Using renewable energy in a sustainable and holistic manner as a tool to eradicate rural poverty in Africa

Authors: Izael Pereira Da Silva[1] Vivian Vendeirinho[2] Paul Njuguna[3] Mwaura Njogu[4]
Strathmore University[1]; RVE.SOL - Soluçoes de Energía Rural Lda[2]; UNIDO - Kenya[3];
Masinde Muliro University of Science and Technology[4]

Key words: Integrated Systems and Products; Rural Electrification: Power for Infrastructure

Abstract

Rural poverty in developing countries is a social problem that is well recognized and causes concern globally. The UN recently met to review the MDG's[1] and acknowledge that there was limited progress to date; a looming target date have highlighted the difficulty in addressing development issues on the ground where people are trying to survive, often on as little as $2 per day or less.

This paper demonstrates the model of rural village energy services centres by using solar energy to provide solution to most of the problems of a typical African rural village.

This stand alone system provides energy services solution leveraging sustainable resources in a holistic, community-integrated fashion to improve health, information, communication, education and preserving the environment while it kick-starts micro-economies in rural villages. It intends to increase productivity and ultimately eradicate poverty. This solution is still in a prototype stage but has its special interest because it hopes to provide clean water and biogas apart from the solar generated electricity.

Through the implementation of community energy services, stand alone decentralised solutions intend to divert rural current expenditure on kerosene, offering significant reductions in carbon emissions, environmental damage and respiratory-illness related deaths which were recently estimated at 1.6M per annum worldwide as per a World Bank report.

This corresponding increase in energy efficiency drives an increase in productivity and thus a step closer to the realization of the MDGs as has been documented in various case studies (Annual Report 2008 (. (2008). Renewable Energy Services for Developing Countries - In Support of the Millenium Development Goals) [8].

This paper covers the technology implementation starting from demand until it reaches the level of success which then makes it suitable for replication.

Introduction

The concept of off-grid energy systems in not innovative in itself – many top-down, technology focused solutions have been implemented in the past with surprisingly high failure rates attributed to, amongst others: lack of community ownership, lack of local know-how, limited access to finance, technology failure without appropriate means of recourse, a not "fit-for-purpose" implementation and lack of understanding of the demographic in question. (T. Urmee, D. Harries and A. Schlapfer, (2008) "*Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific*" [3].

Figure 1 proposes a model for sustainable, rural development that has been proven to deliver results in various studies.

Whenever a case for extending modern types of energy to rural areas is considered, the path to market is best identified by the local demand. If there is no demand there is no need for setting up anything. This seems quite obvious but one would be surprised when studying the situation of rural sub-Sahara Africa where carcasses of "white elephant" projects litter the horizon as an icon to the generosity of the Western tax payers and the lack of common sense of implementers.

[1] Millennium Development Goals

Once demand is identified, the first step to consider is "fuel". By fuel we understand anything that can be converted into electricity, heat or both. The sun for instance is a very widespread fuel available in the region of the Equator. Once fuel is identified the next step is which technology is most suitable to convert that specific fuel into electricity. If for instance a locality has a river nearby one has to study which small hydro power technology is best suited to convert the head and the flow of that river into power.

A third step is what we call "application". By application one understands the use the community will make of that electricity or heat. For instance the electricity from the above-mentioned hydropower can serve to power a small maize mill which can become an income generating activity which in time can pay back the investment the community has made in the installation of the hydro power system. The more one study this specific use the better as it makes for sustainability.

Many project implementation plan come up to this point and proceeds to the building phase. To our understanding this is a mistake as a very important fourth step is missing.

This is what we call the "human factor". A simple sociological study has to be done to find out how the beneficiaries live, what kind of work pattern do they have, the prevalence of people given to drinking, the ethical feature regarding stealing and misuse of common property, etc.

In a feasibility study case commissioned to set-up a multi-function platform in Uganda, all issues related to demand, fuel, technology were perfect but the human factor was completely eschewed as the men of that small village were all given to drinking a cheap beverage they brew and thus by ten in the morning practically all male adults were stunned. Obviously, the project was abandoned.

Having got the "green light" on all the above steps, the engineer gives way to the businessman. The fifth step is thus the "economic viability". Here the cost of each unit of power is calculated taking into account operation and maintenance. A simple payback period is determined and a business model is applied.

Issues such as cost of money, ownership, training of technicians and operators, stocking of spare parts and cost of replacement come into play. It is convenient to have the ultimate beneficiaries such as owners of the unit, users, technicians, security guards, etc to be involved from the design stages to foster ownership. It may take a bit more of time but it can save quite a lot in the long run.

An important player in this stage is the micro finance institution. As most of the rural people in Africa have little access to bulk quantities of funds, financial arrangement must be made to avail what it takes to meet the investment capital. Contribution in kind such as building material (sand, stones, etc) and labour has to be given by the community to reduce capital investment but more important than that to create ownership.

Finally, one has to consider for the very start of the project the environment impact of such a project. Where mandated by local law, the environment authority may request a study be conducted – often however with small scale renewable energy projects this is a formality. This nonetheless cannot be overlooked for the concern for environment preservation is a worldwide concern nowadays. Figure 1 summarises the above comments.

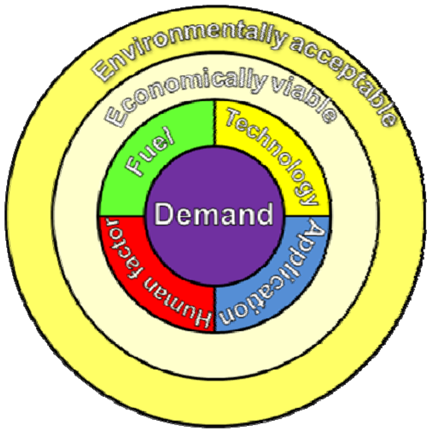

Figure 1 – RE System Sustainable Path

Two added models

Following the above described criteria, failures rates are certain to fall it its good consequences for the dissemination of solar photovoltaic technology. We nonetheless have to still consider some other aspects which are somehow essential to the success of any RET implementation and sustainability.

The choice of the market

When considering a village or trading centre where there is no provision of renewable energy sources, Figure 2 shows an interesting analysis of the market:

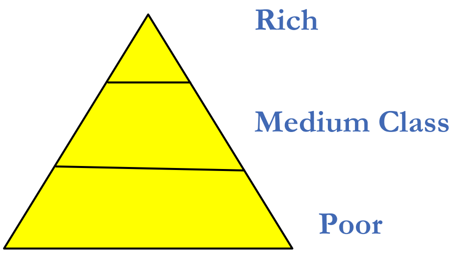

Figure 2 – Market distribution in terms of average income

These three categories mentioned in Figure 2 are to be taken in a subjective manner for rich or medium class and poor can be totally different when considering different villages or trading centres. For instance, here we consider that rich are those who mostly engage in business activities as opposed to cultivation of a small piece of land on a subsistence manner. A rich person in this sense would be the shop owner who may or may not have a car, the owner of a small maize mill which can process some few sacks of flower per day, the owner of a boat who has fishermen working for him, etc. These people have regular income and therefore, once educated on the advantages of RETs can purchase a SHS for instance without the support of donor agencies of government subsidies.

The lower bottom of the social pyramid shown in Figure 2 represent to real poor. These people are the ones considered poor by the criteria of "less than a dollar a day". They work to get daily food and to be able to afford a minimal of education for their children. An eventual sickness can create a real crisis as the concept of savings or health insurance is completely alien to them. For this category, RETs is totally out of bounds.

The medium class then is the target group for projects and would most certainly profit from government subsidies to purchase SHS or solar lanterns with charging phones facility to do away with kerosene. A social study of this section of that society would go a long way to provide for the sustainability of any RET project.

The use of energy

As explained at the beginning of this paper, the use of energy is crucial for the long term success of a RET project. Figure 3 shows how it is possible to bring modern types of energy to rural areas in Africa and perhaps to any other developing country in a similar manner as the one explained above in the segmentation of a rural market.

As opposed to many of the projects on renewable energy in Kenya which are funded by development agencies, this solution has been funded by a social entrepreneur. A hybrid solution, it intends

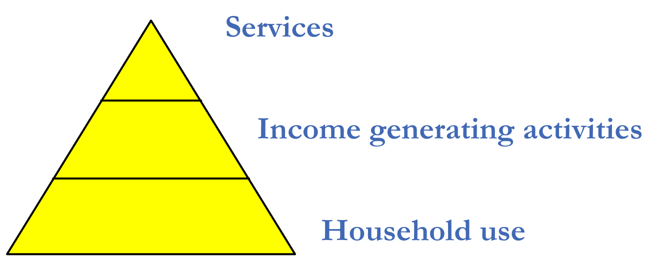

Figure 3 – Different use of RET in rural areas

Figure 3 shows that RET implementation has to start from the top of the pyramid. Services such as health, education and communication are all based in the availability of electricity and falls into the category of infrastructure which in principle should be catered for by the government.

The installation of a institutional Solar System in a health centre, school or district local government to provide phone, fax and internet facilities is very good not only because of the obvious improved living standards which come along with these services but also because they educate people for the possibility of sourcing power from the sun which until the installation of this unit was absolutely out of their frame of mind.

Another advantage of starting from services is that in general funds for dissemination of renewable energy are available from the donor community to government units such as ministry of education, health, local government, etc.

The second step for a full adoption of RETs is the income generating activities. This can be the ubiquitous solar charging for mobile phones but also quite a number of other wealth creation activities such as: barber shop, beverages cooling, entertainment halls, grain milling, etc. The target group for the ownership of these kinds of projects are the ones labelled as "rich" in Figure 2. Once they see the business sense of the venture they will certainly have the financial muscle to purchase and install it.

Case Study - Rural Village Energy (RVE) solution

As opposed to many of the projects on renewable energy in Kenya which are funded by development agencies, this solution has been funded by a social entrepreneur. A hybrid solution, it intends to provide rural base of pyramid communities with the following utility services on a pre-paid basis:

1. Fresh, potable water
2. Biogas for cooking instead of wood and coal
3. Electricity for lighting and increased productive time
4. Organic effluent for use as fertiliser in agriculture, rejuvenating over-used lands

The community benefits are many, including reduced deforestation and carbon emissions, improved health due to reduction of raw water consumption and open fire cooking, clean energy generated from renewable resources, decreased use of and dependency on kerosene, improved agricultural output and ultimately poverty reduction and wealth creation (Obeng, George Yaw and Evers, Hans-Dieter (2009): *Solar PV rural electrification and energy-poverty*) [7].

System description

The RVE consists of a solar PV plant, an anaerobic digester, a water purification plant and a control and monitoring system.

The solar PV plant generates 825Wp panel power with a battery reserve of 18,000Wh. The batteries used are no maintenance valve regulated lead acid type. AC Electricity is provided for up to 10 homes in the trial – power is limited electronically to 0.5A or 1.0A per home, providing enough power for two CFL lamps, mobile phone charging and powering a radio and small TV. Which have been seen as high priority for Solar PV users in rural Kenya (Arne Jacobson, (2006). "*Connective Power: Solar Electrification And Social Change In Kenya*") [5]. Reticulation to homes is provided based on a mini-grid approach with a radius of less than 1.5km.

The biogas plant consists of a 2 stage, batch-fed, temperature monitored system in which thermophyllic digestion takes place. It is dimensioned to provide up to 4000l of gas daily, with minimum methane content of 65%. Provided biogas stoves consume 125l/hour, requiring approximately 500l per family per day to meet cooking needs.

The water filtration system is force fed ultra-filter system, offering a 16m2 filter area and a theoretical filtration rate of up to 2,560 l/h. This is limited by the raw water supply. Virus, bacteria and parasites are removed with >99.99% effectiveness.

As a power backup solution and for higher power demand situations, a 5kVA self-start diesel generator is provided.

Business Models

A number of business models arise from the colocation of the unit in a village.

1. Energy vendor – employed by the community and trained by RVE.SOL to manage the RVE unit on a daily basis and carry out some basic maintenance tasks, the energy vendor ensures that consumers
2. Water collectors – by employing young boys to collect raw water from the local water source, other community members' time is freed up for more productive tasks
3. Cattle Manure – owners of cattle can now trade their fresh manure as a tradable commodity; in addition collectors of manure can provide transport services to the central energy hub location.
4. Electricity for daily productive tasks. The consumers have access to power at night via a mini-grid but during the day, that power can be used for productive tasks like a barber, tailor or convenience store with fridge.
5. Consumers can pre-pay for services such as electricity in the home, biogas for cooking and fresh water on tap.
6. The community leadership or project steering group then redeploys these funds for community projects that benefit all members.

Community Ownership

As previously mentioned, the concept of local ownership of the infrastructure is fundamental to ensuring long-term sustainability. In this case study, a pilot program for which will commence in June in Kenya, prior sensitisation of the village members has been conducted by a locally accepted and trusted community based organisation. Sensitisation involves explaining to the villagers the concept of the technology, what it can do for them and a very clear iteration of the expectations on them. This model requires them to consider the alternate renewable energy sources and make a conscious decision to divert their expenditure on kerosene, wood and coal to electricity and biogas. This is contrary to what was been done before (Feasibility Study (2007). "*Promoting Biogas Systems in Kenya"* [6].

Summary

Looking back to our rural development model, we see that there is much alignment between the model proposed and the planned pilot. Basic demand exists in the form that 35 villages and numerous households surveyed at the end of 2010 all indicated to a person that they saw the benefit of electricity and biogas, in terms of convenience but more importantly in terms of productive time gained, efficiency and long term savings.

High quality technology supported by an appropriate service and maintenance schedule and infrastructure, applied in a way that addresses holistically the issues causing rural poverty, leveraging fuel that is largely discarded nowadays or not useable by rural villages, integrated with a community ownership focused model that generates revenue speaks to a solution that is sustainable in the long run. When villagers have access to technology that generates income and improves their lives, their motivation to keep it working is greatly influenced.

Economic viability during the pilot program is ensured through external developmental funding – although the vision is to bring the cost down to a point where a risk-assessed community would be able to finance such a unit on their own.

Lastly, no negative environmental impacts have been identified to date - in fact the impact is positive through the sustained use of renewable resources

General conclusions

The case above provides some extra value because provision of biogas has a direct positive impact in forest preservation as wood for cooking is one of the causes of deforestation in our region.

More study is required nonetheless to evaluate its performance once the pilot units are installed in a couple of months.

Bibliographic References

1. Kenyan Ministry of Energy, "*Wind Energy Resource Atlas of Kenya* " (2006)

2. Paul Njuguna, "*UNIDO Oloshoibor Energy Center Report* " (UNIDO-Kenya 2010)

3. T. Urmee, D. Harries and A. Schlapfer, "*Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific*" Renewable Energy (2009)
   Volume: 34, Issue: 2, Publisher: Elsevier Ltd, Pages: 354-357

4. Timur Gül. "*Integrated Analysis Of Hybrid Systems For Rural Electrification In Developing Countries*"TRITA-LWR Master Thesis, Stockholm 2004

5. Arne Jacobson,(2006) " *Connective Power: Solar Electrification And Social Change In Kenya*". World Development Vol.35 No.1 pp 144-162, 2007 © 2006 Elsevier Ltd.

6 . Biogas for a Better Life. 2007a. *Promoting Biogas Systems in Kenya*: A Feasibility Study. October, 2007.http://www.biogasafrica.org/Documents/Kenya-Feasibility-Study.pdf

7. Obeng, George Yaw and Evers, Hans-Dieter (2009): *Solar PV rural electrification and energy-poverty: A review and conceptual framework with reference to Ghana*. In: MPRA Paper. *RePEc: pra:mprapa:17136*.

8. Annual Report 2008. *Renewable Energy Services for Developing Countries - In Support of the Millenium Development GOals: Recommended Practice & Key Lessons*. Report IEA-PVPS Task 9