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ECONOMIC VIABILITY OF ALTERNATIVE SOURCES OF ENERGY FOR A TYPICAL COMMUNITY OF THE REGION NORTH AND NORTHEAST OF BRAZIL

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ABSTRACT

The objective of this work is to perform a study of viability of alternative energy sources for typical communities of the North or Northeast of Brazil, which do not have access to the electric energy. Brazil presents a great economic and social disparity among its several regions. There are several poor communities, mainly in regions far from big cities, without electrical energy. The Brazilian government has a program known as "Luz para Todos" (Light for All). The big challenge for this program is to bring electrical energy for everyone using new alternatives energy sources. In this work initially a literature review was made concerning the following alternative energy sources: wind, solar and biomass. These energy sources can be used to supply the demand to bring electrical energy for poor communities. For this work it is intended to choose a community that has population between 1,000 the 10,000 and does not have access to electrical energy. For this community an economic viability study will be made to evaluate alternative energy sources. The best energy source resulted from the point of view of the economic viability study will be implemented in that community. A new study will be performed to evaluate cost and environmental impact. In this new study the future social development of the community caused by the installation of electrical energy will be considered. Also, this best energy source will be compared with the new generation of nuclear reactors, for instance, the IRIS reactor.

1. INTRODUCTION

One of the great challenges of the Federal Government, besides preventing the crisis of supplying from 2013 is to take the electric energy to all Brazilian population. The objective is to decrease the electric exclusion in the country, mainly situated in the areas of lesser Index of Human Development (IDH) and in the families of low income.

The electric energy would be the vector of social and economic development of these communities, contributing for the reduction of the poverty, increase of the familiar income, integration of the social programs of the Federal Government, beyond the access to the services of health and education.

For this challenge the Federal Government launched the Program Light for All [1] that has as objective to take electric energy for more than 10 million people of the agricultural regions until 2008. The Program is co-coordinated by the Ministry of Mines and Energy (MME) [2], with the participation of “Eletrobrás” [3], and associated companies.

The Brazil Electric Matrix, Fig.1 [4], has 75.7% of energy generated by hydroelectric, and this value is increasing. Therefore, from the Government point of view, this kind of energy would be the most feasible solution in order to supply the demand and to fulfill the Plan of Acceleration of the Growth (PAC) [5]. Perhaps this solution is not possible in short time, due governmental process and the ambient licenses necessaries to prevent risks.

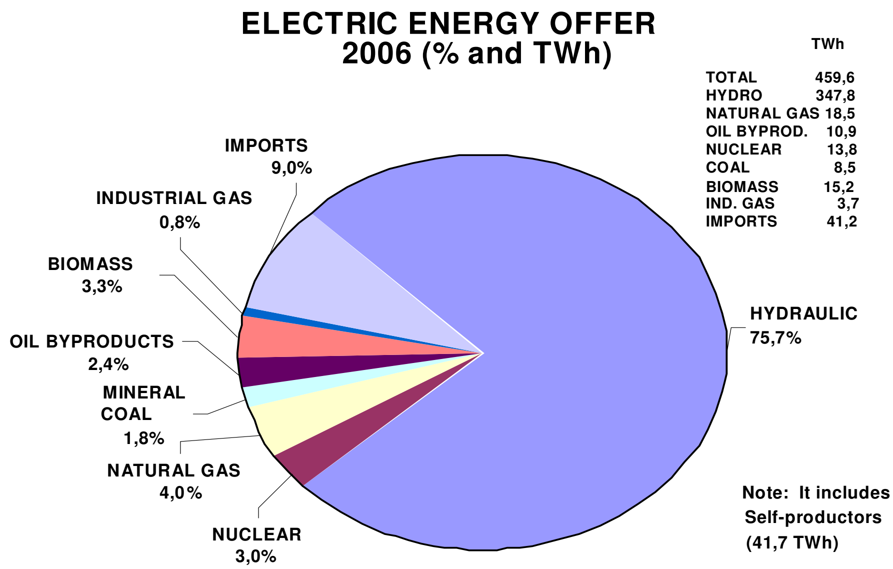

Figure 1. Energy offer (2006).

Additionally, the most important is to guarantee the energy supply continuity, that is, its sustainability. This scenario of sustainability is possible through energy planning policy that has the objective to promote better energy efficiency and the use of alternative energy sources, for example, biomass, aeolian and solar. This will make possible: job opportunities, nature preservation and pollutant emissions reduction.

Due to the necessity of the rational use of energy and solutions using technological innovations, the use of alternative energy sources was considered, because they preserve the environment and guarantee the sustainability. Among these kinds of energy sources, the nuclear energy is also being considered, since it has an appropriate planning and waste radioactive precautions.

The objective of this work is to study feasible projects using alternative energy sources to small typical Brazilian communities, specifically to Maranhão State located in the Northeast region. This state was chosen because, according the MME, it has a great amount of domiciles without electric energy access.

In order to reduce the extension of this study, three forms of energy generation had been chosen: aeolian, solar and biomass. These three types will be compared with nuclear energy. However, during the development of this work, other kinds of energy generation can be considered.

2. DEVELOPMENT OF THE WORK

2.1. Methodology

This work is being developed in three stages, because there are vast and rich referring literature related to the subject that will be applied in the government program "Light for All".

In the first stage a study of the country was made and a state with low development was chosen.

The estimated cost of this program is around R$ 7.4 billion, with R$ 5.4 billion from federal government resources and the remaining will be shared between the states and agents of the sector.

The installation of the electric energy until the domiciles will be gratuitous for the low income families with consume lower than 80kWh/month. For the remaining domiciles the tariffs will be reduced, according to the legislation. To supply the existing demand, the government will also count on the alternative sources of energy as, for example, the aeolian, the biomass and small hydroelectric central, with the estimate of generation of 1,100MW of each source. Ahead of this challenge appeared the motivation of this study, in order to facilitate the viability of projects for small communities.

The chosen region to become a feasibility study of energy was the northeast Region. The choice was made from the literature review presented in this work. Fig.1 shows that the main energy source in Brazil is hydroelectric plants and in second place the thermoelectric. The Northeast region, due to its climatic conditions, could generate electric energy by other sources as suggested in this work. In this work a Data base was detailed and structuralized with information of the following sources: Brazilian Institute of Geography and Statistics (IBGE) [6], “Eletronorte” [7], “Cemar” Energy Company of the Maranhão [8], Project Light for All [1], Map of the Human Development [9], Program of the United Nations for the Development (PNUD) [10], Map of Electric Energy [11] and City of the Maranhão and cities [12], where they are view the following:

- Survey of the towns without electric energy;
- Description of the locality: it is referred as a “submunicípio” (small town);
- Social situation of the locality, for example: “povoado” (town), “Quilombola” (typical community of slaves’ descendants), etc;
- Survey of the number of domiciles in the agricultural region: sum of the domiciles for locality that do not possess electric energy;
- Total population of the locality: sum of the population for locality without electric energy;
- Population of the town: total population of the town;
- Area territorial in km^2: area of each town;
- Distance to the capital in km: total distance of the city until the capital; in km;
- GDP: Gross domestic product of each town;

- Vegetation: survey of the type of vegetation of the region;
- Relief: type of soil in the region;
- Climate: type of climate in the region;
- IDH 1991: Index of human development in 1991 of the towns; and
- IDH 2000: Index of human development in 2000 of the towns.

Table 1. Profile of Maranhão "municípios"

"MUNICÍPIO"	SOCIAL SITUATION OF THE PLACE	TOTAL POPULATION	TERRITORIA AREA Km^2	DISTANCE TO THE CAPITAL Km	GDP (2004) AVERAGE PRICES (1.000,00 R$)	IDH 1991	IDH 2000
104	4 "GAMBIARRA"	590,175	103,637	25.18 to 753.05	6,7 to 177,03	0.366 to 0.597	0,492 to 0,681
	2 "ASSENTAMENT(						
	1 "QUILOMBOLA"						
	372 " POVOADO"						

3. RESULTS

The results obtained in this research had generated a Data base that possess 5,460 registers referring to 180 towns and 1,140 "submunicípios", without electric energy. It was adopted as analysis' criterion the "submunicípios" that have between 1,000 and 10,000 inhabitants in the agricultural area. Table 1 shows the information that are condensed to be used with more easiness.

Analyzing Table 1, it can be concluded, of macroscopic form, that the physic/economic profile, of the supplied example is the following:

- There are 104 cities in the state of the Maranhão without electric energy. The social situation of these cities are divided in: 4 "Gambiarras" (illegally used energy), 2 "Assentamentos" (small group of people that are in an area without infrastructure), 1 "Quilombola" and 372 "Povoados", totalizing a population of 590,175 in habitants;
- The territorial area of these cities is of 103,637 km^2;
- The distance of the cities to the capital varies from 25.18 to 753.05 km, being 50% of the total more than the 200 km of distance, where exist 176 towns and 293,722 in habitants;
- The GDP (average prices of 1,000 Reais) varies between 6.7 the 177.03; and
- The IDH in 1991 varied between 0.366% and 0.597%, and in 2000 between 0.492% at 0.681%, where the highest percentage is given by the cities next to capital. It is verified also that even without electric energy the IDH had a significant increase during this period in this region. Certainly the increase of the GDP and the IDH will be more significant when these towns will have electric energy and thus to be socially included.

The characteristics of vegetation, relief and climate of the analyzed region, are described as follows. These information are in the Data base, that has been elaborated:

- The vegetation is constituted of:
  - "Cocais": Characteristic vegetation of the Maranhão where it predominates "babaçu" and "carnauba", has covered the central part of the State;
  - "Campos": next to the "Golfão" Maranhense it has as characteristic the flooding herbaceous vegetation by the rivers and lakes in the low region of Maranhão;
  - "Mangues": they predominate in the Maranhense coast between the River "Gurupi" and the River "Periá"; and
  - "Cerrado": predominant vegetation in the Maranhão that is formed by trees of average high and low vegetation.

- The relief possesses reduced altitudes and regular topography, presents a relief with about 90% of the surface below 300 meters.

- The Climate of the Maranhão west is in the equatorial climate region with high levels of rains and temperatures. However, in the biggest part of the State, the climate is tropical with rains distributed in the first months of the year.

The second stage of this work was to make a macroscopic survey of the possible sources of energy to be used in the towns of Maranhão, as it was previously mentioned.

The three alternative sources of energy chosen in this work and the most suitable to this region are described as follow [13]:

- **Aeolian**: Aeolian energy is renewable and has very low environmental impact. To generate it, there are no gases emissions, no effluent refuse, and no other natural resources, such as water, are consumed. To have an idea of soil occupation, the equipment occupies 1% of the aeolian power plant's area, while the remaining portion can be used for crops or pasture, and no trouble is caused for animals or plants. People can live as close as 400 meters to aeolian plants without being disturbed by their noise. In fact, in Denmark, farmers have aerogenerators installed right next to their homes. A major impulse for aeolian energy will be the redemption of the carbon equivalent credits resulting from the production of clean energy compared to the same amount of energy produced using fossil fuels.
- **Solar:** The solar energy is a process through which it is transformed in electric energy through a photovoltaic module, with no intermediary mechanical devices. Thermal energy is already used to heat water in homes and commercial facilities in several Brazilian cities. This source of energy is highly beneficial for society, as it allows for electric shower substitution and for a reduction in oil byproduct consumption. Photovoltaic solar energy is used in niches where its high costs are balanced out by the benefits allowed for by the reduction in energy supply logistics, usually in remote locations.
- **Biomass:** is the generic denomination for materials of vegetal or animal origin that are used as a source to produce heat or electricity. Technologies are gasification, pyrolysis, and developing hybrid systems to generate energy, such as using biomass complemented by natural gas. Historically, firewood has been the biomass that has been used the most for energetic purposes in Brazil. In addition to it, other materials take the spotlight.

Additionally it was made a study related to a new generation nuclear power plant, reactor IRIS, which is described as follow:

- **IRIS:** Salient features of the International Reactor Innovative and Secure (IRIS) are the following: IRIS, an integral, modular, medium size (100 - 335MWe) PWR, has been under development since the turn of the century by an international consortium led by Westinghouse and including over 20 organizations from nine countries. Described here are the features of the integral design which includes steam generators, pumps and pressurizer inside the vessel, together with the core, control rods, and neutron reflector/shield. A brief summary is provided of the IRIS approach to extended maintenance over a 48-month schedule. The unique IRIS safety-by-design approach is discussed, which, by eliminating accidents, at the design stage, or decreasing their consequences/probabilities when outright elimination is not possible, provides a very powerful first level of defense in depth. [14].

Table 2 shows in summary the main characteristics of each one of these alternative energy sources and also presents the advantages, disadvantages and the environmental impact of each one of them.

Table 2. Summary of the alternative energy sources

	DESCRIPTION	ADVANTAGES	DISADVANTAGES	ENVIRONMENTAL IMPACT
AEOLIAN	ENERGY GENERATION BY THE WIND	IT DOESN'T EMIT GASSES THAT INCREASE THE GLOBAL HEATING AND THEY CAN BE INSTALLED IN ISOLATED PLACES	IT DEPENDS IF HAS THE WIND TO WORK AND IT HAS HIGH COST	IT HAS PROBLEMS WITH SOUND, VISION AND INTERFERENCE IN THE COMUNICATIONS
SOLAR	ENERGY GENERATION BY TRANSFORMATION OF THI NATURAL LIGHT IN ELECTRICITY	IT DOESN' T NEED OF LINES OF TRANSMISSION IN ISOLATED PLACES	HIGH COST AND LIMITED APPLICATION	STORAGE OF BATTERIES USED FOR PROVISIONING OF ENERGY
BIOMASS	ENERGY GENERATION BY MATERIALS OF VEGETABLE ORIGIN AS: THE PULP OF CANE-OF - SUGAR AND FIREWOOD	IT USES RENEWABLE SOURCES OF ENERGY	DESTRUCTION OF THE CURRENT NATIVE FORESTS FROM THE MONOCULTURE OF THE CANE AND IS LONG TO BEGIN THE PROCESS	AGGRESSION TO THE SOIL - BURNED
NUCLEAR	ENERGY GENERATION BY THE NUCLEAR FISSION	USA USES FUEL OF THE LOW COST, IT DOESN'T THROW CARBON GAS, IT DOESN'T DEPEND ON CLIMATIC FACTORS	RISK OF LEAK RADIOACTIVE AND HAS PROBLEMS WITH THE WASTE RADIOACTIVE	STORAGE OF THE WASTE NUCLEAR WHICH CAN CAUSE LEAK TO ENVIRONMENT

In the third stage it had been used two studies: the first is on the estimate of electric consumption in the agricultural area of developing countries /(G8, 2001)/, that was calculated around 50 MWh/month. This value corresponds to a 5 people family. This work adopted a consumption of 150 MWh/ month (three times), because it was considered a growth projection for the region. The second study was carried out by the Ministry of the Mines and Energy (June/2002), that considers the technical-economic characteristics of the possible energy sources to be used in the cited towns. For a community of 590 thousand inhabitants the necessary energy is of 25 MWe. Table 3 shows only the costs of installation for each one of the considered energy sources in this work.

Table 3. Technical/Economic characteristics of the energy sources

SOURCE	INSTALATION COSTS (US$/K W)	GENERATION COSTS (US$/MWh)	CAPACITY FACTOR (%)	CAPACITY INSTALATION (MW)
AEOLIAN	900 to 1,400	50 to 95	25 to 40	63 to 100
SOLAR	6,000 to 10,000	500 to 1,160	18 to 22	115 to 140
BIOMASS	700 to 1,000	45 to 105	45 to 85	30 to 60
NUCLEAR	700 to 1,200	80 to 90	40 to 85	30 to 60

However, considerate the installation costs, it has not been assumed the costs of the environmental and social impact, that would be significant to modify the values presented in Table 3. This complete analysis is part of the work of master degree that is being developed at IPEN-CNEN/SP.

4. CONCLUSIONS

The results previously obtained are still very precocious to choose one of these energy sources. Additionally studies of ambient impact and socioeconomic viability of the energy sources will be the complement of this work, which will be presented in the work of master degree of the student Silvia Vanni.

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