a questionnaire was designed and utilised to collect information on field lamp performance, customers' preferred features and benefits of using them. Failing products or products that did not perform according to expectations were brought to CREEC to investigate cause(s) of failure.

3.3 Results

3.3.1 Failing Lamps

Out of a total of 124 solar lanterns deployed in the energy kiosk, 27 lamps failed within the first seven months of operation. The cause(s) of failure are presented in the chart below.

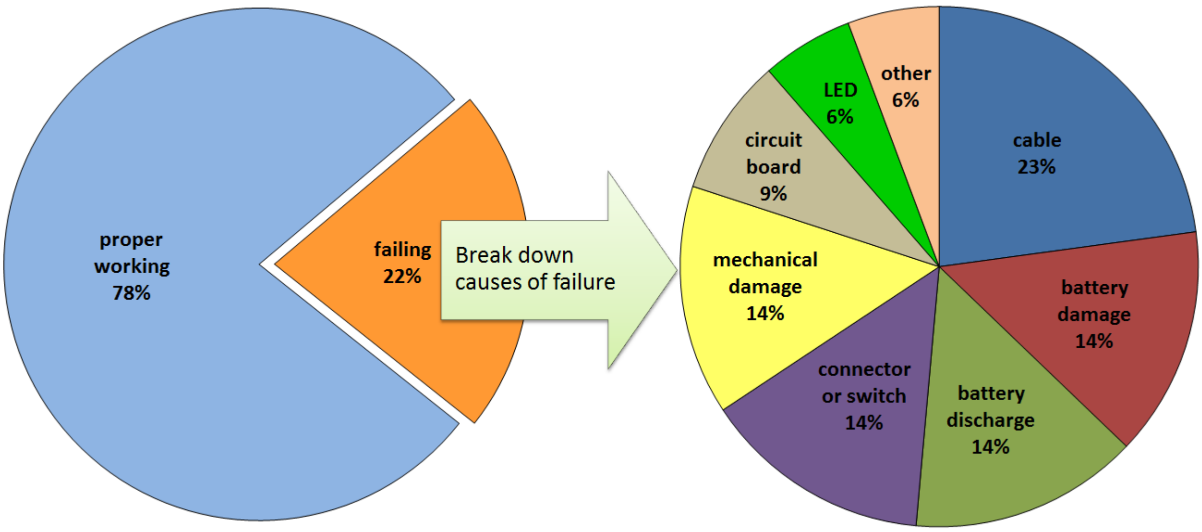

Figure 3: Causes of lamp failures

Figure 4 shows that the biggest percentage of lamp failures was caused by broken cables, battery damage, battery discharge, weak connectors or switches and mechanical damage. The other causes were continuity loss on conduction paths of circuit boards, LEDs with low or no lumen output, discolouration of light reflectors, among others. The results show that the biggest weaknesses are in battery and mechanical robustness. This shows that even products that pass laboratory tests need improved quality to withstand field conditions. The products with battery problems were analysed and the investigations showed that the damaged batteries were Nickel Metal Hydride (NiMH) which were not recharged for several months during shipment and storage. The above chart mentions battery dicharge failure in case it was not possible to recharge the lamp with its own panel but it was possible to recharge the battery with a comprehensive grid-connected charging device.

3.3.2 Essential features on the solar lamps and their benefits

Users of pico-PV products were interviewed for the benefits of using solar lanterns and their essential features. The answers are classified and shown in the chart below:

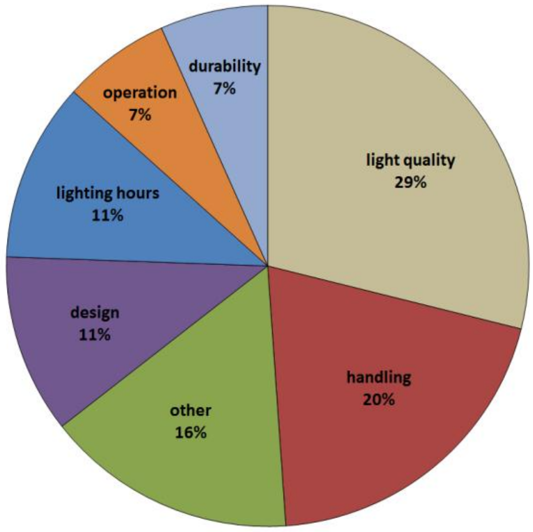

Figure 4: Essential lamp features for customers

Figure 5 shows that the most essential features on the lamps are light quality, lamp handling, design, hours of lighting and others. It is assumed that the relatively low percentage of durability is because the liability of a failing lantern lies with the energy kiosk and not with the end user. Light quality indicated in the graph is defined as personal opinion on the amount of light (lumen output), distribution and colour.

The reported benefits of using solar lanterns are illustrated in figure 6.

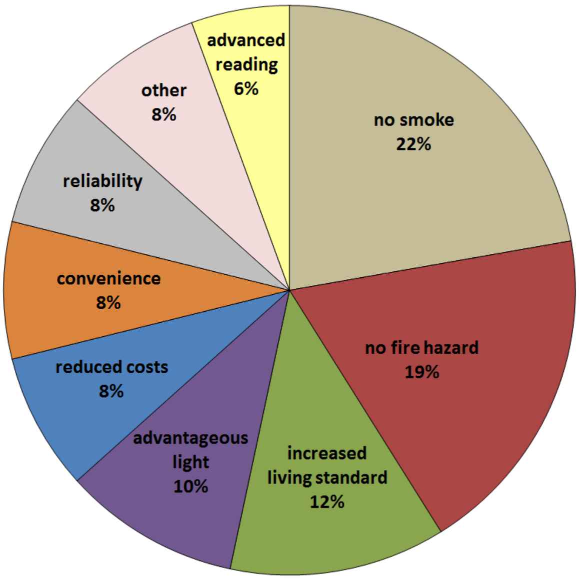

Figure 5: Customers' benefits of using solar lamps

End users appreciate no smoke, no risk of fire hazards, increased standard of living, and advantageous light, among others on the usage of solar lanterns. It is assumed that the relatively low percentage of cost reductions is because on average the villagers of Kabanga spend USD$0.06 per night (150 UGX per night) on kerosene for lighting hence it is more expensive to rent the lamp at the energy kiosk.

3.4 Challenges

Some of the challenges experienced by the Energy Kiosk are listed below. Not all of them are technical but some social and cultural. These are:

- Some customers must travel a long distance from their homes to the energy kiosk hence it is more convenient to use kerosene lanterns.
- Some potential clients already have bad experiences with sub-standard solar lanterns so they do not borrow lanterns from the kiosk.
- Potential clients are afraid that the energy kiosk will hold them responsible for failing lanterns hence fear to borrow one.
- The price of hiring a lamp from the energy kiosk (between USD$ 0.12 – 0.28 per day) is higher than that of lighting using a kerosene lamp (on average USD$ 0.06 dollar) per day. Most people therefore still find it cheaper to use kerosene lanterns.
- The number of lamps rented out per day is still low with an average number of four lamps. The price per lamp was therefore reduced to a range of USD$ 0.16 - 0.20 in April 2013 to attract more clients.

3.5 Summary and Future Work

CREEC has identified some of the causes of lamp failures in the field, important features on the lamps for the customers and customers' benefits of using the lamps. The most prevalent causes of lamp failure were battery and mechanical damages. CREEC intends to share the relevant information with technology providers to enhance the quality and functionality of pico-PV products. Research continues to investigate other causes of lamp failure and lamp performance overtime. The quality of data collected will in future be enhanced.

The energy kiosk can be evaluated for it's socio-economical benefits to the users e.g. how the lamps have improved children's performance at school, how women continue to engage in income generating activities in the night among others.

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