Energy for Poverty Alleviation in Sahel

Intelligent Energy Project

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Introduction

Access to energy in developing countries is a multi-sector issue involving policy development, financing opportunities, socio-economic impacts, availability of resources, environmental issues and technological aspects. Of these appropriate technologies are of crucial importance. For meeting the energy needs of the world's poor, this means technical solutions that are small-scale, low cost and low maintenance and, preferably, that use natural resources in an environmentally-friendly way.
However, understanding the local population's needs, and their local resources is the first step in improving their access to energy. These factors vary, not only between countries, but also between regions and communities. For this reason, a participatory approach to both energy policy development, and local energy projects is vital.

This newsletter contains a brief description of some technologies suited to better satisfy the energy needs of the less wealthy and overcome specific barriers faced by developing countries. The list, with no presumption of completeness, has been identified following the criteria of low environmental, social and financial costs and possible positive social impacts on the local situation.

To correctly identify the technology choice, the energy demands and utilisation of the target group has to be well understood. Typical uses of energy in rural areas include cooking, private and public lighting, mini-grid generation, artisan and small-scale industrial activities, water pumping, agricultural needs (i.e. pre-processing of crops), transport, communication, health, schools and public places.

Different low cost technologies are already in use in several developing countries, reducing the upfront cost of providing energy to the poor, and providing energy independency, especially in the rural and per-urban areas.

We can divide the technologies in three groups, following their field of appliance:

1) Distributed generation;
2) Low cost transmission and distribution; and
3) Local appliances and energy efficiency.

1. DISTRIBUTED GENERATION

The choice between off grid systems, independent mini grid and the interconnection with the national grid depends on a great number of factors, including: number of households to be served, household consumption, load intensity, productive loads, projected demand growth, load curve, availability of energy sources (renewable or not), fuel costs, distance from the closest grid and political planning. There have been developed several computational methods to assess the optimal mix depending on these and other factors.

In most regions and villages in remote areas, potential consumption is too low and the distance from the grid is too far for systems other than stand alone generation and independent mini grid. For that, the most commonly used technologies are:

- Micro Hydro turbines
- Wind energy (particularly for water pumping)
- Modern Biomass Technologies
- Solar PV

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Micro Hydro

Micro (and Pico) hydro systems are one of the most cost effective solutions to produce energy locally if the right conditions are present. Naturally the implementation of the systems largely depends on geographic and climatic conditions, and on the stability of the rainfall, of the level of lakes and of the flow of rivers during the year and in a multi-years perspective. Climate change could seriously affect hydro generation.

The design of micro and pico hydro can be done with several degrees of complexity, with corresponding costs and efficiency (depending of the ratio between water fall and water mass flow). One technical possibility that is normally least-cost option is to use standard water pumps working as water turbines for power production.

Pumps As Turbines - PAT- solutions offer the possibility to decrease the costs of equipment and maintenance, or more generally, the capital-intensive nature of small hydropower plants. The main difference is that a PAT cannot make use of the available water as efficiently as a turbine due to its lack of hydraulic controls.

Applications of PAT range from direct drive of machinery in agro-processing factories and small industries (flour mills, oil expellers, rice hullers, saw mills, wood and metal workshops) to electricity generation both in stand-alone and grid-linked stations.

Fig1.PAT

In most instances, no design changes or modifications need to be made, provided that selection has taken into account the nominal turbine speed has been taken well below maximum permissible pump speed.

The main advantages o of PAT are:

- Investment costs may be less than 50% of those of a comparable turbine (especially for small units below 50 kW);
- More simplicity in the installation
- Availability at the market. Due to their widespread use, standard pumps are available and manufacturers are world-wide present;
- Maintenance and spare parts are always available, and no special equipment and skills are required.

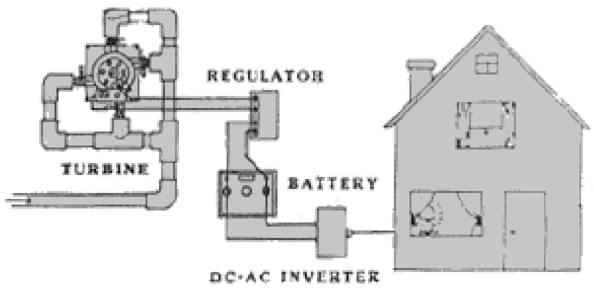

Fig. 2 pico hydro scheme.

The main disadvantages are:

- No hydraulic control device: therefore, a control valve must be incorporated in the penstock line (additional costs) to start and stop the PAT. If the valve is used to accommodate to seasonal variations of flow, the hydraulic losses of the installation will increase sharply.
- Lower efficiency at part load: a conventional turbine has an effective hydraulic control (adjustable guide vanes, nozzles or runner blades) to adjust the machine to the available flow or the required output. If PATs are operated at other than the design flow, i.e. below their best efficiency point a relatively rapid drop of efficiency will occur.

The disadvantages of PATs can be reduced to a minimum if the PAT is very carefully selected and only applied where justified. Poor performance due to an inappropriately selected machine or application will lead to a reduction of gains. Summed up over the entire lifetime of the machine, this reduced output might by far offset the cost advantage of the PAT (lower investment costs) in comparison to a conventional turbine.

PAT can also be incorporated in a medium to long energy planning, when first the civil work is used with a PAT, and after the energy demand grow, a proper turbine and its control equipment replace the water pump, by so increasing the amount and quality of the energy produced.

Reference:
http://energy.saving.nu/hydroenergy/small.shtml.

Wind Mill for Water pumping

The use of wind energy for water pumping has been done for centuries and still provides a valuable opportunity for meeting water pumping needs in rural areas, the system hold a *simple and often low cost design, suitable for the smallholder farmer, who has a water source at a rather lower deep, and needs a limited amount of water for a few livestock and his/her domestic needs* (Enda-TM, 2005).

Fig. 3 Wind Mill for Water Pumping

Modern Biomass Technologies

<u>Biogas</u>

Production of biogas for heating or for electricity production starting from human and/or animal dung is a very simple and economic process, been widely used in China and India.. Anaerobic digestors produce a combustible gas and the residual material coming out from the process can be used for farming process, working as a natural soil enhancement material. Naturally, this process is more adapted to be applied where the animals are held in closed and controlled spaces (that is not always the case of African Countries), anyway the advantages of producing biogas are significative, including the low maintenance of the system, the low cost, the environmental and health advantages and the versatility of the utilisations of the gas produced.

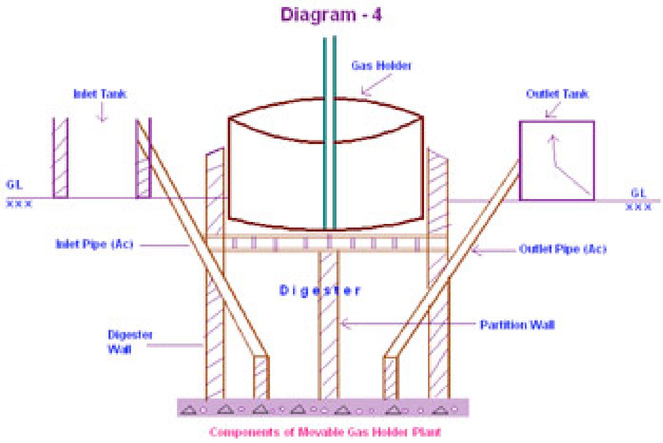

Fig 4. Biogas production scheme

<u>Biodiesel engines (jatropha oil)</u>

Diesel engines have always been the most widely used solution to produce either electricity or power for mechanical appliances. It's often the more "easy" or "at hand" solution to have energy in remote areas far from the electrical grid. Nevertheless the cost of diesel and the difficulty of transport might seriously lower the advantages of using this technology as a long term, widespread solution.

In Mali and in other countries in the Sahel, hundreds of villages have been "empowered" trough the use of Multi functional platforms, i.e. simple design diesel engines that may be connected to a variety of mechanical appliances and used for mini grid electricity generation. Those diesel engines, as many others, have the particularity that can be very easily run with Jatropha Oil. Jatropha is a plant widespread in several regions of the Sahel and to obtain the combustible oil is just necessary to collect, press the seeds and filter the oil. The trees can produce around 660 up to 825 liters of oil per hectare per year. Reference at: http://www.jatropha.de/.

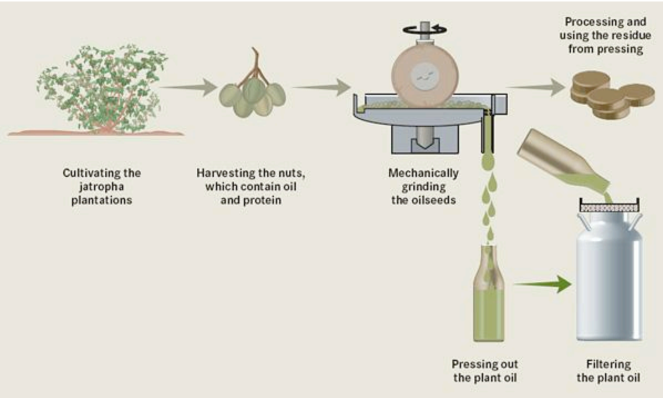

Fig 5 and 6. Jathropha Oil production and Jatropha plant

Solar photovoltaic (PV) :

Solar PV systems are considered the most expensive solution for mini grid solutions and for stand alone systems, nevertheless they can be the only option available in remote areas without other natural resources. Solar PV systems need little maintenance, are easy to install and run. Batteries are the most important variable costs as they have to be replaced regularly.

As stated by the World Bank, several renewable energy technologies are potentially the least-cost option for mini-grid applications and the renewable energy are more economical than conventional generation for off-grid (less than 5 kW) applications, where renewable energy technologies considered were - wind, mini-hydro, and biomass-electric – as show in Figure 1. For Mini-grid applications were considered village- and district-level networks with loads between 5 kW and 500 kW not connected to a national grid.

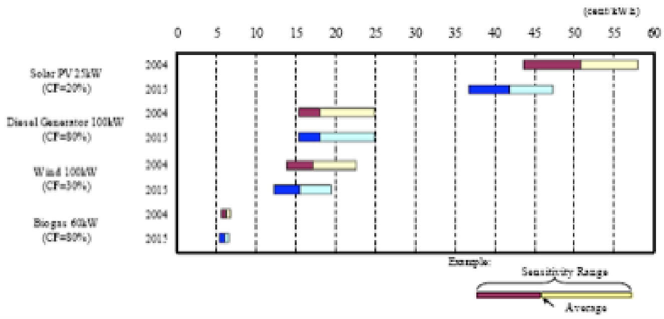

Figure 7: Electricity Costs for different mini grid generation technologies (source: Wolrd Bank, 2005).

2. LOW COST TRANSMISSION AND DISTRIBUTION OPTIONS

<u>SWER (Single Wire Earth Return)</u>

This is an electricity transmission method that make use of only one wire instead of the minimum two on standard systems, with the return path through earth ground connection (open loop system). It is a technology already successfully used in New Zeeland, Australia, Canada, India, Brazil, Asia and Africa (Botswana, Cote d'Ivore, Gabon, Morocco, Uganda, Eritrea and South Africa). Its main goal is to attend sparsely populated rural areas, and when correctly applied, can provide an economic supply method for rural electrification.

Its main advantages are:

- Cost reduction:
- • One conductor, less equipment;
- • Long distance between the posts (hilltop to hilltop spans); and
- • Fewer switching and protection devices.
- •- Design Simplicity;
- •- Speed of Construction;
- •- Reduced maintenance costs; and
- •- Reduced bushfire hazard – avoid conductor clashing.

The main constrains to its use are:

- Need a good earthling system / to prevent dan

Fig. 8. Solar refrigereted Vaccines

Fig 9 SWER

gerous step and touch potentials;
- Telephone interference, similar to 2 wire single phase lines, worse than three-phase lines;
- Load balance problems can erode efficiency of three phase supply line;
- Voltage control can be difficult;
- Power quality can be compromised; and
- Has load density limitations.

It is important to notice that for its implementation ad use, it is necessary to secure that the appropriated regulation is put into force and standards and safety measures considerations are revised.
References: http://www.ruralpower.org/.

Equipment standardisation

Standardisation of equipments has the potential to lower costs, also allowing for bulk procurement of parts and components, not only for rural electrification but also for peri-urban areas. It is also an important form to secure that local equipment providers can have a significant part in this business, not only in regional term, but also in international terms, as the cooperation and transposition of this strategy can lead to the same standards to be applied to more then once country.

In many cases, the upfront costs of the connection (i.e. connection board), can alone represent up to 300 % of the monthly income of pour households, and this would lead inevitably to the increase on the illegal connections. In some cases, the required standards are too high and the costs just follow the scale. The use of compact ready boards, when well foreseen in the regulation, can include all the necessary equipments, as earth-leakage connection, and even top mounted light, this in the case of electricity.

Those above cited technologies are not the only ones, as we can also nominate (AFREPREN/FWD, 2005):

- Reduce the conductor size. Due to the lower power demand in rural areas, it is sometimes possible to use smaller conductor sizes, that costs less, as in the case of Zimbabwe, up to 15%.

- Increasing distances between transformers without incurring significant voltage drop. In Keynia a standard 600 meters is used, not as a function of consumer density, in the other hand, Uganda transformers location are calculated on a line by line basis, and up to 1000 meters distance are common, leading to significant costs savings.

- Load Limiters. Those devices are miniature of circuit breakers, that limit the amount of electricity at the final user (i.e. a household). The use of load limiter instead of meters can reduce the service connection, installation costs (can lead to reduced size of the cables) and also lower operation costs, as the tariff can be made on a fixed basis, excluding the need for monthly reading (fixed rate).

3. LOCAL APPLIANCES AND ENERGY EFFICIENCY

Energy efficiency is the way to deliver the most appropriated energy to each application, minimising wastes, energy conversions, and costs. Understanding what is to be delivered is the key to optimising any energy system, in Sahel as everywhere else on the planet.

Energy efficiency in local appliances might play a consistent role in reducing losses of energy, and so the costs that have to be faced to have the service of energy. This concept does not only apply to electricity, as one of the most important energy efficiency field in Africa is about improved cookstoves, that can both sensibly reduce the use of woodfuel and also the interior pollution.
Efficiency is a concept that is central to the aim of lowering he costs of satisfying energy needs, in its real need (heat, light, power), and protect the environment.

Provision of community lighting (high-mast flood lighting)

High-mast community floodlight, consist of providing light to centralized groups of households, especially in low income urban areas, normally up to 300 houses, and the main focus were security, lowering the community lighting and the main reflexes were the setting of SMcEs.

These types of actions are normally associated with local market places and fish landing sites, and also lead to the extension on the useful hours for the community, and indirectly the local income.

Fig 10 Improved cookstove

Centralized three-phase stations

In this case, where a series of local entrepreneurs can be clustered, and a higher quality electricity supply can be offered, with a better protection system, to work with and towards the feasibility of small crafts and workshops (i.e. mechanical repair, mechanical industries, sewing units, etc). This would prevent the need to extend of a high quality grid (that otherwise could be done in only two phase), at the same time that secure the production framework that those business would need to develop (like a nursery centre for SME – Small and Medium Enterprises).

4. HOW TO SUPPORT THE ADOPTION OF THESE TECHNOLOGIES?

The question here is not just about "investing" in technologies, but also how to support their implementation and remove obstructions. . For example, if the government decides that mini/micro hydro is one technology that is to be pursued, the environmental licensing process could be simplified, the taxes on the equipments can use a lower taxation system, the local companies that provide the equipments and services can have access to special finance and micro credit lines, the local engineering schools would have the subject included in the curricula, etc.

When considering the SWER, in Brazil where the rural electrification program made use of this technology ("Luz no Campo" and "Luz da Terra"), the model main strategy was the creation of a commission responsible for the rural electrification in rural areas, in charge of the coordination and development of the program, whose main goal was the social inclusion of the rural population. The main conclusions and lessons learned from those two programs were: previous technical analysis of the projects by a Technical Body (Partnership with University) to optimise the cost / benefit ration, on the financing, were used different financial schemes that included, financing with monthly payment on the electricity bill in 60 to 75 (starting from 1 to 2 years after the connection been established), inclusion of the local rural institutions as part of the technical assistance prociders (Betiol Jr. et.al., 2004).

The choice between different technological solutions plays a central role in the fight for providing the poorest with energy access. The multidisciplinary of the issues advices to well calibrate between the many options available, and consider the different consequences on local economy, environment and society. Often, the choice is not only between more or less cost effective options, but between the failure or the success of the process of improving the poorest life providing them with the necessary energy services.

References:

Betiol Jr, Genásio; Strazzi, Paulo Ernesto; Ribeiro, Fernando Selles; Pazzini, Luiz Henrique & Carmo, José R. Do. The Engineering Technical Standards Applied to the Rural Electrification Programs in the São Paulo State (in Portuguese). Proceedings X Brazilian Energy Congress –Energy Access to All, COPPE – UFRJ, Rio de Janeiro – BR, 26 – 28 October 2004.

Karekezi, Stephen & Majoro, Lugard. Improving modern energy services for Africa's urban poor. Energy Policy 30 (2002) 1015–1028.

AFREPREN/FWD. Making the African Power Sector Sustainable. Final Regional Report. Nairoby: African Energy Policy Research Network – AFREPEN. 2005. Available at: www.uneca.org/eca_programmes/sdd/documents/Making_the_Power_Sector_Sustainable.pdf.

Giannini, Marcio & Machado, Aluísio Campos. Energetic accountability of the production factors: ex-ante and ex-post the rural electrification programme "Luz no Campo" – ENERSULMato Grosso do Sul (in Portuguese). Proceedings X Brazilian Energy Congress – Energy Access to All, COPPE – UFRJ, Rio de Janeiro – BR, 26 – 28 October 2004

Eletrobrás. Systems Selection SWER – RER – 05 (in Portuguese). Brazilia: Cepel, 2000.

Enda-TM. The role of renewable energy in the development of productive activities in rural West Africa: the case of Senegal. Final Report: "Renewable Energy Technology Working Group" - Global Network on Energy for Sustainable Development, March 2005. Available at: http://www.gnesd.org/Downloadables/RETs/ENDA%20RETs%20final%20version.pdf.

World Bank Technical and Economic Assessment: Off Grid, Mini-Grid and Grid Electrification Technologies. Discussion Paper Summary Report, Energy Unit Energy and Water Department, November 2005. Available at:http://web.worldbank.org/WBSITE/EXTERNAŁTOPICS/EXTENERGY/0,,contentMDK:20796696~pagePK:210082~piPK:210098~theSitePK:336806,00.html

Figures
Fig1:http://www.people.cornell.edu/pages/vkm2/asanksummary.htm
Fig. 2.http://energy.saving.nu/hydroenergy/small.shtml
Fig 3 http://www.emanphoto.com/
Fig. 4 http://www.gramvikas.org/
Fig 5 and 6 Daimler Chrysler
Fig 7 World Bank
Fig. 8 Shell Solar Fund.
Fig. 9 www.ruralpower.org
Fig 10 www.wenetcam.net
Fig 11 UNDP
Fig 12 REEP

Fig 12 Improved Cookstove

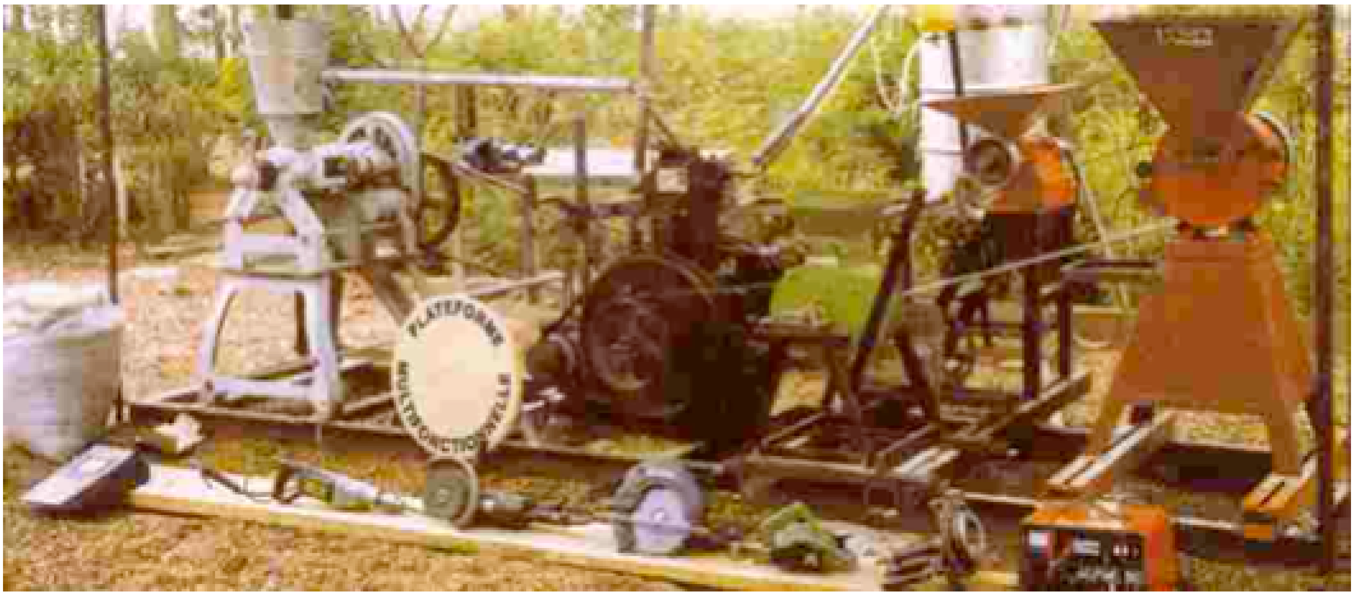

Fig. 11 Multi Functional Plateform

Project Schedule

The project is scheduled to be developed until mid-2007, with the realisation of two main Workshops, from where the project team already ask for interested parties to mark in your agenda.

1st Workshop - June 2006 – Niger

2nd Workshop - March 2007 - Niger

Besides these two Workshops the project is also committed to involved institutions to build a permanent network between the professionals

Istituto Superior Tecnico RGESD - IST Portugal	ESD - Energy for Sustainable Development ltd UK	CRES - Center for Renewable Energy Sources. Greece	ARC - AGHRYMET Center Niger
Long experienced research team in the field of energy planning and renewable energy systems.	Consultant firm with experience in energy policy and regulation.	The Greek national centre for Renewable Energy Sources, Rational Use of Energy and Energy Saving.	Specialised institution committed with the food security and to help the management of natural resources in the CILSS region..

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