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Technical note

Making isolated renewable energy systems more reliable

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ABSTRACT

A hybrid renewable energy system (HRES) uses several kinds of sources, including wind and solar, to make better use of the natural resources in standalone applications. A common application of HRES is in remote communities, where interconnected electrical grid is unreachable due to economics and physical reasons. Due to the long distance and difficult access to these isolated areas, electrical generation systems used in these applications must be reliable. And the reliability of the system, especially the inverter used to regulate the AC voltage, is one of the main problems associated to these systems, and it is responsible for the lack of confidence in renewable systems at several locations in Brazil. This paper shows the results of using renewable hybrid systems specially designed for isolated areas, focusing attention on reliability, efficiency and expansion flexibility. It presents the system description, mode of operation, inverter design, and experimental results measured in a pilot plant located in Lençóis Island, a small isolated community in the north region of Brazil.

1. Introduction

The supply of electricity to isolated communities in Brazil and other developing countries, in general, is still done in a precarious way, using diesel generators, which operate for 3–4 h a day [1,2]. This has happened mostly due to the high cost associated with the expansion of the conventional power grid to these communities. In some cases, technical and environmental constraints also have been factors that have prevented the full electrical service in these communities, especially those located on oceanic islands.

For societies to have or attempt to maintain a sustainable development it is necessary a lot of effort in the discovery and use of renewable energy sources as well as in the increase of the efficiency in the processing of use these energy sources. In this aspect, the electric power generation based on solar photovoltaic and wind turbines technologies has been effective in distributed generation systems and also in standalone systems for supplying isolated communities [3,4]. In standalone systems, those solutions have been shown appropriate for areas of difficult access, dispersed, with environmental restrictions or with a population formed by low-income people, even when these adverse characteristics represent a difficulty for the sustainability of the designed generation system. Technical and operational troubles, and supply interruptions are difficult to be solved due to the non availability of technical assistance. The delay of remote assistance leads to long periods of lack of electrical service, causing loss of credibility in this kind of system [5,6]. Thus, to overcome these difficulties, isolated systems must be projected taking into account reliability, minimizing the dependence of maintenance and human intervention, mainly because it is expensive and quite often not available.

2. Critical issues to feasibility

The factors that most influence the reliability of standalone systems based on renewable energy are the following [5–8]:

1. *Protection coordination:* inadequate coordination leads to increased number of customers without electric service due to faults;
2. *Distribution network in marine environment*: distribution network exposed to aggressive marine environment are more vulnerable to mechanical failures and fatigue, phase- ground faults and hot spots in connections;
3. *Intermittent nature of renewable resources*: solar and wind energies have an intermittent nature, contrasting with the need to provide continuous and reliable energy;
4. *Voltage regulation*: the voltage of power distribution systems generated from intermittent sources must fulfill the power quality standards of conventional distribution systems;

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5. *Short circuits and faults in general*: requires adequate protections;
6. *Power inverter*: the dependence of unique inverter is critical for feasibility;
7. *Maintenance*: distance, natural obstacles and population with poor economic conditions make difficult the maintenance of isolated systems.

These critical issues must be addressed in order to make reliable the operation of isolated renewable energy based systems. A practical example is the system installed on the Island of Lençóis in the northeast of Brazil. This autonomous system was projected to provide electrical power 24 h a day for a community formed by approximately 390 inhabitants distributed in 90 homes. At the end of 10 years of operation, the full power consumption of the island was estimated to be approximately 6,800 kWh a month. This estimation takes into account the residential, small businesses, public agencies (school and health post) consumptions, and the consumption of a small ice factory with an average of 720 kg/day.

Fig. 1 shows a panoramic view of the Island. At right side, wind micro-turbines are observed.

3. Mixing renewable energy sources

Solar and wind energies are sources frequently available in most of isolated applications. However, they are intermittent in nature, contributing to energy supply with low reliability. To reduce this effect and to improve reliability, a practical solution is to mix these sources, obtaining the so called hybrid systems. Unfortunately, some difficulties still remain: the quality of energy must meet the standards set by regulatory agencies; what to do when all the primitive sources are not available? A well designed renewable hybrid generation system must meet some basic requirements in order to have power quality and its autonomy should be such that it achieves the community expectations. The simplified block diagram of the proposed system is presented in Fig. 2. It is formed by a solar sub-system, a wind sub-system, a battery bank, a backup diesel generator, an inverter system, and a sub-system of control and management based on a programmable logical controller (PLC).

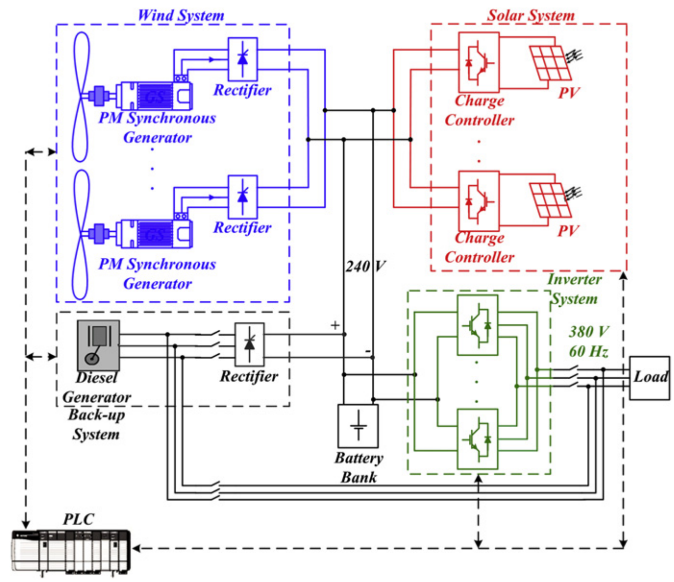

Fig. 2. Block diagram of the hybrid power system.

The solar sub-system is composed of 9 PV’ strings in parallel, each one formed by 18 photovoltaic modules in series. The strings were installed on the roof of the powerhouse as illustrated in Fig. 3. Each string has a controller to provide the correct charging of the battery bank. The total maximum power of this sub-system is approximately 21 kWp.

The electrical specifications of the solar modules that were used are shown in Table 1. Its electrical characteristics (current versus voltage as a function of temperature and solar irradiation) are shown in Fig. 4.

The wind sub-system is formed by three small wind turbines, each one with 3 blades up wind, BCW EXCEL-R/240 model (battery charging version), manufactured by Bergey WindPower [9]. These turbines were installed near the sea, on towers with 30 m high, as shown in Fig. 5. The wind generators are three-phase permanent magnet synchronous type, with an exterior rotor drum type with

Fig. 1. View of island of Lençóis, Maranhão Brazil.