Rural Electrification using off-grid Solar PV powered Energy Kiosks

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ABSTRACT

Access to electricity in rural Kenya and other developing African countries is low because historically power utilities employ a centralized grid system of electrification that is expensive to expand and would take decades to reach the majority in these areas thus opening opportunity to decentralized solutions.
An off grid solar PV powered Energy Kiosk is one of the possible models of electrification which makes commercially sense in the task of bringing energy to isolated communities. Using data and experience from a pilot energy kiosk installed in Kenya, this paper shows how this facility ably electrifies isolated rural communities and points out how it could be replicated in the rest of developing Africa. Using PV which is a proved technology, the target is to avail electricity for basic domestic use and enterprises in rural communities.

Background

Studies have shown that in most rural communities where the electricity grid is available, access is low at about 30% only. Among other reasons it is clear that the cost of initial connection is a barrier. The seasonality of most household income also does not tally with electricity monthly bills, once connected.
The Kiosk facility does not require connection and can be used in conjunction with other sources of power such as paraffin as people get used to the new technology. Once technology is dealt with comes the use of energy and here it was found out that people use it for: recharging batteries of lanterns; recharging larger batteries catering for some few lights and TV/radio; recharging mobile phones. Arne Jacobson, (2006) "*Connective Power: Solar Electrification and Social Change in Kenya"* [4].
Apart from those, the energy kiosk is also an enterprise that provides ICT services such as internet, photocopying and printing. It also supports other small rural enterprises like hair clipping, low power (1hp) grain milling, small electric poultry hatcheries, liquid soap making, milk cooling, etc. Yet another common business is the provision of village entertainment though satellite TV gadget which allows people to watch English premier league games.
The energy kiosk is thus a sustainable enterprise because all services are offered at a fee. The IRR and simple payback period is described later on in this study.
One could ask why not provide solar home systems (SHS) instead of the kiosk? It was found that SHS solution is much more expensive in terms of USD/kWh. When the initial investment capital is shared among users of the energy kiosk it becomes more affordable and commercially viable. Ownership and sustainability are vital issues in this kind of venture and they are also dealt with in this study.
Another advantage of the energy kiosk is its ability to scale-up starting from 100Wp all the way up to 20kW. This makes it suitable to arguably any rural community.
The case study used here is a pilot energy kiosk setup by UNIDO in a Maasai village 40km SW of Nairobi. It runs on a 2kW solar PV system supported by a 3kW wind turbine. The electricity is used at the energy center for small business activities and also supplied to a local school and hospital. The whole energy center facility cost USD 50,000 while the Solar PV alone accounts for USD 18,000.
The ownership model used is a hybrid of community owed and private management system where the community elects an executive committee to represent them

(equivalent to a board of directors in a business) and the committee employs suitable people to run the centre on a day-to-day basis.
The paper shows how energy kiosks can be a successful tool for electrifying rural communities in Africa in a sustainable manner. The study concludes with some analysis of the social changes brought about by this facility.

The United Nations Industrial Development Organization (**UNIDO)** with the support from the Australian Agency for International Development (**AUSAID)** has setup a renewable energy based, Energy Centre, in Oloshoibor, Ngong (Paul Njuguna, (UNIDO-Kenya 2010) "*UNIDO Oloshoibor Energy Centre Report* ")[2].

This is an off-the-grid energy facility generating electricity from a hybrid system of Solar, Wind power and a Straight Vegetable Oil (SVO) generator to provide power for small industrial activities. This installation is not a new concept. (Timur Gül. (2004) "*Integrated Analysis of Hybrid Systems for Rural Electrification in Developing Countries*") [3].
The general population in the area is estimated to be about 8000, and is dominated by the pastoralist Maasai community.
Despite it being relatively close to the capital city of Nairobi, this community is not a target for grid extension due to its sparse household location and the current low consumption levels. Prior to the installation of the Ngong Energy Centre, the locals have had to travel long distances using expensive public means to do anything that requires electricity. Now with the energy centre that has changed and they can enjoy a number of electricity related services locally.

Technical Features

This hybrid power system consists of an array of solar panels providing 2000Wp of power at 24VDC on a very stable manner as the area has abundant solar radiation throughout the year. The other source of power is a wind turbine generating up-to 3000W of power.

Oloshoibor is a windy location especially in the evenings and at night when speeds reach average 3 to 5 m/s (Figure 1) Kenyan Ministry of Energy, (2006). "*Wind Energy Resource Atlas of Kenya"* [1]. This is a perfect combination for when the sun goes down is precisely the moment wind speeds pick-up thus providing regular charging to the battery bank.

Apart from these two sources of power, the system has also a dual fuel 9 kW generator that uses either vegetable oil or diesel. It is used to power applications that need higher or 3 phase power e.g. workshop materials like welding equipment, pumping water or grain milling. The local community plans to begin producing vegetable oil from sunflower for domestic consumption and will use a small fraction of it to power the generator and cater for the above mentioned energy needs.

Energy Uses

Power at the Energy Centre supports various facilities given to the community at a fee:

- ICT centre offering email and internet access services
- Hair cutting and clipping salon
- Soap making facility for local women
- Mobile and Solar Lantern Recharging centre
- Welding workshop and milling facility.

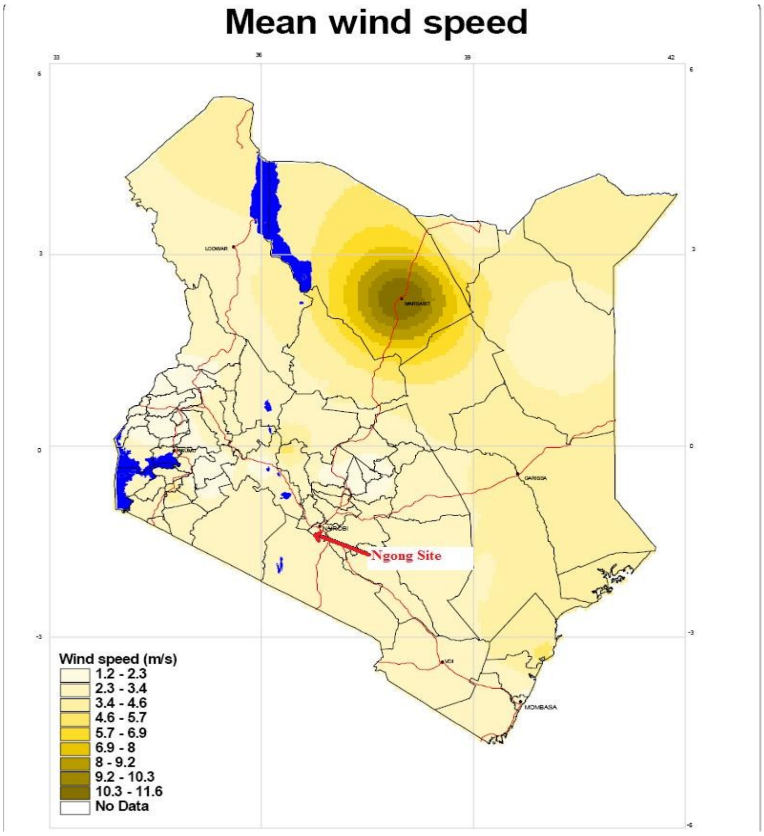

Figure 1 - Mean wind Speeds map of Kenya

Figure 2 - The 3KW turbine Installed and Solar Panels (seen on roof above)

Figure 3 - Power House showing the controllers and Battery Bank

Mini-grid

Besides the energy centre, electricity is distributed to three public facilities namely: school, church and hospital. Currently five households are also served by the mini-grid using a 3A load limiters and being charged a 9 USD flat monthly fee. Given the amount of power produced, there is room for connecting ten more.

The house owners are happy for the fee is more or less what they used to pay for kerosene but now they get other services such as mobile charging and radio/TV powering which used to be done at an extra fee and the use of dry cells respectively. As a matter of fact, the managers of the centre think that in all fairness a higher fee should be charged when they next renew their contract.

The primary school has been using electricity for lighting and to power a computer laboratory. Children can now learn how to use computers as a tool and source of knowledge.

The local dispensary uses electricity to light up its maternity facility and run an AC refrigerator for keeping vaccine. Table 1 shows the percentage of energy consumed by these loads.

Table 1 - Percentage energy consumed by typical loads

Hospital	Lighting + Refrigeration	**15**
School	Computer + Lighting + TV	**20**
Business Centre	ICT+ Charging+ Industrial +Hair salon	**50**
Homes	Lighting +TV + Radio+ Mobile charging	**15**
		100

Income

As mentioned above, the investment capital made to setup the energy centre was a grant of US$ 50,000 from the government of Australia. This makes it simpler for the beneficiaries to achieve economical viability as they have to raise the funds to support the centre with maintenance and provision for battery change in some 4 to 5 years plus salaries for the ones managing it. The Oloshoibor Energy Centre (OEC) has been operational for the past 14 months working well as an income generating initiative on a pay for services basis. Currently the OEC is making an average Kshs. 10,000 per month (about USD 125) and this income is projected to double in the next 6 months given the current trend of income growth. (Table 2 and Figure 4).

Table 2 – Energy Centre Income

				Monthly Income (Kshs)		
	Jul-10	**Aug-10**	**Sep-10**	**Oct-10**	**Nov-10**	**Dec-10**
Energy Services						
Charging	5,270.00	7,252.00	7,620.00	6,530.00	6,159.00	8,553.00
Hair clipping	1,740.00	1,538.00	2,480.00	2,330.00	1,150.00	80.00
ICT	693.00	185.00	175.00	123.00	148.00	164.00
Electricity sales	0.00	0.00	1,800.00	1,500.00	500.00	2,700.00
Workshop	0.00	0.00	170.00	0.00	7,000.00	0.00
Total	**7,703.00**	**8,975.00**	**12,245.00**	**10,483.00**	**14,957.00**	**11,497.00**

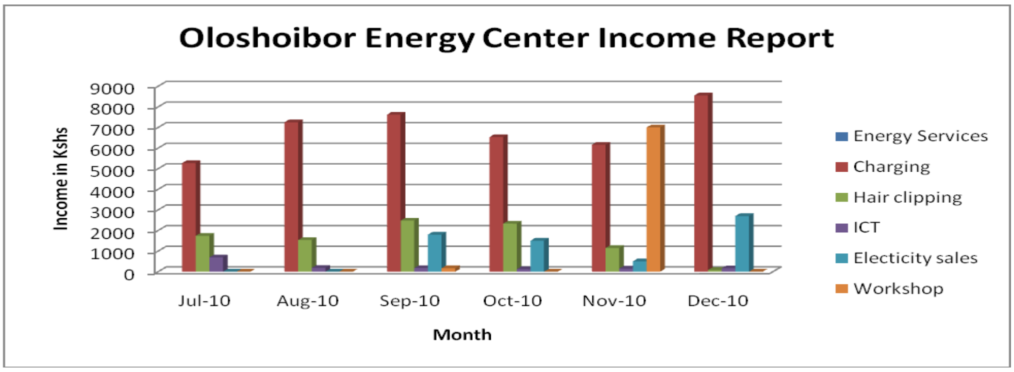

Figure 4 - Income reports for Oloshoibor Energy Center

Economics of the model

During some two months the wind turbine of the OEC had some maintenance problems and this gave the authors the chance to realize that even without it the battery bank was charged and could serve the loads well. For replication purposes thus we consider the PV plus the generator with its US$ 18,000 cost. Table 2 shows that the workshop can provide a regular monthly income of US$ 90. If we consider the added 5 households the income is increased by another US$ 90. The charging cell phones and lanterns have stabilized on some US$ 100. All the other income adds some US$ 20 bringing the total figure to US$ 300 per month. Deducting the salary of the manager and the maintenance fee to cater for battery replacement, the payback period is 7.5 years.

The achieved IRR is not exactly one which would make business people excited about. Therefore, government and donor community must work together to provide investment capital for this kind of centre so that living standards are lifted in rural areas and technology penetration increases. In a community like the one we are studying it is much more likely that the more economically favoured people will save to purchase a SHS as they now have come in touch with the technology.

Management

This is an important aspect of the project for if little importance is given to it the likelihood of success of the project is minimal. Here the community which owns the OEC come together and elect its representatives to the OEC committee so that they will represent their interests. The local government, local business community, and project sponsors/donors also second a representative to committee.

The committee acts as the "board of directors" of the centre and identifies the people to run it: manager, computer teacher, security person, a maintenance person etc, and employ them. They run the centre professionally as a private business i.e. have a work schedule, keep records, account for cash and report to the committee. As it was a grant, once salaries and maintenance fee are catered for, part of the profits (dividends) are enjoyed by the community (owners). This hybrid management system has worked well so far.

This can be represented in the diagram below

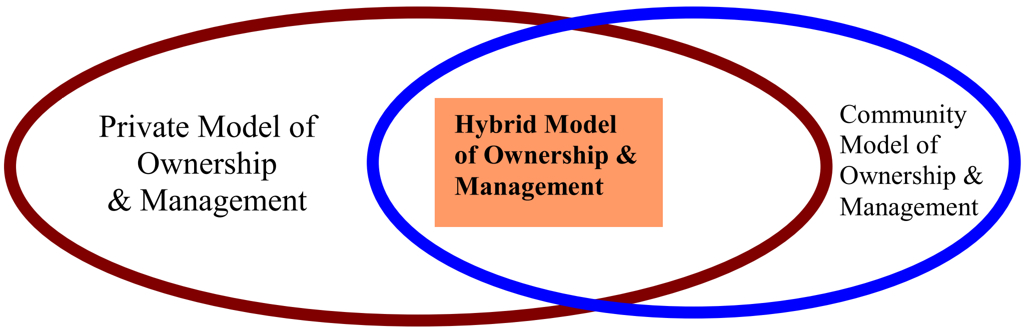

Figure 5 - Energy Center Management Model

The above management model achieves the best of all the two worlds, effectiveness of a privately run business and ownership satisfaction of the community hosting the OEC. UNIDO has plans to replicate this model in the next five years plan for Kenya.

Achievements and Conclusions:

The project so far has managed:

1. Create a model of stand-alone sustainable energy generation system using locally available renewable energy sources. This has been met by generating electricity using the locally resources of Wind and Solar radiation.

2. Stimulate the creation of small-scale industries through the provision of affordable and clean energy. Small scale industries like soap making and maize milling have been setup.

3. Provide social benefits by replacement of polluting kerosene based lighting with clean, low energy and bright LED lamps thus improving the health conditions in households, especially for women and children, by the reduction indoor air pollution. School going children have now extended their study time at night and as a consequence have performed better in the national examination when compared with their results when the school had no electricity.

4. Building capacity of local communities in running renewable energy-powered, self sustainable business support centers and small enterprises thus creating employment and hence improving living conditions.

Therefore the OEC project is meeting all objectives with positive results so far. As it can be seen clearly the uptake of renewable energy to serve the needs of rural people in sub-Sahara Africa is a given. Perhaps to increase the rate of penetration Government, Academia and Private Sector should work together each contributing their specific potential to make successful renewable energy projects a reality.

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