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Renewable energy generation for the rural electrification of isolated communities in the Amazon Region

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ABSTRACT

From 1999 to 2013, in a 14 years' period of time, rural electrification programs brought access to electricity to 16 million rural inhabitants in Brazil. Approximately 155,000 rural households remain without access to electricity in the Amazon Region, conforming very isolated communities that cannot be supplied by the expansion of the existing grid. To supply electricity to these communities, off-grid generation through diesel fuel has traditionally been the only option considered.

The Amazon Region has a huge potential in renewable energy, specially: hydraulic, biomass and biofuels, solar as well as wind in the coast. The Brazilian Government has started to consider the use of these local renewable sources for the electrification of isolated communities. Several experimental projects have been deployed, supplying electrical power through appropriated off-grid renewable energy technologies: run-of-the-river and hydrokynetic, biomass (direct burning or gasification), biofuels and vegetable oils, and hybrid (solar–wind–diesel). Regarding these technologies, the most significant projects conducted in the region were evaluated. Analyzing the costs, technical and social issues as well as the performance of these systems, after a 10 year's evaluation period, this paper shows that some renewable energy technologies have proven to be a more convenient and economic option than electricity generation through diesel, in these isolated communities.

Contents

1. Introduction

The United States pioneered in 1935 rural electrification programs for vast territories with the "Rural Electrification Act" which provided federal loans for the installation of electrical distribution

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systems to serve rural areas. By 1960, household electrification in USA had reached 99.0%.

USA had in 1920 the same percentage of population with electricity access that China had in 1970, Brazil in the end of the 70's, India in 1985, or South Africa in 1990, as shown in Fig. 1.

By observing the curve of household electrification related to Brazil, in Fig. 1, an interesting fact can be revealed. According to this curve, the electrification process of rural areas in Brazil passed from 45% to 93% in a period of fifteen years, starting in 1980. By 1995 rural electrification had reached a stagnation point, as the curve was limited by an asymptote of 93% of household electrification considering the whole country. This limit was caused by the difficult geographical conditions of the Amazon Region (Brazilian northern states), as well as the lack of specific rural electrification programs, which led the electrification initiative to utilities and private companies not interested in investing in undeveloped rural areas. Because of these reasons, around the year 1995, while most of rural areas in the South and South East parts of the country had already reached 99.0% of electrification rate, the North and Northeast Region remained with rates of 75% and 42% of household electrification [2]. It was not until 2000 that the stagnation point was surpassed. Since that year it can be observed a turnaround in the electrification curve, coinciding with the upcoming of specific, and ambitious, rural electrification programs by the Brazilian Government. In 2013, the electrification rate in Brazil had already reached 99.7%, with 3.3 million of people lacking from access to electricity [3].

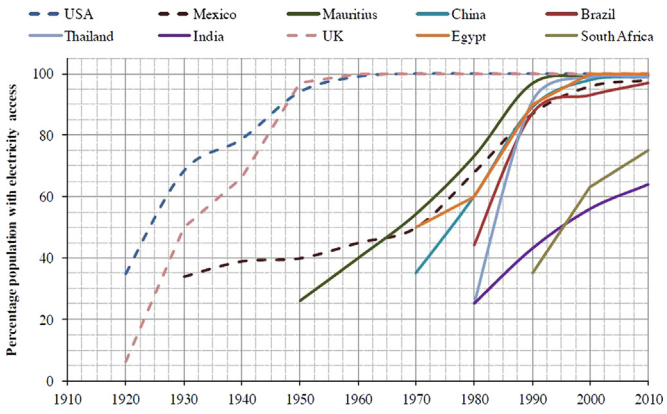

Fig. 1. Evolution of household electrification in different countries. .
Source: [1] (2010)

Between 1999 and 2002 a first attempt was made with a rural electrification program called "Luz no Campo" (Light in the Country), that gave access to electricity to 1 million households.

In the year 2000, a census revealed that 2 million of families lacked from electricity access in Brazil [4]. That census indicated that the number of homes without access to electricity in the Amazon Region was 770,000 resulting in a population of around 3.8 million people. Of these, it was estimated that approximately 615,000 households would be able to be powered via the expansion of the electrical network (on grid connection). From the remaining 155,000 households, 55,000 are extremely isolated and may be preferentially supplied by photovoltaic systems, while 100,000 were grouped in small villages able to be supplied by isolated mini grids.

In November 2003, the Federal Government of Brazil launched the "Luz para Todos" (Light for All) Program, trying to mitigate this situation. The Government stated that the energy would serve as a vector of social and economical development, contributing to poverty reduction and to the rise in the incomes of those families. As the program stated, "the arrival of electrical energy helps the integration of the government social programs, as well as the access of health services, education, water and sanitation" [2]. In several communities assisted, it was possible to implement a Production Community Center, which is a unity composed of machines and equipment for the process, storage, and conservation of farm products. With the increase in productivity, rural undeveloped communities can go beyond the subsistence agriculture with the sales of the production excess. Health assistance gets benefited as vaccines and medicines can be safely stored thanks to refrigeration. Also, education gets improved as electric inclusion guarantees digital inclusion. The linkages between development and rural electrification through the Human Development Index (HDI) within the context of the Amazon Region were analyzed by [5,6]. Fig. 2 shows that Brazil is a good example of how closely related are the access to electricity (measured as rate of service provided) and the human development rate.

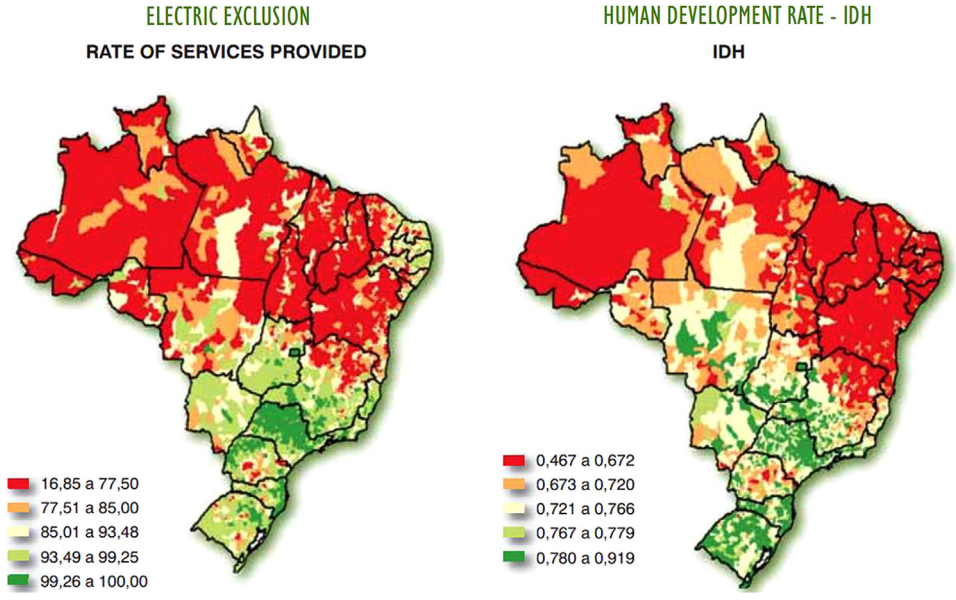

Fig. 2. Electric exclusion and human development rate in 2000. .
Source: [7] (2003)