Study of the Availability of Alternative Electricity in Communities of Costa do Parú - PA

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Abstract

This paper addresses electric power as a relevant factor in the development of a region. For this reason, it highlights the importance of electricity in hard-to-reach communities, since the absence of electricity impacts the economic, social and political aspects. Aiming at rural electrification of low-income and isolated communities, the federal government created the Luz Para Todos program, since access to public energy is the right of the Brazilian citizen and social exclusion is vetoed by existing laws in the country. In this sense, the main objective of this study is to find a possible viable alternative for interconnecting the Costa do Parú communities to the local utility. For this, an analysis of the communities will be done to map the real conditions that portray importance and the necessity of the use of electricity among the families of the community. In addition, a survey will be conducted with the local utility about the Light for All program for the region. A model of photovoltaic system for the region will be elaborated based on surveys made with companies operating in the solar energy area. In the development of the research, it was found the various ways used in the Light for All Program to bring electricity to hard-to-reach regions, as well as the difficulties presented by the community for direct interconnection by the local utility. Relevant results were obtained about the real electric power conditions of the families. Based on this, a photovoltaic system model was designed for a possible LPT project that would meet the local needs of families. It is proposed that the maintenance of the off grid photovoltaic system be carried out by the local power utility.

Keywords: hard to reach communities; rural electrification; photovoltaic solar energy;

1. Introduction

Electricity is a relevant factor in the development of a region. Communities with difficult geographical

access may be delayed in their development due to unavailability of electricity, which impacts many aspects that are essential for any society, such as its economic resources, infrastructure, education and entertainment. The Federal Government has created a program called Luz para Todos, which aims to bring electricity to regions without access [1]. Although many states and municipalities have been covered by the program, there are still many regions where there is no forecast, such as the Costa do Parú Communities. From the location of the communities, it can be observed that there are some challenges for this energy to reach the place.

Electricity brings many benefits to the classes and societies affected by it. In an undeveloped rural community, the presence of electricity would represent an achievement and a new era to be lived, where the region's progress and development would gain space and incentive, as electricity is the fuel for growth in any region. , city or country [2]. In this sense, it is essential that this proposal can be carefully analyzed. Renewable energy plays an important role in accessing electricity in isolated regions, where due to technical or even financial difficulties, it is difficult to bring the grid through off - grid projects [2]. There are many families in rural areas who have been adopting this system because of the benefits it has, despite its high cost.

The present work aims to present a viable possibility of interconnection of riverside communities to the local energy concessionaire, describing the main existing ways of interconnection to the public electricity service, assessing the difficulties encountered in bringing electricity to the local. Despite the forms of interconnection presented, a photovoltaic system model is proposed for Costa do Parú communities including costs based on local needs.

2. Theoretical Referential

2.1 Energy

Energy can be defined as the ability to do work [3]. Energy causes changes in matter and, in many cases, irreversibly. Electricity is the most widely used form of energy in the world. It can be obtained in many ways, but the main source comes from hydroelectric plants [4]. Electricity is fundamental in contemporary society and can be obtained from hydropower, nuclear, thermal, solar, wind and other renewable sources [5]. Electricity is easily transportable, has low energy loss and is essential for the operation of machines, appliances and equipment in general [6]. The viability of electricity refers to all the situations in which it is used.

Guaranteeing access to electricity is a basic right of the population and should be offered by the government. The universalization of electric energy is not implicit in the decrees, ordinances and laws. Therefore it is understood as part of mandatory provision by the concessionaires, according to art. 175 of the Federal Constitution and Article 6 of Law 8.987 of 13/02/95 [7].

Another law that guarantees access to electricity is Law No. 9,074, which vetoes social exclusion, including from rural people [7]. On July 29, 2003, ANEEL (National Electric Energy Agency) established Resolution No. 223 aiming at general conditions for the elaboration of the Electricity Universalization Plan, establishing the responsibility of public utilities and electric power distribution concessionaires [7].

The Light for All Program (PLPT) has as its main objective to expand the grid in isolated regions with a

reduced budget [8]. This program promotes social and digital inclusion [8].

2.2 Photovoltaic Solar Energy

Photovoltaic solar energy, in turn, consists of the direct conversion of sunlight to electrical energy due to the so-called photovoltaic effect which consists of a potential difference in the ends of the semiconductor material produced by the absorption of light [9]. A photovoltaic system has four basic components: photovoltaic panel, charge controller, inverter and battery bank. While an off grid system requires batteries and charge controllers, on grid systems only work with panels and inverters as they do not need to store energy [9]. Solar Panel - Considered the most important part of this system. It acts as the heart due to the ability to carry energy to the system.Charge Controller - Serves to prevent overcharging or excessive discharging of the battery, thereby extending its battery life. Inverter - It is responsible for the transformation of the electric energy in direct current (DC) to the alternating current (AC). Batteries - Work on storing electricity so that the system can be used when there is no sun.

3. Methodology

3.1 Study area

The object of study of this research is the Communities of Costa do Parú, a floodplain region, located near the municipality of Óbidos, in the western state of Pará. In the region, there are approximately 150 families. These communities are not interconnected with the public energy service. Thus, to improve the quality of life and entertainment, many people have opted to use gasoline and diesel engines to generate electricity in their homes. There is a minority that uses solar energy. Despite the mobilization of people to join independent electricity, there are still families who do not have access to any kind of electricity in their homes.

In addition, geographic data of the region will be collected as: the distance between Óbidos and the region, depth of the rivers present in the Óbidos - Parú path, among other data.

3.2 Data collect

Based on many years of experience in the region, an analysis will be made of the communities to map the real conditions that portray importance and the need for the use of electricity among the families of the community.

A survey will also be made at the local utility to obtain data regarding the utility's forecast electricity supply, so that data such as forecast, cost, connection challenges, existing and possible forms of interconnection or supply of electricity can be collected. energy.

Information gathering related to the supply of electricity to rural areas will also be obtained through access to books, articles, websites such as MME (Ministry of Mines and Energy) and Local Concessionaire, as well as through the Operation Manual - Light for All Program 2018/2022 [10].

Based on the realization of the daily needs of families regarding the use of appliances and electronic devices, an off grid photovoltaic system model will be elaborated to meet the energy demand of the homes;

A survey will be made of the possible cost for the installation of the photovoltaic system through budgets and market research.

4. Analysis and Discussion of Results

According to the survey, it is found that for a community to have access to the public electricity service is essential to participate in the National Program for Universalization of Access and Use of Electric Energy - "LIGHT FOR ALL", since its social characteristics social and geographical aspects are in line with items I, II and IV of the first article first of article 7.520 of July 8, 2011, which emphasizes whether the program objectives are rurally electrified. Beneficiaries include low-income families enrolled in the federal government's Single Registry of Social Programs, families with beneficiaries of government programs that use social and economic development objects, and schools, health clinics, and water wells [11]. It is important to highlight that or decrease 7,520 of July 8, 2011 was changed by Decrees 8,387, of December 30, 2014, 8,493, of July 15, 2015 and 9,357, of April 27, 2018, the last business problem. by the Light for All program by 2022 [12]. Families residing in the region fall within these items.

For interconnection to the public utility of Light For All (LPT) are known some ways used for this process performed according to standards set by the utility, which designs the best system to meet the region according to geographical and economic characteristics. Such system models have already been used in other works of the Light for All Program (PLPT) as can be seen.

In Amazonas, to serve the municipalities of Autazes, Barcelos, Beruri, Eirunepé, Maués and Novo Airão through PLPT, Eletrobrás Amazonas Energia implemented the project of 12 mini photovoltaic plants with powers ranging from 9.6 kWp to 16.8 kWp to service 222 households through purely photovoltaic power generation systems and mini distribution grids [13].

In 2007, Eletrobrás Distribuição Acre in partnership with the government and the PLPT State Management Committee developed the Xapuri project to serve about 100 families living in the Chico Mendes Extractive Reserve, in the municipality of Xapuri, Acre [13]. The project consisted of the implementation of individual photovoltaic systems, which can be considered an alternative to the region under study, since the incidence of solar irradiation is considered very high during the year.

Another project developed to serve PLPT communities was the Araras project. The Araras project was developed by CELPA (Power Plants of Pará) in partnership with the Inter-American Institute for Cooperation on Agriculture (IICA), whose objective was to evaluate a sustainable rural electrification model using decentralized generation systems with renewable energy sources and distribution. by mini networks. It serves 80 consumer units of the Araras archipelago in Marajó Island. The project was carried out using three collective photovoltaic systems and one collective hybrid system [13].

In addition to such known processes, one of the alternatives for connecting remote areas is decentralized generation. In the Special Projects Manual, some technological options are considered. These include: Hydroelectric Mini-Central; Micro hydroelectric power station; Hydro kinetic systems; Biofuel or natural gas power generation systems; Photovoltaic solar energy generation systems; Aero Generators and Hybrid Systems resulting from the combination of two or more of the following primary sources: solar, wind, biomass, hydro and / or diesel [14].

An alternative also to bring energy to the community that is separated from the city by the river is the option for underwater cables, a technique used in the state of Pará, Marajó Island, to bring energy to Ponta de Pedras, Soure, Salvaterra, Cachoeira do Arari, Santa Cruz do Arari, Anajás, Chaves, Afuá, São Sebastião da Boa Vista and Muana [15].

The Costa do Parú region never had in its existence any project of public energy services for its communities Our Lady of Graces, New Core and Sacred Heart of Jesus. The household composition of the communities is approximately 70 families, 20 families and 60 families respectively. According to the data obtained from Google Maps, it was found that the straight line distance from the municipality of Óbidos - PA to the region is 39 km as shown in figure 1. However, taking into account the curves of the earth to To get to the place, the approximate distance is 42 Km. The region where the island is located is separated from the city of Óbidos by the Trombetas River. Within the communities of Our Lady of Graces and New Core, there is a river called Paraná Salvador. In late July 2019, the depth of this river was measured and the result was 13.76 m in the deepest part and 11.27 m in the lower part. To measure river depth, a twisted Nylon Mazaferro 210/018 25 kg (400m) wire was used to support a 16 kg stone.

Figure 1 - Straight line distance from Óbidos to Costa do Parú.
Source: Google Maps, 2019.

There is currently no PLPT project record with the local utility for such communities. Residents who do not have public energy should contact their local utility to register their request. The concessionaire advises that in cases of regions such as this, it is essential that a local representative make a document with data of interested residents, requesting the interconnection of their residence to the public energy service to participate in the Luz Para Todos Program. The representative must follow the process that will be reviewed by the Steering Committee. The role of the concessionaire or permissionaire in this scenario is only of executor [16]. In July 2019, a community representative was collecting data from interested residents to take to the local dealership agency located in Óbidos. Based on figure 2, we observed the positioning of families on the adhesion of electricity on their own in case of no public energy in the coming years.

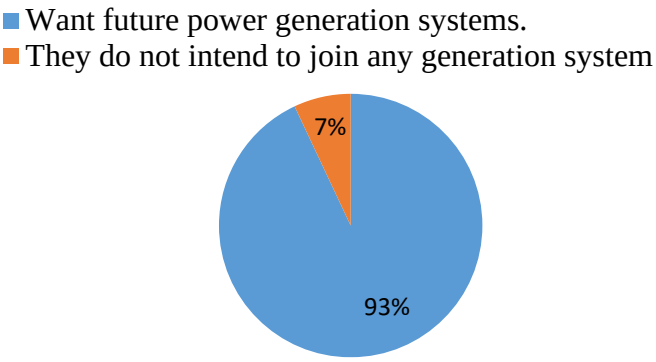

Figure 2 - Adherence to power generation systems.

For the realization of public electricity supply there are some obstacles that can be encountered. They are: high flooding in the region and areas of land affected by erosion with the risk of disappearing. The river begins to flood in November, the ebb period is usually in June. In case of a possible public electrification project for the region, a viable alternative is the generation of photovoltaic solar energy. The region has high incidence of solar radiation as described in figure 3, which allows a good use of this type of system. The solar radiation simulation was performed by the Solar Finger Resource website using a NASA database with surface spatial resolution of about 100 km x 100 km [17].

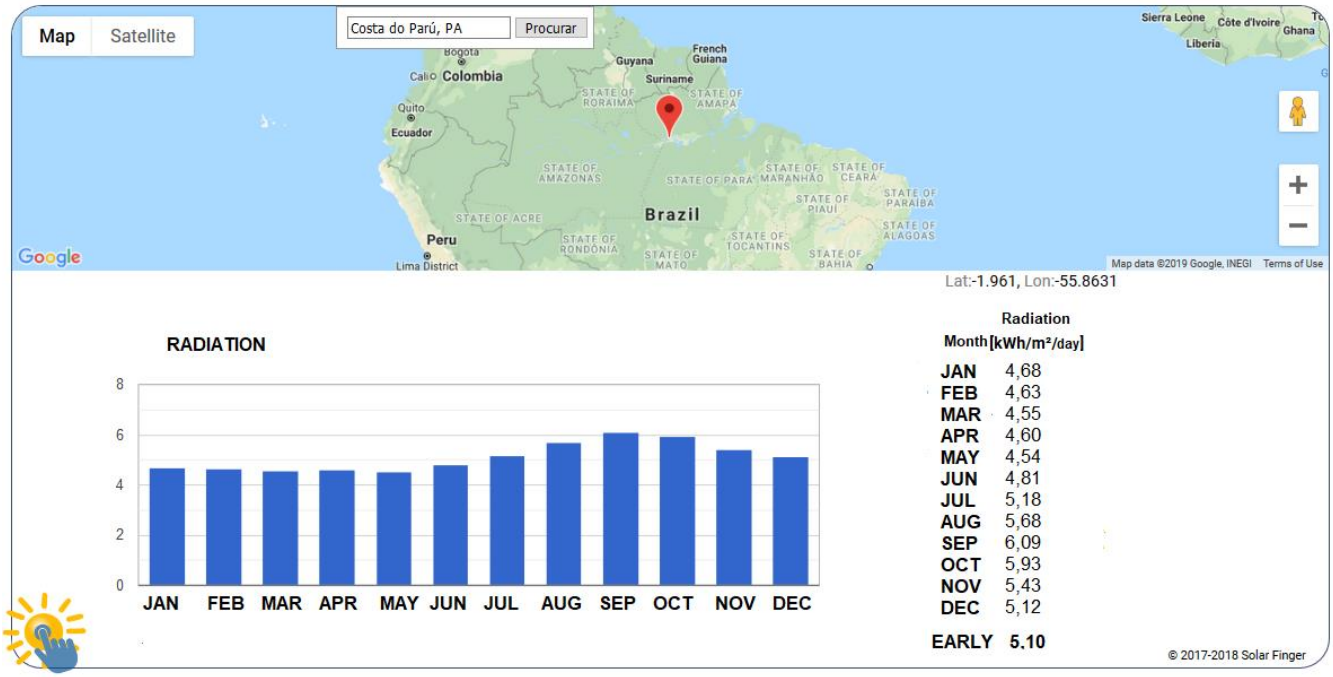

Figure 3 – Solar Radiation Levels in Costa do Parú.
Fonte: Solar Finger Resource, 2019.

As can be seen in Figure 4, it was found that most households that do not have access to energy intend to adopt such a system in case of no public electricity in the region in the future, due to the absence of the monthly cost that solar energy photovoltaic does not present when compared to other sources of electricity generation.

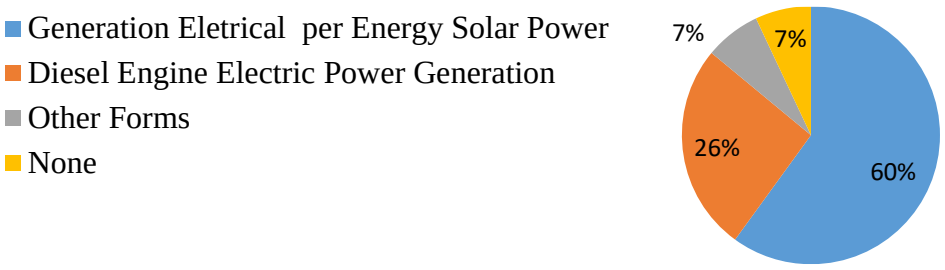

Figure 4 - Future use of power generation systems.

The forms of electric energy are among the main forms known by the community. Currently, as shown in Figure 5, households that have their own energy constitute the following power generation systems:

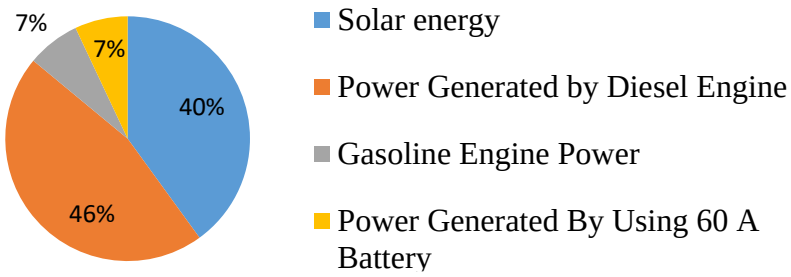

Figure 5 - Electric Power Generation.

However, for many years of experience in the region, it is known that the generation of own energy has changed. When community dwellers began to build their own generation systems, there was only one home that had photovoltaic panel generation. From 2017 - 2019 there was a growth in the use of solar energy. It is observed that 40% of people who have energy already use the Off Grid photovoltaic system today, and some people who have power generated by diesel or gasoline engine intend to switch to solar photovoltaic power generation in the coming years. One of the factors for the change is the cost. Based on a study done, it was observed that to use a gasoline engine for power generation, from 18:30 to 20h, 1 liter of gasoline is consumed, which implies a monthly cost of approximately R $ 150,00/month. During this time, the electronic equipment used is the television, usually 3 cell phones that are plugged in to charge and, on average, 3 lamps. In 2019, the cost of the systems used by households that have their own electricity can be seen in figure 6.

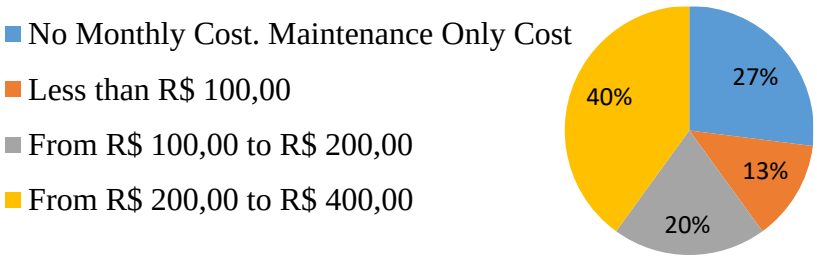

Figure 6 – Cost to maintain standalone generation systems.

The use of solar photovoltaic technology reduces these costs, despite having a high price for its implementation. After the deployment of an off grid photovoltaic solar system, the expected cost is maintenance of the system, since the durability of such a system is 25 years, except for batteries.To meet families, we propose a basic model of Off Grid photovoltaic system for homes, which in case of a possible rural electrification project by LPT, it can be adopted. The proposed system model is described in table 1 below. It is stated that the system designed has as its characteristic to meet the profile of families. The adopted model aims to meet essential services.

Table 1- Alternating Current Loads for a Costa do Parú Community Residence.

Amount	**Description**	**Power(W)**	**Daily Use Time**	**Weekly use**	**Daily intake (Wh/day)**
1	Television	380	8	7	3.040,00
5	Led lamps	20	4	7	400,00
4	Sockets	100	2	7	800,00
1	Refrigerator	300	12	7	3.600,00
1	Water pump	368	1	7	157,71
1	Satellite Dish	300	12	7	2.400,00
Alternating Current Consumption					**11.153,02 Wh/day**

Based on the calculations performed and a survey made with companies that work with solar energy, it was found that the off grid photovoltaic system that meets the described consumption must constitute the following structure: 16 330 W Photovoltaic Panels, 14 105 A Stationary Batteries, 1 Inverter with 2640 W to 3696 W power, 1 Charge Controller that supports an input current of 182.8 A, 48 m of Black Cable, 48 m of Red Cable, 1 Male and Female Connectors and 1 Fixing Kit.

The partial total value of the investment for a residence is described in table 2. For labor, the reported value is based on the actual percentage charged against the value of the material. There are many companies that work with 35% of the value of material for the workforce. Depending on the geographical location of the area where the service will be performed, transport, accommodation and food costs will be added.

Tabela 2 – Material and Cost Survey

Amount	**Description**	**Unitary value**	**Amount**
16	Photovoltaic Panel 330 W	R$ 700,00	R$ 11.200,00
14	Stationary Battery 105 A	R$ 1.142,00	R$ 15.998,00
1	Sine Wave Inverter	R$ 2.500,00	R$ 2.500,00
1	Charge Controller	R$ 1.700,00	R$ 1.700,00
1	Fixing Kit	R$ 100,00	R$ 100,00
16	Male and Female Connectors	R$ 16,00	R$ 256,00
48m	Black Solar Flex Cable 6mm	R$ 3,00	R$ 144,00
48m	Red Solar Flex Cable 6mm	R$ 3,00	R$ 144,00
Labor Value			**R$ 11.211,20**
Total Amount of Service			**R$43.243,20**

To serve 150 families, the approximate cost will be R$ 6.486.480,00 without the calculation of BDI (Indirect Benefits and Expenses). The area to be occupied for installation is 40, 35 m^2. The monthly generation of electricity is 670,50 kWh / month. The power of this system is 5,28 kWp.

5. Conclusion

Given the above, the various forms of rural electrification of communities by the LPT were verified, as well as the challenges for the electrification of the region. During the years of PLPT's existence, many cities have already been contemplated, which has helped to improve the lives of many people. Since its initial project, the LPT has been undergoing changes and the program deadline has been extended because there are still many communities without access to the public energy service. It has now been extended until the year 2022.

The importance of the management committee as well as the community representative in PLPT projects is emphasized, since it is the management committee that analyzes the feasibility of the work and the representative monitors the development of the process. Although reports from residents of Costa do Parú communities about the request for electricity were made in other years, it is not known if there was follow-up.

In response to the interests of the communities under study, this work proposes a basic model of off grid photovoltaic system that could be adopted and implemented in case of a LPT project for the region. In addition, it is suggested that the maintenance of the proposed off grid photovoltaic system be performed by the local utility, ensuring the operation and continuous use of the system, since the resident families are low income families, the salary they have is directed to your livelihood.

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