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Autonomous Photovoltaic Solar System for a Home in the San Clemente Community, Las Chacras de Río Chico

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Abstract

In recent years, renewable energies have been gaining power over conventional energies. The most used renewable energy is solar, and thanks to its electromagnetic radiation, energy can be captured through solar cells to obtain electrical energy through a converter. With the invention of photovoltaic systems, many people who saw it as far away or impossible to have electricity in their homes could count on the service through an isolated system. This document details the basic concepts necessary to be able to carry out an isolated photovoltaic installation, and after that, the step-by-step implementation of the system in the home of a resident of the Rio Chico parish, in the city of Portoviejo, and in this way, we can improve the standard of living of the inhabitants and help eradicate certain inequalities caused by the absence of electricity. The objective was to implement an autonomous photovoltaic system for the electrification of an isolated home in the Chacras de Rio Chico. An inductive-deductive method, qualitative and quantitative research, in addition to the field study, were used. The result was the electrification of the isolated home in the area.

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1 Introduction

For centuries, electrical energy has been fundamental in the lives of human beings, its use being increasingly essential, because it intervenes in all aspects of daily life, so now it is impossible to imagine a city without energy. Currently, due to the increase in fossil fuels and environmental pollution produced by the emission of greenhouse gases into the atmosphere, the population is beginning to migrate towards renewable energies, as they are clean, inexhaustible, and can be used in the same place where they are produced. Among these energies, one of the most used is solar energy, which today is growing at an exponential rate and represents zero monthly costs.

Nowadays electrical energy is a basic need of the first order and we cannot do without it. The production and use of energy are the main causes, along with transportation, of environmental pollution, being the ones that currently have the most impact on climate change. In the European Union, solar energy plays a very important role, becoming increasingly independent of fossil fuels. In turn, China and Japan are among the largest suppliers of renewable energy and technology. Europe and Asia have the highest demand for solar energy. But in Ecuador, solar energy moves very slowly despite being one of the most privileged countries due to its geographical location. The province of Manabí has high rates of solar radiation that could be used in the implementation of grid-connected and grid-isolated photovoltaic systems. Benefiting rural communities where electricity is deficient (Wissem et al., 2012; Karamov et al., 2021).

Isolated systems are an alternative designed to generate electrical energy through renewable sources, ideal for places where the quality of energy is low or does not exist. They are autonomous systems completely disconnected from the distribution network. The purpose of this document is to design and implement an isolated system for a home located in the community of Las Chacras, in the rural parish Río Chico, of Portoviejo. The house does not have electricity service; candles, diesel lamps and kerosene are used for lighting (Majji et al., 2022).

An installation of an off-grid system could supply electricity to a home to improve the quality of life of the inhabitants and would favorably help with daily activities, in addition to reducing environmental pollution and providing autonomy to the home. Due to the demand for electrical energy, more use of fossil fuels has been made, presenting a threat to society in terms of health and the economy. However, fossil fuels are not renewable resources and take millions of years to obtain.

Although electrical energy is essential in any home and business, a small part of the population still lives without electricity. The majority of these people live in rural areas and use basic energy sources to heat their homes or make use of small diesel generators, although solar panels and other renewable sources are increasingly used. Most rural areas where there is no electricity are in economically poor countries. In Ecuador, a transmission line installation is around 9 thousand dollars per kilometre and in most cases, these areas are excluded places (Doukas et al., 2012; Romero & Linares, 2014).

Don Salustino's home is without electrification, causing inequality with the rest of the community; supplying renewable energy to the home would improve the family's quality of life. To reduce environmental pollution, caused by the different types of energy-generating plants from fossil fuels (Vásquez et al., 2018), it is necessary to migrate towards renewable energies since the impact that these energies have on the planet is very insignificant.

2 Materials and Methods

For the development of the research, the inductive-deductive method was used, to know the possibilities of introducing the isolated photovoltaic system, a field investigation was carried out, where the PvSyst 7.2 for simulation and design.

3 Results and Discussions

Photovoltaic systems are an alternative to improve the living conditions of those marginalized areas, as is the case of the study of the residents of Sitio Las Chacras, in the Río Chico parish. The proposed home does not have electricity, because the area where the community is located does not have electricity service. In their home, they take advantage of solar radiation to have lighting during the day and carry out their activities, at night they use candles, diesel lamps and kerosene.

By installing an isolated system, you can obtain the same benefits as doing it conventionally, with the advantage that it is clean energy, contributing significantly by not causing greenhouse gas emissions. Because the rural population has fewer economic and technological resources than urban areas, there is greater unemployment and a deterioration in services. They are generally people with a low cost of living, so it would be difficult for them to purchase an off-grid system.

Photovoltaic systems are considered as the set of electrical and electronic equipment used to produce electricity from the capture of solar radiation. Its main component is the photovoltaic module, which is made up of cells that can transform light energy into direct current electrical energy (Bellia et al., 2015; Beccali et al., 2015). The remaining equipment included in a photovoltaic system largely depends on the application for which it is intended. In this sense, an autonomous system will be designed to supply the user's load 24 hours a day. To carry out the design of the autonomous system, the existence of solar potential was considered, and the economic feasibility study found the distance from the network. Figure 1 shows the solar potential of the studied site.

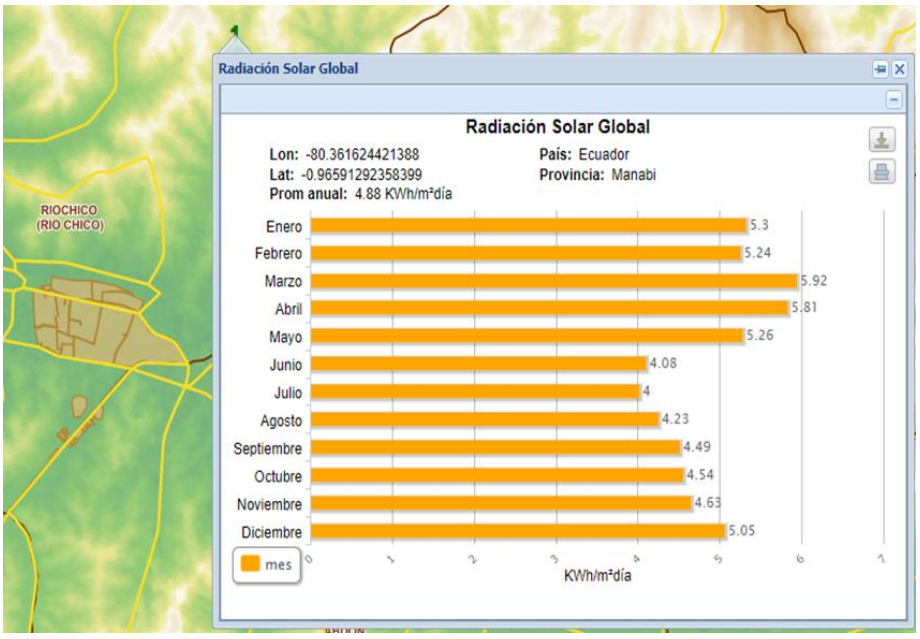

Figure 1. Annual and monthly average solar radiation potential

As can be seen, the months of March and April are the months with the highest solar radiation in the order of 5.92-5.81 kWh/m2 day and the lowest value is in June at 4 kWh/m2 day, these radiation levels allow the autonomous photovoltaic system to be implemented. The autonomous solar photovoltaic system is not connected to the electrical grid, it captures solar radiation and transforms it into energy. Its highest consumption occurs at night, which is why it has an accumulation system to store energy. In Figure 2, you can see the diagram of a grid-isolated system with its main components.

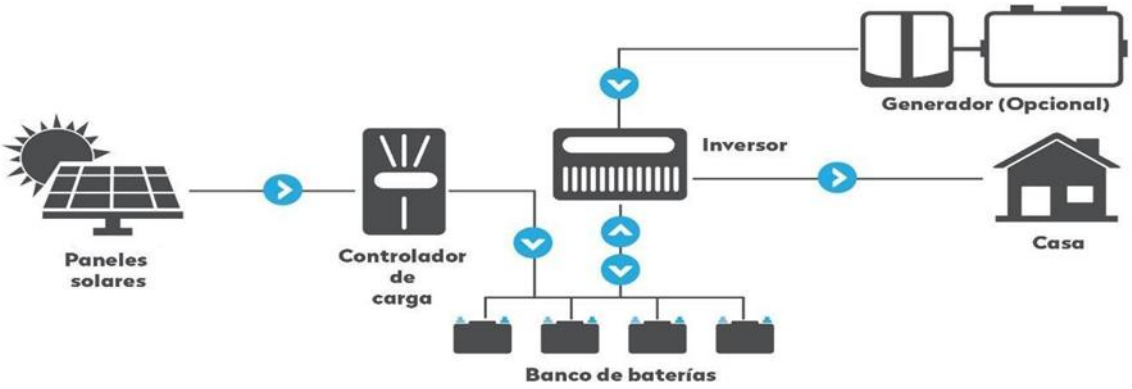

Figure 2. Schematic of a grid-isolated system
Source: (Couple, 2016)

These systems are implemented in places where the electrical distribution network is not available in certain places. These types of systems, generally not being connected to the electrical grid, must normally be equipped with energy accumulator systems, among the most common being electrochemical batteries, to provide electricity in periods of low energy generation or high demands. With its corresponding charge regulator to protect the batteries; they also usually have an inverter that transforms DC energy into AC. In the prior installation of an isolated system, it is recommended to use low-consumption electrical equipment with very good performance, to reduce the size of the components of the isolated system. These systems can be used for water pumping.

Costs and benefits of an isolated installation

This type of installation is usually implemented in places where it is difficult or expensive to bring the distribution network to the site. There are many applications in which the installation of an isolated system has a lower cost than the connection to the general network. If the economic savings in terms of electric bill payments throughout the useful life of the system are considered, this is the most economically rational option for many places and applications, it is sized with sufficient installed power and storage capacity to guarantee a reliable supply for at least three days without solar radiation (Akbas et al., 2022; Sánchez et al., 2015; Mandelli et al., 2016).

Figure 3 shows the house where the study was carried out for the implementation of the photovoltaic system. As can be seen, there are no electric cables or light bulbs. To know the demand that the home will require, a survey was carried out with the owner. 4 people are living in the house and 6 light bulbs are needed, of which 2 are for the bedrooms, 1 for the living room, 1 for the bathroom and 2 for lighting the lower part of the house. Appliances will be a refrigerator to preserve food and a 180 W television.

Figure 3. Electrified isolated home

The program used PVsys 7.2 For the design of the system, for isolated installations or pumping, we start with the energy needs that we want to cover to calculate the power that we want to install. In this type of installation, electrical production is related to estimated consumption to see if the user's needs are covered. This software is a tool that allows the study, simulation, and analysis of complete data of photovoltaic systems, allowing the design and sizing of photovoltaic systems focused mainly on grid-connected, isolated, and pumped types, taking into account the sun's radiation to the location thanks to the meteorological database, (García, 2015).

System design

The rural areas of the Portoviejo municipality have been electrified based on the financing granted by the State to the Rural and Marginal Urban Electrification Fund (FERUM) of Ecuador, for which considerable resources. To design an isolated photovoltaic system, the main thing is to know the demand that the user will require and to have information on the equipment that is available on the market with its characteristics.

The research allowed us to know the study area, providing very effective results on the lack of electricity supply in the community of Las Chacras, located in the Río Chico parish since the place where the house is located is a place that is difficult to access for conventional energy, but it has a high solar radiation index which could be used in photovoltaic systems.

The demand required by the home was calculated, determining the amount of equipment to be used, with their respective voltages and currents. The installed system has two photovoltaic panels of 100 Wp each but made of different materials, one monocrystalline and the other polycrystalline, where it was possible to analyze that the monocrystalline is more efficient since it transforms solar energy more efficiently, but In terms of cost, it is more expensive than polycrystalline, but the price of both has largely become closer in recent years. There is also a 50 AH battery, a 30 A PWM charge controller and a 12 V DC to 120 V AC inverter.

The environmental, social, and economic impact generated by installing an isolated photovoltaic system was studied. For society, it is a concern as to whether the energy is the same, without knowing that this energy is cleaner since the generation of the energy produced comes from the sun and does not require any type of fuel, so it does not generate emissions.

Photovoltaic systems, which make use of solar energy, are an alternative to find a clean and efficient way to generate electricity, they have a minimal environmental impact, and their social impact is positive, allowing both ecological and economic advantages to be taken advantage of the initial investment is much cheaper than doing a conventional installation through the extension of the network (Carbo-Mendoza et al., 2022). In addition, its production does not cause emissions of carbon dioxide gases into the atmosphere, which is the main cause of global warming. Figure 4 shows the house already electrified.

Figure 4. Illuminated housing at night

Autonomous photovoltaic systems are a viable alternative for rural electrification at a lower cost and with greater environmental acceptance, where it is possible to increase the quality of life of the rural population through the participation and use of the endogenous resources that the territory possesses.

The installation of the autonomous photovoltaic system in the rural home has a cost of 827.00 dollars without affecting the environmental environment of the place where it was installed, that is, 8,450.00 dollars less than applying the extension of the network. The funding has been possible from a project of academic linkage with society carried out by two students who are in the final phase of their professional studies in the career of Electrical Engineering, under the tutorship of the Doctor of Sciences María Rodríguez Gámez, professor at the Technical University of Manabí, who with the support of the authorities of the Decentralized Autonomous Government of the Río Chico parish and the cooperation of the

Distribution Company Navia, as well as the Micro-enterprise in Electrical Systems, Transformer Installation and Residential and Industrial Installation, both located in the Portoviejo canton, financed the project and donated the resources acquired to materialize the electrification of rural housing. The autonomous photovoltaic system for rural electrification installed in the home can avoid the annual consumption of 390-kilowatt hours of energy from the National Interconnected System, which during the life cycle of the technology (25 years) represents the saving of 16.7 barrels of oil and an environmental contribution equivalent to stopping the emission of 8.8 tons of CO2 into the atmosphere. Damaged lamps can be replaced by the user, always with the switch in the off position. If, because of the observation, any abnormality is found, the technician specialized in autonomous photovoltaic systems must be notified immediately. The only corrective action that can be taken by the user is cleaning the surface of the solar panels.

4 Conclusion

A photovoltaic system was implemented in an isolated house in the community of San Vicente, thus reducing the inequality caused by the absence of electrical service, thus improving the quality of life of the inhabitants by having electricity in the house, demonstrating that it is economically feasible to install photovoltaic systems in the Las Chacras site. The training was given to the residents of the house where the installation was carried out so that the user can frequently monitor so that it can continue to operate efficiently and carry out constant maintenance and periodic cleaning to ensure that the panels can better transform the energy received and that the system does not present interruptions.

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