Solar Home Systems In Xapuri – A Case Study In Northern Brazil

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Abstract

The universal access to electric energy is a great challenge for both government and energy concessionaires, especially when dealing with the rural areas in North of Brazil. The "Luz Para Todos" program (LPT) is set to provide electricity to all households in Brazil, including the Amazon isolated communities.

Given this reality, a pilot project comparing three different types of Solar Home System that provide DC, AC or DC+AC were implemented in three isolated communities of the Chico Mendes reserve, located in the Xapuri´s borough. A monitoring program of 18 months analyzed their technical performance, the quality and cost of the service provided by the utility, in addition to user satisfaction.

According to the experiences of the project, the remote areas and the difficult access become the O&M costs higher, hence the management model with a well trained local staff is important to successful of any project. As a project outcome, some suggestions were presented to the National Electric Energy Agency ANEEL regarding the current regulations for decentralized energy generation systems, and more specifically Solar Home Systems.

Keywords: Renewable Energy, Rural Electrification, Solar Home System and Monitoring

1. Introduction

In Brazil, the rural electrification process really gained force with the universal access to electric energy that was established by the Law 10438/2002, in which the electricity utilities would have the obligation to electrify all residences in its concession area. To accelerate the universal access to electricity in the country, was established the "Luz Para Todos" program by the Decree 4873/2003, which the aim is to finance and provide subsidies for investment in the rural electrification projects, to be executed by concessionaires of distribution and other performers.

By the end of 2007, about 1.7 million rural households have benefited by this program. However, the pre-set program targets are far from being met because in the Brazil there are remote areas of difficult access, far from the power grid and with a low population density. In these areas, mainly located in the Amazon region, it is economically very difficult to electrify residences through the extension of the distribution grids. In many cases the electrification may be possible with the introduction of the Renewable Energy Sources (RES), which has the peculiarity to generate electric energy in the same place or near where the energy will be used.

Given this reality, in 2005 the ELETROBRÁS established a partnership with the GTZ, a german agency, under the Basic Agreement of Technical Cooperation between the Brazil Government and the Germany Government, to develop a project to spread renewable energy sources in the North and Northeast of Brazil. In this context, the Electricity Company of Acre

(ELETROACRE), in partnership with ELETROBRÁS was authorized by the National Electric Energy Agency (ANEEL) through authorized in Resolution 927/2007, to install and monitor experimentally 103 Solar Photovoltaic Home Systems (SHS) to generate electric energy in three communities of the Chico Mendes reserve, located in the Xapuri´s borough.

The project tested three types of SHS to assess what is more appropriate as a solution to residents scattered in remote communities. The attendance characteristics are shown in Table A1.

Table A1: SHS type of the Xapuri Pilot Project.

Communities in Xapuri-AC	SHS Type	Quantity	PV Power [Wp]	ANEEL Classification	Battery [Ah/C20]
Iracema	AC	31	3 x 85	SIGFI13	2 x 150
Dois Irmãos	AC+DC	35	3 x 85	SIGFI13	2 x 150
Albrácea	DC	37	3 x 85	SIGFI13	2 x 150

The Xapuri Pilot Project has the objective to evaluate in such a way the technical performance of the equipments and the integrated systems as well as to evaluate the financial impacts and the social and economics impacts of the benefited ones. To the end of the project are expected a base of safe information beyond some indicatives and suggestions that can give subsidies for the ANEEL in the improvement of the current regulations and for the ELETROACRE in the improvement of the SHS services.

2. Management Model

The chosen communities of rubber-tappers present a certain difficulty of access, especially Albrácea. However, all houses in the Xapuri Pilot Project can be reached from Xapuri within the same day and therefore the chosen communities may be considered easily accessible compared to other isolated communities in the Amazon. An appropriate management model to deal with SHS in such remote areas needs to focus on decentralization of customer support services. According to the experiences of the project, which was initially designed for direct care from the concessionaire headquarters, the successful management model now counts on local staff. This is a person, preferably a member of the community, trained to solve minor problems, perform maintenance procedures, guide users, deliver the bill (but not receiving any payment), and act as a means of communication with the concessionaire. This concept is based on the necessity to avoid, as far as possible, visits of staff at the houses, especially headquarter staff traveling some hundred kilometers from the state's capital of Rio Branco.

3. Technical Results of the Project

Many of the project's results are peculiar to some communities in the North of Brazil and could not be generalized indiscriminately, but after thorough analysis of the experiences of the Xapuri Pilot Project as well as other national and international projects, it is possible to present the results below as rather general.

3.1.Available Power and Load Profile

Through data acquisition automatic systems installed, it can be identified the daily load profile and the virtually available power. The figure below illustrates this information for two residences in each community.

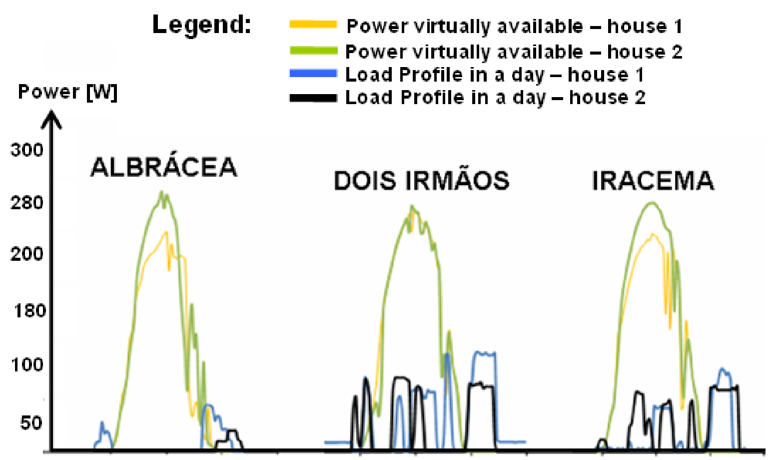

Figure A1: Available power and load profile in the three communities.

In the monitored houses, was evidenced the predominant nocturnal load use and also it perceived that the system can be being underused in the communities, mainly in the Albrácea´s community, where it has diverse houses with just the use of the light bulbs.

3.2.Energy Consumption

Also the energy consumption in each one of the units consumers benefited for the project was measured, through energy meters. The readings had been carried by the users, getting the following results.

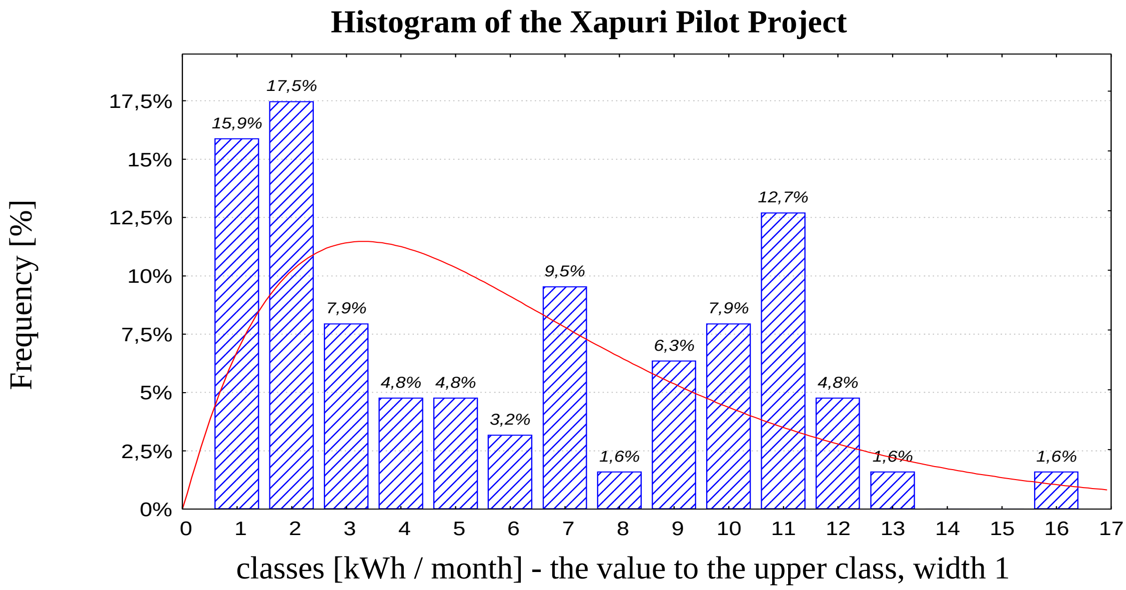

Figure A2: Histogram of the consumption of the three communities

About one year after the installation of the systems, a great parcel of the consumers takes only a small fraction of the available energy by the system:

- ✓ For 33% of the consumers, just 2 kWh/month in direct current (DC) would be enough because they use the energy only for illumination. A smaller system could take care of the demand of this consumers´ group;
- ✓ For 60% of the consumers, 7 kWh/month in DC would be enough because the use of the energy limits to the illumination, radio and low power TV. A smaller system also could take care of the demand;
- ✓ Only 20% of consumers demands over than 10kWh/month, using at least 75% of the available energy by the system. These consumers can reach at the limit of the system in a short time and, later, they can be interested in an increase of the system size ("load increase") in the short or medium period.

4. Field Research

Through one field research was evidenced that over 90% of the equipments or devices used in the SHS are light bulbs, radios, TV or satellite receivers, that could be operated in a DC system easily.

It is important to emphasize that the period of the research is still relatively short to analysis the electrification impacts, but there are some interesting results:

→ In Albrácea, 19% of the residences have TV, receiver and radio, while in Dois Irmãos 73% have TV and receiver and 33% have stereo system. Already in Iracema, 67% have TV and receiver and 37% have stereo system;

→ In Dois Irmãos was noticed a significant amount of blenders and DVD, in Iracema DVD and mobile phone charger;

→ All residences have light bulbs because three light bulbs per households had been donated by the LPT program. The majority of the interviewed people (88%) said they wanted to buy further home appliances, most frequently mentioned: TV, refrigerator, fan and stereo system;

→ However, in Albrácea 20 of 31 homes remain with only light bulbs;

→ About the reduction of the expenses with energy, it has a reduction of the R$ 14 per month in Albrácea, R$ 7 in Dois Irmãos and R$ 10 in Iracema. The main energy ones reduced had been candles, kerosene and diesel;

→ Whereas the monthly bill for electricity is about R$ 2.80, there is a real economy of more than R$ 10 in Albrácea, R$ 4 in Dois Irmãos and R$ 7.50 in Iracema;

→ About the value that the consumers would be willing to pay for energy, they answered on average values from R$ 7 to 9 per month.

5. Financial Results of the Project

5.1.Installation Costs

About the installation costs, the following table describes the values practiced in july of 2007, the main components, labor, transportation and administration, for each type of photovoltaic system implemented.

Table A2: Installation costs of the Xapuri Pilot Project.

Costs [R$]*	Albrácea	Dois Irmãos	Iracema
Modules (3 x 85Wp) + Structure	3,600.00	3,600.00	3,600.00
Batteries (2x 150Ah - 12V)	990.64	990.64	990.64
Controller (30A PWM)	396.50	396.50	396.50
Inverter (250W sine wave)	-	590.00	913.00
Acessories	1,802.45	1,873.37	1,748.40
Total Material	**6,789.59**	**7,450.51**	**7,648.54**
Labor	878.75	878.75	878.75
Transport	121.41	121.41	121.41
Others Materials	112.00	112.00	112.00
Administration	111.22	111.22	111.22
System Cost	**8,012.97**	**8,673.89**	**8,871.92**

*** values at the installation time**

The materials costs revolved around 85% of the total system cost, for installation of 103 units. The photovoltaic modules cost has reached 45% of the total investment. The installation cost varied from R$ 8,000 to R$ 8,800, equivalent to US$ 15,600 and US$ 17,200, and the global installation cost was R$ 875,000, equivalent to US$ 1,706,000.

It is emphasized that these costs are not included values of poles to support the photovoltaic modules, since they were provided by the community itself. Likewise is not included the transportation costs into the communities made by the residents.

5.2.Operation and Maintenance Costs

In the first year of electric energy services with SFD, it had 31 corrective maintenance that demanded the headquarter staff service, but he is located in Rio Branco, whose long displacements had contributed for the high costs. This happens due the fact of that in the first months of installation the local staff was still being enabled and was not prepared to detected and solve all the system failures.

The isolation and access conditions are the ones that get the costs higher. To reduce the expenses it would be necessary to increase the area of operation, the qualification and the participation of the local staff, improving the qualification of the consumers and reducing the frequency of the periodic maintenance.

5.3.Financial Balance

Given this reality and estimating the materials replacement costs, the following financial balance is gotten. In function of the equipments performance in site it was verified that the current battery (free-maintenance stationary type) will have an inferior useful life compared to the previously forecast, what impact directly in the materials replacement costs (“exchange campaign costs”). The battery useful life, previously foreseen for 3 years, was reduced to 1.5 year.

Table A3: Financial balance of the consumer unit (current battery).

Financial Income (R$/consumer)	Annual
Billing	21
Costs (R$/consumer)	**Annual**
Maintenance (Corrective and Preventive), Commercial	975
Defective Materials *	115
Exchange Materials Campaign *	240
Materials in the Campaign *	820
Total	**2,150**
Balance	**-2,129**

* Estimated costs

Based on these results, the Xapuri Pilot Project, which currently takes care 100 households, today brings an imbalance between costs and incomes of approximately R$216,000 annually, equivalent to US$ 420,000, or R$175 per consumer monthly, equivalent to US$ 340, considering the materials replacement estimates.

Considering that the adopted management model can take care of the triple of households and that the high durability batteries as OPzS (5 to 10 years of useful life) are used, the pilot project could reduce the imbalance in 40%.

5.4.Energy Generation Costs

The foreseen energy generation cost and the optimized energy generation cost with high durability battery are presented in the graph below.

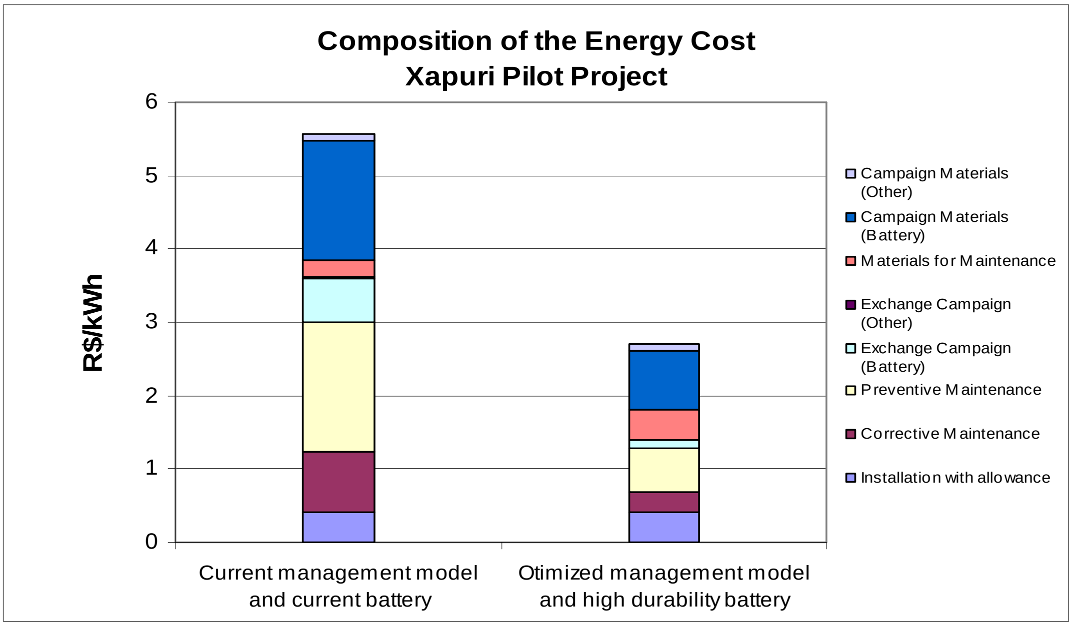

Figure A3: Trade and maintenance costs of the Xapuri Pilot Project

It is important to notify that the referring costs to the batteries are about 90% of the total materials replacement costs and 45% of the total O&M costs. Based on the evaluation of the battery installed in the project, it is estimated that the referring costs to the batteries would be

R$2.20/kWh, above the value of R$1.00/kWh if high durability battery is used. These batteries avoid the costs inherent to the replacement services.

The adoption of an optimized management model and the use of the high durability batteries, the project could reduce the energy generation cost from R$5.60/kWh to R$2.70/kWh, equivalent to US$ 10.90 to US$ 5.30, less than half of the current cost.

6. Conclusions

The main conclusions of the Xapuri experience with SFD:

→ The SFD adoption as a rural electrification way can reduce the fossil fuel consumption in isolated areas and reduce the energy expenses in R$ 7 until R$ 14 per month. There has been a significant decline in the usage of traditional lighting means, such as candles, kerosene, and diesel;

→ Great part of the consumers presented electric energy consumption very lower than the available electric energy. This corroborates the use of in direct current (DC) systems or mixing (AC + DC) systems, because the invertors would have low efficiency with low loads. So, the most important argument for the use of DC is energy efficiency and its subsequent reduction of system costs;

→ Today in Brazil, with average costs of about R$ 0.25/kWh for residential consumers connected to the grid, many energy efficiency measures become economically viable. Considering the costs of energy mentioned above, energy efficiency becomes a critical point and compulsory in design and usage of SHS. The adoption of an optimized management model and the use of high durability batteries could reduce in about 50% the energy generation cost of the Xapuri SHS;

→ According to the experiences of the project, the remote areas and the difficult access become the O&M costs higher. The management model with a well trained local staff is very important to successful of any project;

→ Given these high O&M costs of the isolated systems and the perspective of the universal access to electric energy service it becomes essential grants and subsidies for these costs;

→ As a project outcome, some suggestions were presented to the ANEEL regarding the current regulations for decentralized energy generation systems, and more specifically Solar Home Systems. The suggestions are based on the results of the Xapuri Pilot Project, where only Solar Home Systems were applied, as well as further results from other projects and international norms. A revision of the current rules is worthwhile considering that a major participation of Solar Home Systems is expected within the Luz Para Todos program for remote and isolated areas.

7. References

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