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Photovoltaic System for Self-Consumption in the El Limón Community, Portoviejo, Manabí

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Keywords

distributed generation;
economic viability;
photovoltaic;
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self-consumption;

Abstract

A simulation of a photovoltaic system connected to the grid, located in El Limón, in the Portoviejo canton, for self-consumption was carried out to reduce demand during daytime hours. The literature review was used and the PvSyst tool was used, a system with a total capacity of 3075 Wp was evaluated. Various parameters were analyzed, including energy production, system losses, and economic viability. The results indicate an annual production of 4278.52 kWh and a payback period of approximately 3 years, with an average performance of 84.10%. This study provides a detailed view of the performance and financial implications of the implementation of photovoltaic systems in this region.

Contents

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1 Introduction

Photovoltaic systems connected to the electrical grid for self-consumption have become a viable and sustainable solution for generating energy in homes and companies. These types of systems allow users to produce their own electricity using solar panels, thus reducing their dependence on the electrical grid and lowering their energy bills. Furthermore, when photovoltaic generation exceeds consumption, the surplus energy can be injected into the grid, generating economic compensation for the user (Vásquez et al., 2010).

The rise of grid-connected photovoltaic systems has been driven by several factors, including the decline in solar panel costs, advances in inverter technology, and support for public policies that encourage renewable energy (IEA, 2021). These systems not only contribute to the reduction of greenhouse gas emissions by reducing the use of fossil fuels, but also play a crucial role in the transition towards a more decentralized and resilient energy model (Luthander et al., 2015).

Photovoltaic self-consumption is presented as a particularly attractive option in countries with high levels of solar radiation and high electricity rates, where investment payback periods are relatively short (Pina et al., 2013). Furthermore, the possibility of combining these systems with energy storage solutions, such as batteries, further expands their potential, allowing users to store excess production for use during hours of lower solar irradiation or during power outages (Kairies et al., 2019). As technology continues to advance and costs continue to decline, grid-connected PV systems for self-consumption are expected to become increasingly common, contributing significantly to distributed power generation and long-term environmental sustainability.

Implementing grid-connected photovoltaic systems for self-consumption in Portoviejo presents a significant opportunity to take advantage of the region's abundant solar resource and contribute to the country's energy sustainability. Below, a proposal for the implementation of these systems in Portoviejo is described, considering the advantages of these systems in distributed generation form as it is an attractive option to promote a cleaner, more efficient and resilient energy future.

2 Materials and Methods

For this simulation, version 7.4.8 of the PVsyst software was used, in evaluation mode. A literature review was carried out on distributed generation and self-consumption systems. The photovoltaic modules selected were of the JKM 205PP-48 model, with an inclination of 5 degrees and orientation to the south. The geographical location of El Limón has a latitude of -1.07° and a longitude of -80.43° at an altitude of 54 meters above sea level, a qualitative and quantitative research was carried out.

3 Results and Discussions

Implementation of grid-connected photovoltaic systems in Portoviejo, Ecuador Portoviejo, located in the coastal region of Ecuador, enjoys high levels of solar radiation throughout the year, making it an ideal location for the adoption of photovoltaic systems. The average solar radiation in Ecuador varies between 4 and 6 kWh/m^2/day, which guarantees a significant potential for solar energy generation (Cuji et al., 2018).
Figure 1 shows the solar potential of Portoviejo.

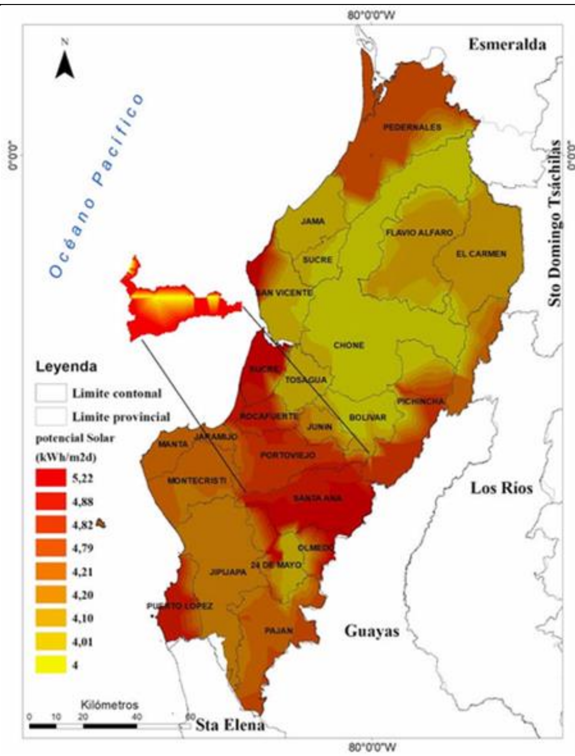

Figure 1. Solar potential of the province of Manabí and Portoviejo
Source: (Vázquez et al., 2018)

As can be seen, there is a detailed study of the solar potential of Portoviejo at different points and the identification of areas with high potential for the installation of solar panels, such as roofs of public, commercial and residential buildings. According to Cuji et al. (2018), the coastal areas of Ecuador have a high solar potential, suggesting that En el Limón could benefit considerably from photovoltaics. Deploying grid-tied PV systems in this city could not only reduce reliance on non-renewable energy sources, but could also help stabilize the local power grid, which is facing challenges due to growing demand and limited infrastructure.

The integration of photovoltaic systems with Portoviejo's electrical grid requires collaboration with the local electrical company, CNEL EP. It is essential to establish agreements for the injection of surplus energy into the grid, as well as for net metering, which allows users to offset their energy consumption with photovoltaic production (Ortiz & Rivera, 2018). Existing grid infrastructure must be evaluated and, if necessary, updated to handle the injection of PV energy. It should be kept in mind that the initial costs of installing photovoltaic systems have decreased significantly in recent years, but a considerable initial investment is still required. A cost-benefit analysis needs to be performed, taking into account the cost of photovoltaic systems, local electricity rates, and possible government incentives. In Ecuador, the Organic Law of Energy Efficiency and Renewable Energies establishes incentives for the adoption of renewable energy, which could make these projects more attractive to local residents and entrepreneurs (Ministry of Energy and Non-Renewable Natural Resources, 2019).

An essential component of the implementation is the training of local technicians in the installation and maintenance of photovoltaic systems. Awareness campaigns must also be carried out to educate the population about the benefits of photovoltaic self-consumption and how they can participate in the transition to energy. cleaner. According to Pérez et al. (2020), lack of knowledge and training is a significant barrier to the adoption of renewable energy technologies in many regions of Latin America. It is good to consider constantly monitoring the systems to ensure their optimal operation and evaluate the impact on the local electrical network. The use of remote monitoring technologies can facilitate supervision and maintenance, ensuring that systems operate at their maximum efficiency (Pina et al., 2013).

Photovoltaic systems for self-consumption, in the form of distributed generation, offer multiple advantages that cover economic, environmental, social, and energy resilience aspects. In the economic sense there is a reduction in costs, by generating their own electricity, users reduce their dependence on the electrical grid and, therefore, reduce their electricity bill and the surplus energy generated can be sold to the grid, providing an additional income (Luthander et al., 2015).

Self-consumption systems allow the generation of clean and renewable energy, which reduces the carbon footprint of users and contributes to the mitigation of climate change. By decreasing the demand for electricity generated from fossil fuels, emissions of greenhouse gases and other atmospheric pollutants are reduced (Ellabban et al., 2014). The energy independence of users is created, beneficial in areas where the electrical grid is unstable or in remote regions where the electrical supply infrastructure is limited in this context they can ensure a constant supply of energy, reducing their vulnerability to electrical outages and fluctuations. of prices in the energy market (Parra et al., 2017).

Off-grid systems contribute to the decentralization of energy production, easing the burden on large generation plants and transmission infrastructure. This can result in increased efficiency of the electrical system as a whole and a reduction in energy losses associated with long-distance transmission (Pepermans et al., 2005). These systems are flexible and scalable, where you can start with a small installation and expand it according to your energy needs and economic capabilities. In addition, photovoltaic technology can be adapted to different types of infrastructure, from homes and commercial buildings to industrial facilities (IEA, 2021).

Self-consumption systems drive innovation in the energy sector and can generate new economic opportunities. The development of a local renewable energy industry can create jobs in the installation, maintenance and manufacturing of solar components, in addition to promoting the training of professionals specialized in solar energy (IRENA, 2019).

When these systems are combined with energy storage systems, they increase their resilience Scala et al., (2013), allow citizens and small businesses to actively participate in the energy transition, making them into "prosumers" (energy producers and consumers). This empowers users, giving them control over their energy production and consumption, and promoting greater awareness about the efficient use of energy (Campos et al., 2024).

El Limón Project Description

For this simulation, version 7.4.8 of the PVsyst software was used, in evaluation mode. The simulated system does not include a 3D scene or shadows. The selected photovoltaic modules were model JKM 205PP-48, with an inclination of 5 degrees and orientation towards the north. The geographical location of El Limón has a latitude of -1.07° and a longitude of -80.43° at an altitude of 54 meters above sea level. The system was designed for a power of 3074 Wp, with a 3 kW single unit inverter, 15 modules were selected.

The simulated photovoltaic system showed a specific production of 1391 kWh/kWp/year, with a total energy produced of 4278.52 kWh/year, the average system performance was 84.10%, indicating a reasonable efficiency in solar energy conversion. to usable electrical energy. Energy production varies monthly, with June and July being the months with the highest efficiency due to lower thermal loss and greater effective irradiation in the collectors. Monthly production values ranged between 317.6 kWh in September and 443.0 kWh in April. Monthly variability is influenced by seasonal patterns of irradiance and temperature, which directly affect the performance of photovoltaic modules (Nyholm et al., 2016; Luthander et al., 2016).

The specific production of the system was 1391 kWh/kWp/year, a value that indicates the amount of energy generated by each kilowatt peak installed. This indicator is essential to evaluate the relative efficiency of the system compared to other similar installations in different locations. Figure 2 shows the results obtained.

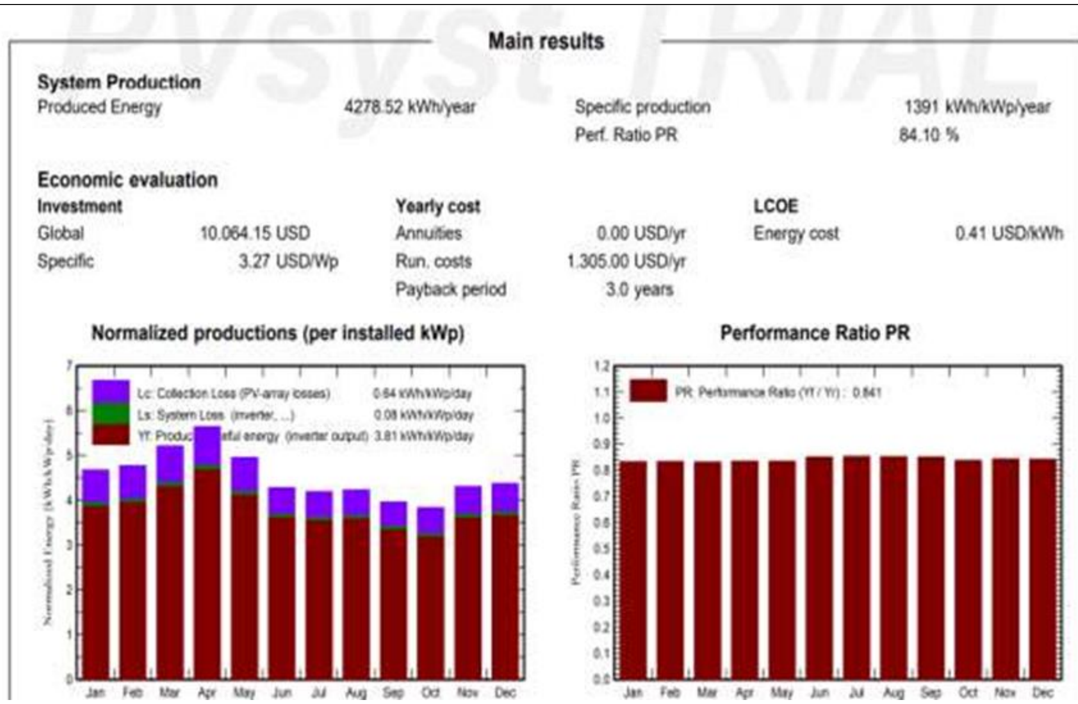

Figure 2. Results obtained

The main losses of the system were attributed to temperature: 9.73%, module mismatch: 2.0%, wiring: 0.95% and inverter efficiency: 2.02%. These losses are inherent to any photovoltaic system and represent technical challenges that must be managed to maximize energy efficiency. Temperature directly affects the performance of photovoltaic modules, and it is essential to consider cooling methods or selection of modules with better thermal coefficient (El Chaar & El Zein, 2011; Bagnall & Boreland, 2008).

Temperature losses represent a significant factor due to the high average temperature in the region. Photovoltaic modules decrease their efficiency with increasing temperature, resulting in a reduction in energy performance Epeni et al. (2023), the efficiency of the inverter also affects the amount of useful energy that can be be delivered to the electrical grid. The economic analysis shows an initial investment of 10,064.15 USD, with an annual operating cost of 1,305.00 USD. The investment recovery period is estimated at 3 years, with a return on investment (ROI) of 578.7%. The levelized cost of energy (LCOE) was calculated at $0.41/kWh, which is competitive compared to local electricity rates (Schuhbauer & Sumaila, 2016; Baumgärtner & Quaas, 2009).

The initial investment includes the cost of the modules, inverters, mounting structure, and installation costs, the operating cost includes regular maintenance of the system, cleaning of the modules, and other minor operating costs. With the system in operation, 27.7 tons of CO will no longer be emitted2, an element that contributes to the decarbonisation of the planet (Pepermans et al., 2005; Lopes et al., 2007).

Finally, the installation of photovoltaic systems can be carried out in unused areas, such as roofs of buildings, without the need to significantly alter local ecosystems, allowing the creation of jobs, reducing the electricity bill and thereby achieving diversification of the matrix. Renewable energy, in addition to improving energy security, reduces dependence on imported fuels. A practical example of these self-consumption systems is the one installed in one of the university extensions with very good results (Gamez et al., 2022). Despite the benefits, the implementation of photovoltaic systems also faces challenges that must be assessed such as the intermittency of solar energy, requiring efficient storage solutions to guarantee a continuous supply of energy, policies and regulatory frameworks must be developed that encourage investment. in renewable energies (Panwar et al., 2011; Ho et al., 2014).

4 Conclusion

The simulation carried out of the photovoltaic system for El Limón verifies that it is viable both technically and economically with an annual production of 4278.52 kWh, this is adequate to meet the energy needs of a typical home, and the financial analysis suggests a return period on the investment. of approximately 3 years, with a levelized cost of energy (LCOE) of 0.41 USD/kWh. The implementation of this system would contribute significantly to the reduction of CO_2 emissions and the promotion of renewable energy sources in the region. The implementation of photovoltaic systems in regions with high solar irradiation, such as El Limón, can contribute significantly to reducing dependence on fossil fuels and mitigating climate change. Solar energy is a clean and renewable source, which helps reduce the carbon footprint and other pollutants associated with generating energy from non-renewable sources.

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