A SUSTAINABLE AND COMMERCIAL APPROACH TO DELIVER PHOTOVOLTAIC–BASED ENERGY SUPPLY FOR RURAL AND REMOTE AREAS OF THE AMAZON REGION - THE RIBEIRINHAS PROJECT

Rubem C.R.de Souza, Rejane Moraes-Duzat*, Breno de S. França, Eyde C. S. dos Santos, Aurélio C. de Melo Jr.
Núcleo de Eficiência Energética (NEFEN)- Faculty of Technology, University of Amazonas
Avenida Gen. Rodrigo Otávio, s/n – Campus Universitário, Manaus-AM**, Brazil**

*** The National Institute for Amazonian Research (INPA/CPPF)**
C.P. 478, Manaus-AM, 69011-970, **Brazil**
Tel.: (0055-92) 643-3083 Fax.: (0055-92) 643-3096
E-mail: duzat@inpa.gov.br; rcsouza@internext.com.br

Abstract: This paper describes the approach taken to develop and implement institutional structures for specifying, installing and maintaining PV-systems applications in rural and remote communities located at the margins of rivers in the Amazon State of Brazil. A pilot project has been carried out, with the objective of supplying 30 communities with energy based in photovoltaics. The project concept approaches social, economics and technical aspects, but its main focal area is to develop and demonstrate sustainable and commercial approaches to deliver community-based renewable energy services. The role-players include the Federal University of Amazonas (UA), The National Institute for Amazonian Research (INPA), The local Electric Utility (CEAM), The Brazilian Research Center of Electric Energy (CEPEL), the National Electricity Agency (Eletrobras), and local communities committees. A complete survey of about 63 communities has been carried out, assessing aspects like actual energy demands, economic affordability of potential consumers, productive and social aspects. To time, the first twenty systems have been installed. Based on the data collected, analyses are underway to find out which strategies can be applied by the local electric utility to install, monitor and charge PV-based energy systems. The results of the first year of the project will be discussed.
Key words: Rural Electrification – 1: PV-System – 2: Villages - 3

1 INTRODUTION

The mains barriers to rural electrification of isolated areas of the Amazon area are basically associated with is its geographic characteristics: great distances, broad rivers and floodplains, sparse rural population, remote sites, high cost of remote electricity and small loads. Those are some of the causes, which makes the supply of energy to isolated communities in the Amazon region a very complex issue. These specific characteristics also influences the technical aspects especially because, on one hand, the small magnitude of the demand makes economical viability difficult and, on the other hand, there is still a lack of appropriate technologies that can utilize the energy resources available in the area, with costs and energy generation capacity adequate to the characteristics of the demands to be met.

The mentioned characteristics and the urgent need for ecological solutions to promote the development of the region compose the ideal scenario for the implementation of renewable energies

Following changes in the whole Brazilian Electric Sector (privatization of generation and distribution utilities and advances in the regulation for independent power producers), several solutions are being investigated as alternatives to Diesel generators (the main source of energy at small and isolated communities). Biomass, hydrokynetics, micro-hydro, vegetable oils and photovoltaics are some of the major technologies considered. However, due to the maturity, modularity and installation simplicity, PV technology presents itself, at the moment, as one of the most favorable solution for electrification or even pre-electrification of communities in the interior of the Amazon region in Brazil.

The present work deals with issues concerning the application of PV systems in the State of Amazonas.

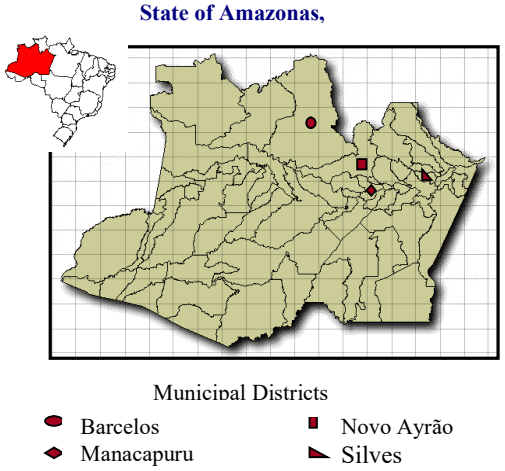

Fig. 1: Sites where the first 60 PV systems have been installed in the frame of the "Ribeirinhas Project".

2 DESCRIPTION OF THE PROJECT

The Ribeirinhas project has been conceived as an effort of the Brazilian government to assess and demonstrate the techno-economic viability of supplying energy to isolated communities in the Amazon Region, with the use of renewable energy resources. The initial idea was to identify local sources of renewable energy, in the area of the project, that could be utilized for the generation of energy for the electrification of remotes communities located on the margin of rivers in the state of Amazonas in Brazil (the word "Ribeirinhas" stands for communities on the rivers side). The main objectives of the project can then be summarized as :

- The implementation of energy supply systems, based on diverse renewable energy sources, in 30 isolated

communities in the interior of the state of the Amazonas , Brazil.

- The development of a commercial strategy to deliver community-based energy services to isolated areas.

The project was sponsored by the National Electricity Authority (Eletrobras) and carried out by the Brazilian Research Center for Electric Energy (CEPEL) in collaboration with the Center of Energetic Efficiency (NEFEN) of the Faculty of Technology of the Federal University of Amazonas, INPA and the local utility (CEAM).

2.1 Phase 1

In the first phase of the project, a field work survey comprising 63 communities was conducted in order to identify the communities to be supplied and the sources of renewable energy available in the area. The choice of the communities were based on the following criteria, as defined by CEPEL:

- the communities should be located on the margins of rivers;
- the communities should have a minimum of 20 houses;
- there should be some degree of organization in the community
- Villagers should be able to afford a minimum cost for having electricity.

Apart from the energetic aspect, the field survey contemplated the energetic, social and economical profiles of each community, obtained through the application of comprehensive questionnaires, which were answered by a member of each residence in the community. The following aspects have been assessed:

- Local potential sources of energy
- Financial affordability of the potential users
- Types of productive systems existent
- Energy consumption
- Energy demand
- Social and economic aspects

Table 1 summarizes the actual situation of the communities surveyed, showing also which type of technology would be applicable for energy generation.

The main productive activities of the chosen communities are agriculture and fishing. The majority of the families produce food for their survival, with some of them producing fruits and cassava to commercialize. Fishing is the main incoming generating activity during the rainy season, but during the dry season it practically does not exists considering the lack of a refrigeration system to store the fish and the other goods.

Municipal Districts	N ° of Comnunities Surveyed	Distance from Manaus (Km)	Average Income (US$/m)	Expenditure for Energy (% Income)
Autazes	07	70	90	23
Iranduba	03	30	90	20
Itacoatiara	18	340	89	20
Itapiranga	03	256	90	22
Manacapuru	13	90	100	24
Manaquiri	06	32	110	22
Manaus	01	-	100	22
Novo Ayrão	10	200	100	24
S. Sebastião. Uatumã	01	125	90	23
Silves	01	380	100	22

Table 1: Summary of the actual situation of the communities according to the field survey (distances are from Manaus to the main town of the districts).

2.1.1 Main problems detected

The initial phase of the project disclosed the great complexity of the problem to be dealt with: Despite the theoretical availability of natural resources for the generation of energy for the electrification of small communities in the Amazon region, it has been realized that, in the majority of the cases, the local of occurrence of the energetic potential does not always coincide with the local of the demand of energy. As an example, in places where exists enough hydraulic potential (small waterfalls) to install a water turbine, or in places were there is adequate water current speed levels in the rivers, to install a free water current turbine, there is no community around it. Besides these aspects, the following difficulties could also be pointed out:

- the economic aspect: low financial affordability of the population;
- lack of availability of appropriate equipment in the national market to produce small power levels;
- Unavailability of important historical data, necessary to implement some of the technologies (precise maps of the region, data about existent energy potential in rivers or in biomass, reliable information on the situation of energy supply in the isolated communities, etc).

2.2 Phase 2

Considering the difficulties pointed out by the field survey to attain the initial goals of the project, a second phase has been initiated with a new approach concerning the technologies to be applied in the short term. From this point on, only PV- technology, micro-hydropower and gasified were considered, with PV as the priority due to the impossibility of utilizing other sources for the majority of the communities. From the 63 communities surveyed, 30 have been chosen to be supplied by PV solar home systems, 1 community to be served by a gasifier utilizing forestry residues and 2 sites to be supplied by micro-hydropower.

3 PARTIAL RESULTS

To present, as a result of phase 2, there are 60 PV solar home systems installed and operating in 5 communities. The installations at the remaining communities are being planned by CEPEL/CEAM. Table 2 presents the characteristics of the systems and Figures 2 and 3 show an overview of one of the villages supplied by PV systems.

Component	Quantity	Capacity
PV module	2	75 W
Battery	1	150 Ah
Inverter	1	600 W
Charge controller	1	
Lamps	3	15 W
TV/Radio connection	2	50 W

Table 2: Type of solar home systems installed in the communities

Fig.2: View of one of the communities

Fig.3: PV Solar Home System installed at a residence in one of the communities.

CEPEL is contacting different producers of gasifiers to make the acquisition of one unit to supply energy to one community. The difficult has been to find the right power level to meet the estimated demand in the national market. The utility company will install the electric grid for the distribution of electricity.

Negotiations are underway with the district authority of Manacapuru (in which the community is located) for the acquisition of a piece of land, within the community, to implement the gasifier system. It is important to mention the participation and interest of the local authorities of this district in the project.

In the meanwhile tests for the utilization of different agricultural residues in the gasifier are being conducted at the university in Manaus (see Fig.3).

Fig. 3: Gasifier under test before installation.

For the energy generated by PV technology, a monthly fee of 6 US$ per residence has been settled by the utility for the payment of the energy consumed. CEAM, who owns the systems, is finalizing the contract terms to be signed by the villagers to regulate fee collection. This has been a complicated issue, since there are still open questions concerning regulation aspects for charging this type of consumers in Brazil. Besides that, the great distances to be overcome will certainly impose too high costs for the charging process, making it economically unattractive for the company.

4 CONCLUDING REMARKS

The Ribeirinhas project has been conceived as a pilot experience to gather information that could serve as base for a future program for electrification of isolated communities in the Brazilian part of the Amazon region. The use of renewable energy sources will certainly play a major role in any electrification program in the future, and the lessons being learned through this project might be of valuable aid to the actions of institutions involved with renewable energy - based electrification for remote areas in Brazil

The fieldwork carried out during the project has provided relevant information for any type of program concerning rural electrification in the Amazon region. The social, economic and energetic profiles of 558 families

17th European Photovoltaic Solar Energy Conference and Exibition, 2001, Munique. Proceedings of 17th European Photovoltaic Solar Energy Conference and Exibition, 2001. v. I. p. 141-142

leaving in 63 communities have been identified and analyzed in detail. The specificity of each community demonstrated the necessity of new strategies to approach rural electrification of remote areas in the Amazon

This study has shown that people in remote communities in the Amazon area can afford to pay the costs for energy supply if these costs would not exceed 20 to 25 % of their monthly income. However, to create a market for renewable energy it is still necessary that government and utilities take actions beyond the energetic domain to support the large-scale dissemination and utilization of the new technologies.

The crucial problem to be addressed in programs of rural electrification in remote areas will be maintenance and fee collection, considering the great distances to be overcome and the access to the communities during certain periods of the year. In some of the community where the PV systems has been installed in the present project, the access will not be possible by boat during the dry seasons. Therefore it is of paramount importance for the sustainability of the project that that utility develop a strategy to charge for the energy delivered. One option would be to employ people in the community to do this task together with the maintenance services.

5 REFERENCES

[1] Núcleo de Eficiência Energética-NEFEN-Universidade do Amazonas. *Relatório Final do Projeto Ribeirinhas*. Manaus, Brazil, 2001.

[2] Calheiros Melo A., Rodrigues Souza, F. *Avaliação Técnico-Econômica do Suprimento de Eletricidade da Comunidade de Apóstolo Paulo/Manacapuru.* Universidade do Amazonas, Manaus,Brazil, 2001

[3] Souza, R. C. R., Pereira, G.A, França, B.S., Martins, G. *Aperfeiçoamento e Difusão de Fogão a Lenha de Queima Limpa no Estado do Amazonas.* Proceedings of the III Encontro de Energia no Meio Rural (AGRENER 2000) Unicamp , Campinas, São Paulo, Brazil, 2000.

[4] Gregory J. A. A, *Institutional Barriers to the Widespread Use of PV in Developing Countries*. Proceedings of the 12th EC PVSEC, Amsterdam, The Netherlands, 1994.

[5] Lysen, E. H., Photovolts for Villages, IEEE Spectrum, October 1994.

[6] Yuyama, K. *Potencialidade agrícola dos solos da várzea e a utilização de leguminosas na Amazônia Central*. In:Ferreira, E.J.G.; Santos,G.M. dos; Leão, E.L.M.; Oliveira, L.A.de. Bases Científicas para Estratégias de Preservação e Desenvolvimento da Amazônia. INPA, Manaus,. 437p, 1993.