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The need of subsidy for the implementation of photovoltaic solar energy as supporting of decentralized electrical power generation in Brazil

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ABSTRACT

The growing demand for electrical power and the limited capital invested to provide this power is forcing countries like Brazil to search for new alternatives for electrical power generation. The purpose of this paper is to present a technical and economic study on a 15 kW solar plant installed in an isolated community, highlighting the importance of the need for financial subsidy from the government. It evaluates the importance of parameters such as the annual interest rate, specific investment, the marginal cost of expanding the electrical power supply and the government subsidy on amortization time of capital invested.

Contents

1. Introduction

Considering the energy development into Latin America, a sector that requires further re-engineering is the electrical power distribution. The countries that make up this region, including Brazil, have a common characteristic, which is the presence of densely populated cities, some secondary urban centres and a considerable percentage of the population distributed in the countryside, in the midst of a difficult to access due to inhospitable geography.

According to [1], 15% of the Brazilian population (about 25 million people) live without access to electrical power. The majority of the population survives on low income and it is located in rural areas where the cost for access to wiring standard is quite high, with respect to the marginal cost of expanding the electrical power supply. Due to the country size, different geographic, social and cultural features suggest several regional solutions to meet the need of electrical power.

In small villages in the Amazon region, for example, electrical power is available through the diesel generator systems, which involve a very high cost associated with low service quality. The existing systems are operated by local public companies that rely with subsidy in the fuel through the CCC—a special account to pay for electrical power generation [1].

However, even with this subsidy that helps reduce the impact of the high cost of generation, studies show that the price of electricity ranges from 0.15 US$/kW h for megawatt scale systems operating 24 h a day, up to 0.50 US$/kW h in small towns where electrical power is provided only between 6 and 12 h per day [2].

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Besides the economic problems, environmental concerns are increasing in order to establish a strong control on emissions from the diesel generator systems. Thus, the development of local technologies for generating energy that do not harm the environment is encouraged, trying to avoid the construction of numerous power transmission lines.

As discussed earlier, it is necessary to solve the existing problem to meet the demand of electrical power in isolated communities, without harming the environment when creating large networks of transmission or generating volume of gases that contribute to the greenhouse effect. Therefore, it must search for alternatives more practical and convenient, where in general, the renewable energy sources are most suitable.

It is considered a renewable energy source, one that appropriately administered, allows its exploration is unlimited, that is, its amount does not reduce the available so far as it is used.

The main source of renewable energy is the Sun. The Sun sends to Earth only radiant energy, i.e., visible light, infrared and ultraviolet radiation. Without restrictions, this kind of energy provides a variety of effects on the atmosphere, some of which have direct importance as energy resources, such as wind energy, energy from biomass, the temperature difference, and the energy of ocean waves and tidal [3].

The hydraulic energy can also consider that this is a derivative form of solar energy, because the Sun comes the driving force of the water cycle. Without restrictions, traditionally is considered that source as an energy form apart [4,5]. This is the largest source of electrical power generation in Brazil. Associated with a large electrical power distribution system, it provides energy for most of the country, except for isolated regions as is the case with many communities located in the Northern region.

In this case, recent studies showed that the use of hybrid diesel/photovoltaic power generation in isolated communities can be an alternative. Focusing on the North Brazilian region, where a significant number of plants have installed capacity of less than 100 kVA, it has shown very positive results from a combination of photovoltaic systems with diesel (hybrid system) [2]. However, despite its advantages such as low fuel consumption and operating costs, using the hybrid system is still unsatisfactory since the initial investment required is much higher than that of a system for diesel.

A recent study of technical and economic feasibility of an isolated system hybrid diesel/photovoltaic for the implementation of a plant with capacity of 300 kVA and peak load at night was present by [6]. It was shown that the current market price, the option of a hybrid system requires investments partially subsidized on the order of 60% or more to obtain rates of return of 12%. However, interest in this new technology increases significantly as the price of diesel oil tends to increase and the acquisition costs of photovoltaic (PV) systems tend to decrease.

According to [7], the Latin American market for photovoltaic solar energy tends to grow substantially, because the pressures to reduce global emissions, the government of some countries, like Mexico, have assessed a short-term plan to invest in the complete replacement of LPG (liquefied petroleum gas) used in homes in large urban centres such as the metropolitan area of Mexico City.

Many authors had studied several technological aspects of photovoltaic power generation systems, such as [8–10] and they had studied a solar PV/diesel hybrid system [11]. Also economic and environmental feasibility aspects had reviewed in some works, such as [12–15]. Energy policies for photovoltaic power systems had studied in [16–18].

This work aims to complement a study on the economic feasibility of a micro photovoltaic facility generating 15 kW to meet the needs of electrical demand in a rural community [19]. This facility is composed of solar photovoltaic panels that may or may not be connected to the local power grid through DC/AC converters. The real need of subsidy for acquisition of system components is evaluated since the power generation facility allows a great social benefit from a technological advance provided in terms of reduced maintenance and operational costs, compared to existing technologies available in the market, to ensure minimum quality of life for the population of an isolated rural community in terms of access to electrical power.

2. The photovoltaic solar system

Considering all the new ways to generate electrical power, the use of solar energy for it has gradually presenting itself as an important alternative, economically viable and environmentally accepted, well suited for isolated areas, where costs for installation of conventional systems are relatively high.

Photovoltaic systems are characterized by high reliability and low maintenance, with its high initial cost often offset by low operating cost. Through the photovoltaic effect, solar cells contained in the panels convert the sunlight energy directly into safe, non-polluting, renewable electrical power and still requiring minimal maintenance.

Photovoltaic solar energy is defined as a renewable energy source obtained by the conversion of solar light energy into electrical power. A typical system of photovoltaic solar energy consists of three basic elements: photovoltaic modules, charge controllers, and the batteries, when necessary.

The modules consist of the photovoltaic cells, i.e., the surfaces that generate electricity, which directly convert solar energy into that one. These surfaces have no moving parts that wear out or suffer breakdowns and work without the use of fuel, without vibration, silently and without harming the environment. But the charge controller is a device of fundamental importance to preserve the batteries, increasing its useful life.

Recently, in addition to solar photovoltaic systems coupled to batteries, also called autonomous systems, other systems have been used to direct interconnection to the public electrical power grid, such as occurs in parallel with generating plants. Thus, the use of accumulator systems (batteries) is exempted, with benefit in reducing the investment cost of the system. This physical connection to the electrical power grid is very good explained in [20,21].

With the growing interest in premises connected to the electrical power grid, where voltages of 110 or 220 V are used, it becomes necessary to use an inverter system, responsible for converting the energy generated by photovoltaic panels (which generate electricity in direct current—DC) into alternating current—AC, also in voltage levels and frequency of network, with low-harmonic and sinusoidal shape wave [20–22].

The components have been explained through researches around the world. Several aspects have been developed, such as simulation, modelling, and design procedures of solar heating and cooling systems, and photovoltaic systems, also development of surface materials for solar cells [23–38].

Photovoltaic solar energy has been extensively applied by countries like Germany, Japan, and the United States, because they have the support of programs aimed at increasing the scale of production of photovoltaic panels and thereby reduce costs for mass production of the current values of about 4.00 US$/Wp to 2.50 US$/Wp by the year 2008, as a tendency by [6].

3. Economic analysis of photovoltaic system

The economic feasibility of a photovoltaic system installation depends on the cost of producing electricity to cover the additional costs compared to conventional care system. In the case of installing