A POSSIBILITY TO ENHANCE RURAL ELECTRIFICATION WITH SMALL SOLAR HOME SYSTEMS USING LIGHT EMITTING DIODES

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ABSTRACT

In order to make Solar PV technology available to people living in rural areas, there is the need to reduce the initial investment in Solar Home Systems (SHS), without compromising quality and life span. This paper presents a study done in Uganda using LED lights instead of the conventional CFLs. This option makes it possible to use small sealed deep cycle batteries, low Wattage panels and avoids using charge-controller. Ten of these LED-SHS were installed in a community far from the grid. For three months research assistants were in touch with the users to provide awareness, technical support and gauge customer satisfaction. The test was a success. At the end of the period all users decided to purchase the system and another bigger group manifested interest in replacing their paraffin lamps by LED -SHS. Following the evaluation, a number of improvements have been proposed. The next step is to involve a micro-finance institution to avail the initial capital to pay in one go the USD 150 for the system. Future development includes hiring a designer to make the product more marketable and negotiations with Government and NGOs for possible subsidies.

1.0 INTRODUCTION

Uganda has one of the lowest levels of Rural Electrification coverage when compared with countries in Africa. Less than 2% of the rural households have access to electricity [1]. They use wax candles or paraffin lamps for lighting and fire wood for cooking.

In order to raise the standards of those households, access to modern types of energy is paramount. The limitation is that most of the rural people live under the poverty line and therefore cannot afford the relatively high investment which implies the purchasing of a conventional SHS.

In Uganda nowadays there are quite a number of dealers in Solar PV technology and maintenance is available in most of the main towns in the country.

Lighting emitting diode technology has made enormous advances over the past decade to the point where they have become practical for lighting application, particularly where the light is required in a concentrated beam.

Awareness is still a major setback on the road to a nationwide PV usage. Nonetheless a number of NGOs and Government institutions are finding ways to demonstrate the technology to larger number of people in rural areas. Also GTZ has set up a program to change the syllabus of technicians in all the vocational schools in the country so as to include Solar PV technology. This change has already been done and the new syllabus is in the National Curriculum Committee for final approval.

Through the support of GTZ, a change in the syllabus of the primary level was made introducing the topic energy. A book was designed and printed for that specific use on a national level. It is hoped that in some year's time all Ugandans are going to be very much aware of the possibilities of solar PV technology.

2.0 TYPICAL HOUSEHOLD IN THE RURAL UGANDAN SET UP

The average energy consumption for lighting purpose for poor households in Uganda falls between 4 and 8 dollar per month [2]. It seems little but for a country were the GDP per capita is below 300 USD per year it means almost 25% of total income spent in lighting. This money is used to purchase wax candles, paraffin and dry cells.

People who cannot afford that expenditure set their timetable in such a way that by night fall

all domestic chores have been done and they sleep.
Even for those households who pay for paraffin, they do not get quality lighting. The light output of a paraffin lamp is small and thus, activities such as reading (essential for children in school age), knitting; matt making, etc are not possible. In fact the national examination results for primary and secondary students show clearly the poor performance of rural areas. This can be attributed to lack of proper lighting.

Another interesting phenomenon is the long distance rural people travel to small trading centres to charge their mobile phones. In Uganda there is network coverage almost everywhere. The rural people pay around US 25 cents to have their mobile charged. They charge it at least twice a week. The LED-SHS we propose comes with a DC-DC converter to charge any model of mobile phone.

3.0 THE LIGHT EMISSION DIODE SHS

The costs of a SHS unit depend on the size of the panel, battery, charge controller and eventually inverter. Within a given technology, solar panels are priced according to their power capacity, which determines their sizes and the number of cells used in the assembly.
Reducing the power capacity of the load to be supplied by the solar units means a reduction in the cost of the solar unit. Solar lighting systems have remained expensive because of relatively high consumption of fixtures such as CLFs (Compact Fluorescent Lamps), which still remain high rated for smaller panels.

A light-emitting diode, LED, is a semiconductor *diode* made by creation of a junction of *n*-type and *p*-type materials. A white LED is, in reality, a blue LED surrounded by a phosphorescent dye that glows white when it is struck by blue light.

White LED greatly extends battery life because its power range is around 1 to 2 Watts only. Actually it wastes very little energy as heat. White LED lumen output nowadays reaches 20 lm/W or higher. Besides LED has a lifetime of 100,000 hours (about 45 years for a 6 hour daily usage).

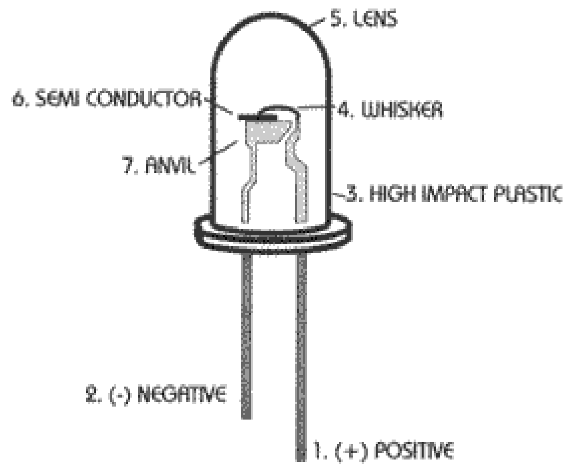

Figure 1: LED diagram

LEDs are highly monochromatic, emitting a pure color in a narrow frequency range. The color emitted from an LED is identified by peak wavelength (lpk) and measured in nanometers (nm).

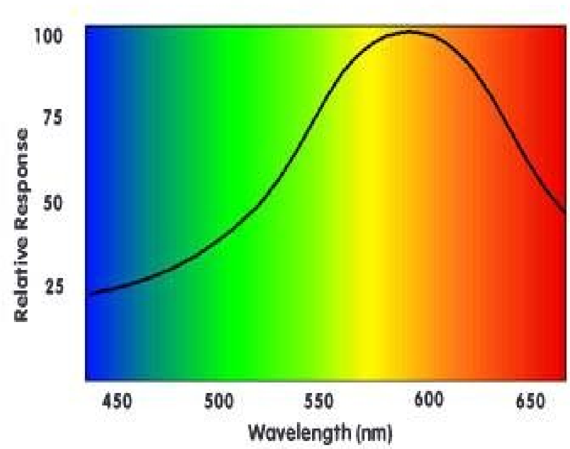

Figure 2: LED Light Spectrum

Peak wavelength is a function of the LED chip material. Although process variations are ±10 nm, the 565 to 600 nm wavelength spectral regions is where the sensitivity level of the human eye is highest. Therefore, it is easier to perceive color variations in yellow and amber LEDs than other colors. LEDs are made from gallium-based crystals that contain one or more additional materials such as phosphorous to produce a distinct color. Different LED chip technologies emit light in specific regions of the visible light spectrum and produce different intensity levels.

In the LED-SHS designed in Uganda, 2 white pale LED were used. These LEDs are powered in DC 3.4 Volts.

As the two lights consume only 1 Ah for 6 hours of usage, the battery was calculated to be a sealed deep cycle 7 Ah. The design parameters of this battery are able to withstand one whole day without sun.

In a conventional SHS, there is need for an inverter as some of the loads are AC. This does not happen in our design. The LEDs are DC powered and so are the mobiles. This brings the cost down by 20 to 25%.

Besides, as the loads are small, the possibility of an over discharge of the battery is rather low. This makes it possible for the LED-SHS to do without the charge controller. This reduction accounts for about 5 to 10 % in the final price.

Three amorphous solar panels sized: 5, 7 and 14 Wp were used in this research. From the very start we realized that the 5 and 7 Wp were not providing enough charge for the mobile phone charging. For a non mobile user, any of the two low rated panels are sufficient.

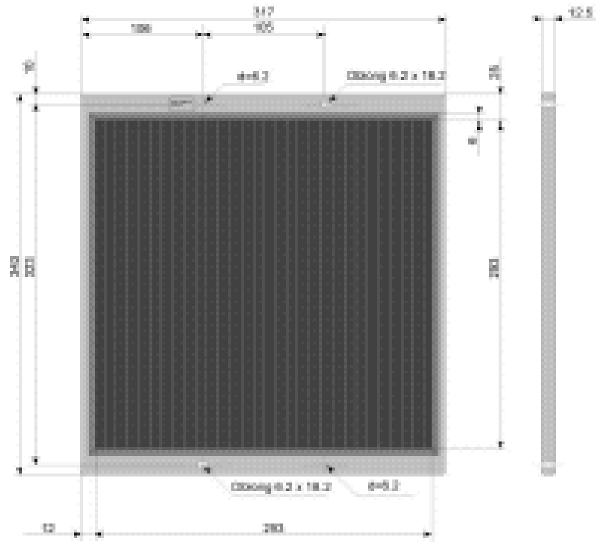

Figure 3: The amorphous panel

Figure 4: The 7Ah deep cycle battery

The LEDs are supplied with a single switch and are fitted with a 4 meter cable each. As the current is minimal, a bell cable was used. It reduces further the price of the system.

The DC-DC converter reduces the 12 Volt provided by the battery to a wide range of voltages suitable to most of the mobile phone makes and models.

A test performed using a luxmeter shows the performance of the one Watt pale white single LED against a number of other light sources such as wax candles, paraffin lantern, CFL, clustered LED, etc. In the bar graphic of Figure 5; the last bar is the one of the LED we adopted. The distances from the source of light to the working surface begin with 0.4 m and go increasing by 0.4 m until it reaches 2 m from the light source. The ordinates are in Lux and varies from zero to 8 Lux. The graphic shows that the LED is very effective for distances below 1.2 m from the working surface but it also shows how it is far superior to the light generated either by paraffin or wax candles.

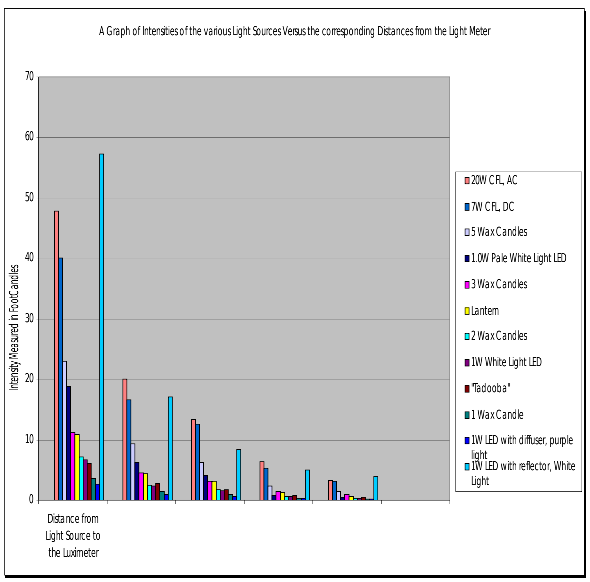

Figure 5: Comparison between the LED and other sources of light

4.0 THE CASE STUDY: NAMULONGE COMMUNITY

Namulonge is a suburb some 21 km off the centre of Kampala. Most of the population of the area is not connected to the grid. Small subsistence farmers, primary school teachers, shop owners make up the bigger part of that community.

Ten households were selected to receive the LED-SHS. They did not have the funds to pay for the total cost of the system. GTZ-EAP (Energy Advisory Project) at the Ministry of Energy and Mineral Development supported the research and subsidized 70% of the system cost.

The idea was to give the system to the beneficiaries and follow their use for three months. After that period, if the user were happy with the LED-SHS, he or she would pay for 30% of the cost of the system and retain it. Those who did not like the system would be free to hand it back to the researchers and get a refund of the 10 USD they paid initially to show commitment to the project.

Four research assistants have been visiting the community on a weekly basis to collect feed back on the system performance and hear any complaint from the beneficiaries.

After those weekly visits to the community, the main results after the three months were:

- All beneficiaries were willing to pay and retain the system
- The 14/Wp panel system was preferred to the 5 and 7 Wp
- True to the suppliers promises, no repair was necessary in any of the systems
- No damage or loss of property occurred to the 10 systems
- The fact that during those three months people were spared from spending money on paraffin and yet had light, made a very good psychological impact to the users
- The much better light compared with the paraffin lamps made it possible for the children to study at night. Also one of the users was a teacher and she could mark papers at night. However, the LED

light is more recommended for general lighting and not for reading.

- One user commented that the system is much safer to user as there is no smoke to affect neither the children nor the danger of fire.

- As a way of raising their living standards the users could listen to radio powered by the DC-DC converter without purchasing costly dry-cells

5.0 POLICY ASPECTS

The Government of Uganda (GoU) is favouring initiatives geared towards the use of renewable energy to cut costs on fuel import and avoid environment degradation.

It is within this context that GoU could allocate funds to support this kind of initiatives. Also a tax exemption on LED lamps could further reduce the cost of the systems by 15%.

Support to micro-finance institutions giving loans for the upfront purchase of these systems could increase the number of users and make more attainable the goal of National Electrification Plan a reality. This program has a target of 400,000 households using modern energy services such as Solar PV.

6.0 CONCLUSIONS

GoU presently strongly favours renewable (solar, biomass, hydro) energy projects whose proper implementation will create sustainable development in Uganda. The 10 years Rural Electrification Strategy and Plan has as target to get rural electrification coverage to 10% before 2010. Projects such as LED-SHS are bound to be successful if supported on a financial and in terms of policy. From the technical point of view there are no hurdles in the technology. From the social viewpoint the acceptance was 100% positive and what is left is just to replicate the initiative increasing the number of beneficiaries. We also intend to increase the level of lighting by using the new 3 Watt LED.

7.0 REFERENCES

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