TECHNICAL, ECONOMIC AND SOCIAL FEASIBILITY OF PHOTOVOLTAIC ELECTRICAL INSTALLATIONS WITH POSSIBILITY OF INTERCONNECTION TO THE PUBLIC NETWORK, FOR RURAL DOMESTIC CONSUMPTION

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Overview

For many decades, electricity production in Peru has been carried out using conventional water sources and diesel thermal power plants. With the use of Camisea gas, as of 2004 year, a change was made in the peruvian energy scenario that made possible that 94.85% of the population can access to electricity supply in their homes [1], and enjoy benefits such as education, health, street lighting, among others. On the other hand, in the year 2008 the Legislative Decree Nº 1002 was enacted, through which the Peruvian State marks a new milestone that promotes the diversification of Peru's energy matrix through the participation of non-conventional renewable energy sources. However, despite the continuous incursion of renewable energies in the electricity market and the efforts to provide quality electricity to more families, in Peru is still an approximate of 1 648 000 inhabitants who do not enjoy this benefit and who, for the most part, live in rural areas of difficult access. Taking into account this situation, the current regulatory framework and the annual solar radiation level of the regions of Peru (between 4.5 and 8 KWh /m2/day) [2], is estimated that these features can be exploited by the installation of photovoltaic systems that allow peruvians who do not enjoy electricity supply, access to domestic electrification alternatives that provide a better quality of life. Therefore, this research focused on the topic "Energy and development" proposes to evaluate the technical, economic and social viability of what type of isolated photovoltaic system or with the possibility of interconnection to the public network would be the most optimal for provide electric power supply to a Peruvian rural area. For the determination of this system, the conditions indicated by the Peruvian Technical Standard (NTP_MEM) [3] will be applied, which implies characterizing the devices that make up the photovoltaic system and evaluating the centralized reading of the electricity supply consumptions of public services. Likewise, for the fulfillment of these objectives, the application of the BT8 tariff and the FOSE subsidy (Electric Social Compensation Fund) [4] is considered, which today is used in isolated rural populations of Peru. Finally, this research seeks to establish the social and economic impact that would be generated in the remote and poor localities of Peru, through the granting of technologies that capture and process the energy coming from the sun for the daily use of the inhabitants.

Methods

This research is developed through the case study methodology, in which the rural town of El Vallecito, belonging to Cusco city, was chosen as a suitable place for electrification through photovoltaic systems because it has not access to public electricity supply, but this place presents a solar irradiance level higher than 5.5 KWh/m2/day during all months of the year. Likewise, this research presents an interdisciplinary methodology through which technical concepts related to mathematics, physics and fundamental electrical properties of each device of the photovoltaic system are developed; economic concepts that allow to establish the viability of an installation with photovoltaic technologies as a function of time and in comparison with the costs of installation to public network currently in force; and, social concepts that make it possible to assess the social value that could be generated with the delivery of a quality electricity supply in sectors not yet connected to the public electricity grid of the country. All these concepts are developed under a legal framework established by the Ministry of Energy and Mines of Peru. Regarding the technical development, which is more extensive in this research, is applied the methodology of simulations through the use of the MatlabR software, which allows the coding of algorithms and the construction of block diagrams that represent the internal structure of each device that makes up the photovoltaic system. In this way, is possible obtain results of the behavior of each device, as well as its interconnection. On the other hand, the methodology of laboratory experiments is used, in which physical tests of the devices is carried out in certain environmental conditions that will then be contrasted with the results found through the simulated model in MatlabR software.

Results

The study of technical, economic and social viability of the installation of isolated photovoltaic systems for home use in rural locations of Peru, intends to acquire the following results: Characterize the mathematical behavior of the devices that make up the photovoltaic system, using software simulations and validating the results with field tests. Through the results found in the simulations, determine the most appropriate models of devices, in technical, economic and legal terms, that would make up an isolated photovoltaic installation for the homes of the rural town of El Vallecito, which must present an efficient behavior before the level of solar radiation and the climatic changes of the place. Identify the need for protection against lightning that presents an address and the possible safeguard measures that should be used. These results will be obtained through an algorithm developed in Matlab that performs the risk assessment by entering data corresponding to the area of the land to be studied. Establish the economic viability of the installation of a photovoltaic system for the rural community of El Vallecito, in such a way that it offers a monthly fee for electricity service cheaper than the current rate established for the surrounding localities by concept of electric service from the public network. Detail the benefits related to the quality of life that users of this type of electrical installation will enjoy and that until now they lack. And, finally, establish the use of technologies related to the apply of unconventional renewable energy sources as a means of social inclusion, through which is possible the reduction of the poverty gap in Peru and the integration of the most remote communities in the country that do not enjoy of the basic services of any citizen.

Conclusions

The mathematical characterization of each of the devices that make up the photovoltaic system as well as their interconnection between them, allows acquiring a better understanding of the behavior of this alternative of electrification before variables external to the system such as solar irradiance, climate change and the atmospheric phenomena of the installation location. On the other hand, the simulations of the system in a software are a previous process that allows a better efficiency at the moment of selection of components of the installation because, remotely, preliminary results of the behavior of the devices can be obtained in the conditions of the place and as a function of time. Also, the technical study of this project leads to assess the risk conditions of the area before the possibility of electrical storms, which is beneficial because allows to determine in an automated way the risk zone and the necessary systems of lightning protection . Thanks to the technical development and simulations through the MatlabR software, it is possible to determine with greater precision the type of devices capable of taking advantage of solar energy when are installed and, accordingly, allow generate a quality electric service for the study location. This improvement in the selection process makes possible that the devices provide a more resistant behavior to the change of temperatures and levels of solar irradiance, and thus avoid spoiling or requiring maintenance in a much more continuous way than established. On the other hand, this alternative of electrification turns out to be economical for the rural sectors of Peru given that, through the BT8 tariff and the Electric Social Compensation Fund (FOSE), the monthly tariff for electricity supply is reduced in more 50%. Finally, providing electric service to rural areas of Peru is an alternative that allows reducing the poverty and social inequality gap existing in the actual context of Peru. Through the photovoltaic installations intended for home consumption, social inclusion strategies take place, allowing the beneficiaries not only to enjoy a quality electric service, but also, take advantage of opportunities such as education, health and communication with the rest of the population of the country and the world. Likewise, helping these less favored societies with a photovoltaic installation, makes possible start and expand commercial activities that could support basic economic needs of the people and allow them a better quality of life.

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