An Overview on Renewable Energy Technologies for Developing Countries: the case of Guinea Bissau

C. Boccaletti[1], G. Fabbri[1], J.Marco[2], E. Santini[1]

[1] Department of Electrical Engineering
University of Rome "La Sapienza"
Via Eudossiana 18, 00184 Rome, Italy
Tel. +39 06 44585762, Fax +39 06 4883235
e-mail: chiara.boccaletti@uniroma1.it; gianluca.fabbri@uniroma1.it
[2] Department of Civil Engineering,
Universidad Politécnica de Madrid
Alfonso XII, 3 y 5 - 28014 Madrid, Spain
Tel. +34 91 336747, Fax +34 91 3367958
e-mail: luisjaime.marco@upm.es

Abstract.

This paper addresses the need for electricity of remote rural communities in developing countries and the possibility to use renewable energy to supply electricity to non-electrified villages in isolated rural regions. An overview of the main available renewable energy technologies is given and the case of Guinea Bissau is studied. Using a software tool developed in previous works the practical case of a photovoltaic water pumping system to supply water to non-electrified villages in isolated rural regions of Guinea Bissau is analyzed. Details, simulations and estimated costs are given.

Key words: Photovoltaic energy, renewable energy, rural electrification, remote communities, PV pumping systems.

1. Introduction

The role of energy is crucial for the development and the economic growth of any country. An estimated two billion people in the world lack access to modern energy carriers and the access to energy varies widely among the countries. Energy use in developing countries is closely linked to a range of social issues: poverty alleviation, health, education, population growth, employment, communication, urbanisation. Finding ways to expand energy services, while addressing the environmental impact associated with energy use, represents a critical challenge for humanity. In recent years there has been a significant development of alternative energy technologies, both in terms of performance and cost reduction. Moreover, many developing countries - like Guinea Bissau - are particularly well positioned when it comes to development a new generation of energy technologies. Energy needs to become more accessible to large sectors of the population, including the poor, vulnerable people and those living in rural areas, and to contribute more to the social and economic development of the country. Renewable energy such as solar, hydro-electric, biomass and wind can give an important contribution to reduce the problems caused by the consumption of fossil fuels, which include the strategic dependence on petrol producers, high fossil fuel prices, pollution and greenhouse gas emissions. Renewable energy sources could meet the demands of the dispersed rural population which has low energy needs and few resources whilst protecting the natural environment and promoting sustainable development.

2. Overview of available renewable energy technologies

Renewable energies can represent an initial answer to energy poverty and a feasible model for sustainable energy strategies, helping to reduce CO_2 emissions and slowing down the negative global temperature trend. Furthermore, they are not just a must, but also a business opportunity. Different available technologies are briefly described in the paper.

Photovoltaics

Photovoltaic (PV) technology is cost-effective in providing electricity to rural areas at the smallest scale in areas with no access to grid electricity and where electricity demand is characterised by such low levels and infrequency that even diesel generators cannot compete. A particular application of photovoltaic technology is the solar water pumping which has several advantages over traditional systems; for example, diesel or propane engines require not only expensive fuels, they also create noise and air pollution in many remote areas. Solar systems are environment friendly, require low maintenance, and have no fuel cost.

3. The energy profile of Guinea Bissau

Electrification covers only 12% of the country and with electric service costs five times higher than in Senegal. The numerous shortages caused by the Public Company of Water and Electricity (EAGB) have thrusted companies to install electric generators. Moreover only 13% of the Bissau's population has access to water, the supply of which is frequently subject to interruptions by the EAGB due to the poor condition of infrastructures. Surface waters and underground waters represent the main hydraulic potential of the country, while the contamination risks are regular. Guinea Bissau is endowed with several renewable energy resources; in particular it receives good amounts of solar energy.

4. Rural applications: simulation of solar water pumping system

A software tool to evaluate Stand Alone Systems has been developed in our department. The tool includes ready-to-use component models with the potential for user-defined modifications and for the construction of a customer-adapted model. With the developed tool is possible to couple detailed technical models to economic models that account for both investment and operational component costs simplyfing the task of evaluating design options for stand-alone applications. The possibility of installing a PV water pumping system to meet the drinking water and livestock watering needs of a remote typical rural community in Guinea Bissau has been evaluated using the above software tool. The characterstics of the rural community under study are shown in Tables I and II.

Table III shows the annual energy production of the system. Table IV shows the estimated costs and life span for different energy sources (PV, diesel generator, and AC with a new distribution line) used for remote water pumping.

TABLE I. - Data about the location

Nearest location for weather data	Bissau
Latitude of the location	11.9 °N
Annual solar radiation (tilted surface)	2.05 MWh/m²
Annual average temperature	27,7°C
Water demand for 12 months analysed	10422.6 m³
Wind regime	poor
Equivalent pumping energy demand	669 kWh

TABLE II. - Water use per unit

Water pumping application	Unit	N° of units	Water use per unit		Daily water required (m^3/d)
Domestic	Person	500.0	L/d/person	45.0	22.50
Livestock	Head	160.0	L/d/head	40.0	6.40
Total water	m3/day				28.90
Energy demand		Daily	1.85 kWh	Annual	676.65 kWh

TABLE III. - Annual energy production

Annual energy production (12 months)	Unit	Estimate
Water delivered	m³	10362
Specific yield	kWh/m²	39.0
Overall PV system efficiency	%	1.9%
PV system capacity factor	%	4.0%
Renewable energy delivered	kWh	**665**

TABLE IV. - Comparison of energy options for remote water pumping

Energy source	*Estimated capital cost*	*Operation cost*	*Maintenance*	*Life span (year)*
PV Systems	6.8 $/Wp	None	Low	10-15
Gen Set	2.5$/W	0.6$/kWh	High	5-10
Electric utility	22$/W	0.05-0.13 $/kWh	Low	N/A

Figure 1 compares the three water pumping methods - solar PV, diesel generator, and AC with a new distribution line- considering each system pumping the same amount of water. The figure is calculated for a system capacity of 1000W and taking into account capital costs, transportation costs, fuel and maintenance costs for the three pumping methods.

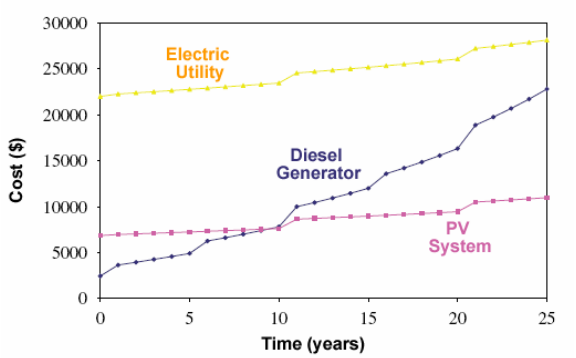

Fig. 1. - Cost comparison among a new utility line, solar pumping system, and diesel generator

It is evident from the figure that the PV system is the most cost effective for remote water pumping, even though it has higher capital cost than the diesel generator. Electric utility has the highest capital cost, also it has higher O&M cost than the PV.

5. Conclusions

The use of renewable energy technologies in developing countries like Guinea Bissau has a huge potential in terms of volume applications with concomitant reduction in costs, providing in clean/reliable power, reduction of green house gases especially carbon dioxide, creation of employment opportunities, community development and bringing about a better quality of life to the small farmer community. A solar water pumping system has been analyzed in this paper and compared with traditional energy sources; this kind of system can be suitable for a small scale remote application where 24 h electrical service is not necessary and presents several advantages over traditional systems.

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