A COMPARATIVE STUDY OF TWO DIFFERENT MANAGEMENT MODELS OF RENEWABLE ENERGY SUPPLY SYSTEMS FOR REMOTE COMMUNITIES OF THE AMAZON REGION

Rejane Moraes-Duzat*, Rubem C.R.de Souza, 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: In this paper, a proposed methodology for the management of renewable energy applications for electrification of rural and remote communities of the Brazilian Amazon Region is presented. The study is part of a pilot project to supply small communities of the Amazon region with a combination of technologies, based on renewable energy resources. The main focus is the investigation of different management approaches. Two communities in the interior of the state, both located in the right margin of the Amazon River, were chosen for the proposed studies. In both communities, energy is to be generated by using solar energy (photovoltaic and solar drying) and biomass (gasification of agricultural residues). In one community, the energy system's management will be in charge of the local Electric Utility (CEAM), while in the other, the system's management will be done by the community itself, through a village committee. Aside from the reliability aspect, efforts were directed to the organization, giving support to the communities productive systems in order to stimulate the auto-sustainable development of them. The project is planned to be executed within a time period of two years and preliminary results of the first year will be discussed.

Keywords: Rural Electrification –1: PV System –2: Villages -3

1. INTRODUTION

The Amazon Region, with its 3.5 million square kilometers (40 % of the national territory), is characterized by a low population density, great distances, large rivers and a rate of rural electrification of only 2 %. The supply of energy to isolated communities in the Amazon Region is a very complex issue, 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 demand to be met. The solution to this problem is not only a goal for the population directly involved, but also for the government and other public organizations that are responsible for regional development and consequently for fulfilling the social demands.

Electricity generation in the Amazon region, where it exists, is based mainly on isolated Diesel systems in the range of a few kilowatts in small villages. The cost of remote electricity is very high, due largely to operation and maintenance and low capacity factor, and secondarily, to high fuel costs. The small systems are normally unreliable, leaving the small villages for long period of time without energy.

The changes which are taking place in the Brazilian Electric Sector (privatization, advances in the regulation for independent power producers, etc) are creating new opportunities for the applications of renewable energies in the country. Especially for the North Region, where energy is a major problem, the use of photovoltaic for small villages, for instance, can be a major technology to be considered in the near future. The government has already decided that fuel subsidy for thermal generation (the main source of energy in the Amazon region) can be used to finance renewable energy projects that reduce fuel consumption, and there has been interest demonstrated by private entrepreneurs to substitute subsidy by an initial grant for renewable equipment purchase. This and other actions taken by the government, as the new law being established by The National Agency for Electric Energy – ANEEL, obliging the utilities companies to supply 100% of all consumers in the country in a time period of five years, call for new strategies to develop a market to implement renewable energy technologies in large scale.

The project's activities described in this article represent concrete efforts taken by institutions from the Amazon State, to create the technical and academic infrastructure to support the dissemination of technologies based on renewable energies in the region.

2. GOVERNMENTAL PROGRAMS

In the last decade, the Brazilian government has taken some actions concerning the electric supply of isolated communities through the implementation of programs and projects based on renewable energy sources.

In 1994, the Ministry of Mines and Energy (MME) launched the national program PRODEEM (Program for the Development of Energy in States and Municipal Districts), with the objective of supporting the introduction of renewable technologies in projects for electrification of communities not served by electric grid, around the country. The main technology utilized in this program has been photovoltaic systems for illumination of communal buildings and water pumping for villages. The PV-systems are financed by the MME and are installed by state utilities and technical schools. The systems are propriety of the Ministry and the responsibility for their operation upon installation is not clearly defined.

In the year 2000, Eletrobras (the National Electricity Holding Company), through its Research Center for Electric Energy (CEPEL), conceived a pilot project to promote the dissemination and application of renewable technologies to supply isolated communities in the interior of the Amazon State. Differently from the PRODEEM approach, the objective of this project was to supply only the domestic energy needs of the individuals in the communities, who would pay for the energy consumed.

With the mentioned projects, the Brazilian government is signalizing its crescent interest in developing and deploying renewable energy technologies as alternatives to grid extensions or to reduce fuels and financing subsidies. However it is still necessary to encourage governments and utilities to undertake energy programs which also include parallel economic development aspects. Without a strategy which permits that the energy supply issue can become part of the process of development, creating gains and employment for the population, there will be great obstacles to the implementation of renewable energies in the electrification of isolated areas in the Amazon region.

3. SCOPE OF THE PROJECT

As an extension of the activities developed on the Ribeirinhas project, a methodology has been developed to stimulated the auto-sustainable development of isolated communities in the Amazon region, with the main focus on the supply of energy. The objectives of the studies are:

• to implement and monitor the general performance of energy conversion systems with adapted technologies based on renewable resources

• to assess, on-site, the social-economic and cultural changes in the organization and social relations imposed by the utilization of the technologies proposed

• to implement and monitor the performance of a cooperative productive system that will provide the means for refrigeration and processing of local fish and pulp of Cupuaçu (a local fruit with significant commercial appeal), assessing as well the social and economical effects of this action

• to evaluate the applicability of the rational utilization of the natural resources existent in flooded areas of the Amazon basin

• to stimulate the commercialization of products with improved quality, in order to generate income which can be used to pay part of the costs for energy

• to stimulate the members of the community to adopt agricultural and social practices which can promote the conservation of the environment.

The project has been carried out by a multidisciplinary team (electric and agronomic engineers and social workers), and aside from the energetic focus, much efforts were concentrated in developing and implementing actions and strategies concerning agricultural productivity and generation of income for the villagers, which are fundamental aspects for the development of the community and also for the creation of a market for the technologies proposed. The project therefore also addressed current concerns about promoting sustainable development for populations of low income in isolated areas of the Amazon Region. An interesting characteristic of the project is that the beneficiaries (end users) of one of the communities would be able to buy their own energy, as for instance a photovoltaic home system, while on the other village, they would only pay for the energy service.

To attain this objective an experiment is being implemented, in which two communities are to be supplied by a combination of technologies, and for each of them, a different method of management of the systems is to be tested. The idea is to assess the pros and cons of both strategies and come out with some guidelines for rural electrification, in a phase of huge changes in the energetic policy of the country. The challenge of the project is to implement a methodology to achieve sustainability in projects concerning applications of renewable energy in isolated areas of the Amazon region.

Fig. 1: Map of Brazil indicating the project location

3.1 Apóstolo Paulo

The community of Apóstolo Paulo is located on the right margin of the Amazon river, approximately 85 km upstream from Manaus. Accessible only by boat from the municipal district town of Manacapuru (see Figure 1).

According to the field survey carried out in the project, there are 31 families leaving in the village. There is a Diesel generator unity (7.5 HP) serving the church, the vicar's residence and a house annex to the church, the electricity is distributed through a small electricity line (50 m) in precarious conditions. The other communal buildings are a school, a health clinic and a catholic church, that also serves as meeting point for the villagers.

The economics activities are the cultivation of manioc, maize, banana and other fruits which are sold mainly in the town of Manacapuru. The most important activity is fishing, which brings revenues and is the only source of income when the dry season is over and the river floods the area normally used for cultivation.

The villagers utilize the following sources of energy: gas, firewood, gasoline, candles, dry batteries, Diesel and Kerosene. The current average energy costs represents about 24% of the families income.

3.1.2 Proposed methodology for the implementation of the energy supply

The proposed methodology for the electrification of this community comprises two components: a) the supply of electricity by means of local renewable energy sources (a gasifier to utilize agricultural wastes and solar energy)

and b) a strategy to promote the auto sustainable development of the community.

The base for the implementation of the methodology is the involvement of the population as a organized entity. The organization of the villagers will be done through the creation of a cooperative. A management system will be established with the creation of a revolving fund which can permit to maintain and expand the infrastructure implemented.

As strategies for the economic development of the community, the following actions will be implemented:

1) a cooperative production system comprising refrigeration and processing of local fish and Cupuaçu pulp (Theobroma gandiflorum), a local fruit of significant commercial appeal in the country.

2) the instalation of a solar dryer to dry the Cupuaçu seeds, which can be sold to the chocolate and cosmetic industries;

3) to give technological support to the cultivation of Cupuaçu, a program has been established to provide the community with the knowledge of modern forestry agricultural techniques, to improve productivity without advancing against the forest and to reduce the occurrence of plagues. A team of agricultural engineers is giving specific training to the villagers.

4) in addition to the agro-forestry issue, courses about environmental education, energy conservation, electrician formation, community organization and communal leadership will also be ministered.

An important point in the implementation of these actions in this community is that the local authority (municipal government) is involved as an active partner in the process.

Fig. 2: General view of the community

Fig.3: Model of the Gasifier to be installed

3.2 Nossa Senhora das Graças

The community of Nossa Senhora das Graças is located on the right margin of the Amazon river, about 80 km upstream from Manaus, accessible only by boat from the municipal district town of Manacapuru (see Figure 1).

There are 30 families leaving in the village. A Diesel generator unity supplies 10 residences during 3 hours a day. Fuel costs for electricity generation are shared among the users that pay a charge of 3,5 U$S per month. There is a school and a catholic church with its own Diesel generator.

The economics activities are essentially the same as in the other communities (cultivation of manioc, maize, banana and other fruits which are sold mainly in the main village). The most important activity is fishing, which is consumed and sold in the market. An important source of income to the community is the production and commercialization of cassava flour, which is a typical source of aliment for the population of the Amazon region.

The villagers utilize the following sources of energy: gas, firewood, gasoline, candles, dry batteries, Diesel oil and kerosene. The average costs with these energetic sources represents about 23% of the families income.

3.2.1 Proposed methodology for the implementation of the energy supply

In the frame of the Ribeirinhas project [1,2], this community has been chosen to be supplied by PV systems. According to the goals of the project, only residences were to be attended. The state utility is the owner of the PVsystems and will charge for the electricity delivered. A monthly rate of 6 US$ has be defined, corresponding to the currently average expenditures for the conventional sources of energy used by the villagers that will be substituted by PV. All the PV systems installed are basic solar home systems composed of 2 solar panels, a battery, an inverter and a charge controller.

Considering that the low per-capita income of the community and the lack of an appropriated electricity generation system to allow the implementation of a mechanical productive process would hinder the sustainability of the project, a complementary project has been developed with the objective of promoting an increase of income of the villagers. The idea is to assure the payment of the energy consumed and also to create real

conditions for the development of the community. To attain this objective, the following actions will be taken:

1) in the houses served by the Diesel generator, incandescent lamps will be substituted by fluorescent ones in order to reduce the costs with fuel.

2) implementation of a unit to process fruit pulp so that the villagers can have another source of income.

3) introduction of modern agro-forestry systems for the cultivation of Cupuaçu in the community in order to increase the productivity and the area cultivated.

4) Dissemination of a high efficiency cooker, to reduce the costs with gas.

The production system to be implemented at this community will be based on a cooperative approach similar to that of Apóstolo Paulo.

Fig. 4: PV system installed at one of the houses in the community.

Fig. 5: Village meeting to discuss the project implementation.

The utility has already installed 12 Solar Home Systems in the community. They are operating, but so far people have not start to pay for the energy consumed, since there are still open questions concerning regulation aspects for charging this type of consumers in Brazil. Other open questions are:

a) how often and by what means the utility company will collect the fees? The great distances to be overcome and the possibility of not finding the consumer at home at the time of collection (he can be working far away from home) will impose too high costs for the charging process.

b) Another source of complication is the fact that in most of the cases the consumer is not the owner of the house where he lives, and the company is not sure by whom the contract to pay for the energy should be signed. There is the possibility that if a person signs the contract, he or she will take the system with them in case they move to another place.

4 CONCLUDING REMARKS

• Government and Utilities must take actions beyond the energetic domain in order to promote the dissemination and utilization of renewable energies.

• People in remote communities can afford to pay for energy consumption if adequate financing options are created for them.

• Local cooperatives should be used to collect fees and carry out basic maintenance (the great distances of the region will make it unattractive for the utilities).

• Multidisciplinary programs, also involving institutions which have available capital to finance incomegenerating activities, can be one solution.

• A model for intervention of non-governmental organizations should be introduced.

• 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.

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.